Dataflow analysis

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Reference reading material:

- A Unified Approach to Global Program Optimization by Gary A. Kildall, POPL 1973. Gary's Ph.D. thesis at U.W. He is also known for the CP/M operating system that was an early competitor with MS-DOS (Microsoft).

run time

x = 10*5

x = 50

msg $50, x

Optimizations:
- constant propagation and folding ✓
  - x=10*5; ← x=50;
  - a=x; ← a=50;
- common subexpression elimination ✓
  - Similar to partial evaluator
- live expression analysis ✓
  - Similar to liveness analysis in register allocation

a = b+c

d = (b+c)*10

d = a*10

for i=1 to 10

x=5*60;

Peel iteration

A: a=1

B: c=0

for i=1...10 {

C: b=2

D: d=a+b

E: e=b+c

F: c=4

}

A: a=1

B: c=0

i=1

C: b=2

D: d=3

E: e=2

F: c=4

for i=2...10

{

E: e=b+c

}

i=2

E: e=6

for i = 1 ... 10

i = i + 1

i = 1

$\hat{i} = \hat{i} + 1$

$\hat{i} = \hat{i} + 1$

Path of execution

A: a=1

B: c=0

for i=1...10 {

C: b=2

D: d=a+b

E: e=b+c

F: c=4

}

b = C

	A	{ }
	A->B	{(a,1)}
P_3 C	A->B->C	{(a,1), (c,0)}
P_4 D	A->B->C->D	{(a,1), (c,0), (b,2)}
	A->B->C->D->E	{ , (d,3)}
	A->B->C->D->E->F	{ " , (e,2)}

ABCDEFC $\{ \ldots (c,4) \ldots \}$

ABCDEFCD $\}$

ABCDEFCDE

ABCDEFCDEF $\{ (e,6),(c,4)\}$

FCDE

P_i ; F

$\bigcap_i P_i$; F

i=1 ABCDEF $\{(a\ 1),(b\ 2),(c\ 0),\ d\ 3,$

i=2 ABCDEFCDEF $\{a\ 1,\ b\ 2,\ c\ 4,\ d\ 3,$

i=3 ABCDEFCDEFCDEF $\{$

⋮

10

$$\bigcap P_i\ ;\ F = \underline{(a,1)\ (b\ 2)\ (d\ 3)}$$

A: a=1

B: c=0

for i=1 ... 10 {

C: b=2

D: d= a+b

E: e=b+c

F: c=4

}

$f(A,S) = \{(a,1)\} \cup \{S - a\}$

{}

Transfer func. → monotonic, d

$f(A,S) \Rightarrow$ next state

to execute

state of current system

$X \leq Y$

$f(X) \leq$

$f(X \wedge Y$

meet

$i = 1 \ldots 50$

$1 \quad 5$

$6 \ldots 10$

$e\,2\}$

$e\,6\}$

$\{a\,1 \quad b\,2 \quad d\,3\}$

$\{a\,1 \quad b\,2 \quad d\,3\}$

istribution

$b(\cancel{x})$

$) = b(x) \wedge b(x)$

commutativ

" $\cup \{S - a\}$

$f(B, S) = \{(c, 0)\} \cup \{S - c\}$

$f(C, S) = \{(b, 2)\} \cup (S - b)$

$f(D, S) = \text{if}\{(a, n) \in S\} \text{ and } \{(b, m) \in S\}$
$(d = n + m) \cup \{S - d\}$

else
$\{S - d\}$

meet operation
intersection

$\top$

meet

$A \leq B$

$A \wedge B$

commutative

& associative

$= A$