Dataflow Analysis Assignment

Very Busy Expression

	Dataflow Problem X
Domain	Sets of Expression
Direction	Backward: in[b] = f_b(out[b]) out[b] = ∧ in(succ[b])
Transfer function	f_b(x) = Gen_b ∪ (x - $Kill_b$)
Meet Operation (∧)	∩
Boundary Condition	out[exit] = Ø
Initial interior points	in[b] = U

Iterazione 1

OUT[BB_8] = $\emptyset$

IN[BB_8] = Gen_{BB_8} ∪ (OUT[BB_8] - $Kill_{BB_8}$) = $\emptyset$ ∪ $(\emptyset - \emptyset) = \emptyset$

OUT[BB_7] = IN[BB_8] = $\emptyset$

IN[BB_7] = Gen_{BB_7} ∪ (OUT[BB_7] - $Kill_{BB_7}$) = $\{a - b\}$ ∪ $(\emptyset - \emptyset) = \{a - b\}$

OUT[BB_6] = IN[BB_7] = $\{a - b\}$

IN[BB_6] = Gen_{BB_6} ∪ (OUT[BB_6] - $Kill_{BB_6}$) = $\emptyset$ ∪ $(\{a - b\} - \{a - b\}) = \emptyset$

OUT[BB_5] = IN[BB_6] = $\emptyset$

IN[BB_5] = Gen_{BB_5} ∪ (OUT[BB_5] - $Kill_{BB_5}$) = $\{b - a\}$ ∪ $(\emptyset - \emptyset) = \{b - a\}$

OUT[BB_4] = IN[BB_8] = $\emptyset$

IN[BB_4] = Gen_{BB_4} ∪ (OUT[BB_4] - $Kill_{BB_4}$) = $\{a - b\}$ ∪ $(\emptyset - \emptyset) = \{a - b\}$

OUT[BB_3] = IN[BB_4] = $\{a - b\}$

IN[BB_3] = Gen_{BB_3} ∪ (OUT[BB_3] - $Kill_{BB_3}$) = $\{b - a\}$ ∪ $(\{a - b\} - \emptyset) = \{a - b,\ b - a\}$

OUT[BB_2] = IN[BB_3] ∩ IN[BB_5]= $\{a - b,\ b - a\}$ ∩ $\{b - a\} = \{b - a\}$

IN[BB_2] = Gen_{BB_2} ∪ (OUT[BB_2] - $Kill_{BB_2}$) = $\emptyset$ ∪ $(\{b - a\} - \emptyset) = \{b - a\}$

OUT[BB_1] = IN[BB_2] = $\{b - a\}$

IN[BB_1] = Gen_{BB_1} ∪ (OUT[BB_1] - $Kill_{BB_1}$) = $\emptyset$ ∪ $(\{b - a\} - \emptyset) = \{b - a\}$

BitVector = <b-a, a-b>

	Iterazione 1	
	IN[B]	OUT[B]
BB1	<10>	<10>
BB2	<10>	<10>
BB3	<11>	<01>
BB4	<01>	<00>
BB5	<10>	<00>
BB6	<00>	<01>
BB7	<01>	<00>
BB8	<00>	<00>

Dominator Analysis

	Dataflow Problem X
Domain	Sets of Basic Blocks
Direction	Forward: out[b] = f_b(in[b]) in[b] = $\wedge$ out(pred[b])
Transfer function	$f_b(x) = b \cup x$
Meet Operation ($\wedge$)	$\cap$
Boundary Condition	in[entry] = $\emptyset$
Initial interior points	in[b] = U

Iterazione 1

IN[A] = Ø

OUT[A] = {A} ∪ Ø = {A}

IN[B] = OUT[A] ={A}

OUT[B] = {B} ∪ {A} = {A, B}

IN[C] = OUT[A] = {A}

OUT[C] = {C} ∪ {A} = {A, C}

IN[D] = OUT[C] = {A, C}

OUT[D] = {D} ∪ {A, C} = {A, C, D}

IN[E] = OUT[C] = {A, C}

OUT[E] = {E} ∪ {A, C} = {A, C, E}

IN[F] = OUT[D] ∩ OUT[E]= {A, C, D} ∩ {A, C, E} = {A, C}

OUT[F] = {F} ∪ {A, C} = {A, C, F}

IN[G] = OUT[B] ∩ OUT[F]= {A, B} ∩ {A, C, F} = {A}

OUT[G] = {G} ∪ {A} = {A, G}

BitVector = <A,B,C,D,E,F,G>

	Iterazione 1	
	IN[B]	OUT[B]
A	<0000000>	<1000000>
B	<1000000>	<1100000>
C	<1000000>	<1010000>
D	<1010000>	<1011000>
E	<1010000>	<1010100>
F	<1010000>	<1010010>
G	<1000000>	<1000001>

Constant Propagation

	Dataflow Problem X
Domain	Sets of Pairs (variable, costant)
Direction	Forward: out[b] = f_b(in[b]) in[b] = ∧ out(pred[b])
Transfer function	f_b(x) = Gen_b ∪ (x - $Kill_b$)
Meet Operation (∧)	∩
Boundary Condition	in[entry] = ∅
Initial interior points	in[b] = U

Iterazione 1

IN[BB$_1$] = $\emptyset$

OUT[BB$_1$] = Gen_{BB_1} ∪ (IN[BB$_1$] - $Kill_{BB_1}$) = $\emptyset \cup (\emptyset - \emptyset) = \emptyset$

IN[BB$_2$] = $\emptyset$

OUT[BB$_2$] = Gen_{BB_2} ∪ (IN[BB$_2$] - $Kill_{BB_2}$) = $\emptyset \cup (\{(k,2)\} - \emptyset) = \{(k,2)\}$

IN[BB$_3$] = OUT[BB$_2$] = $\{(k,2)\}$

OUT[BB$_3$] = Gen_{BB_3} ∪ (IN[BB$_3$] - $Kill_{BB_3}$) = $\emptyset \cup (\{(k,2)\} - \emptyset) = \{(k,2)\}$

IN[BB$_4$] = OUT[BB$_3$] = $\{(k,2)\}$

OUT[BB$_4$] = Gen_{BB_4} ∪ (IN[BB$_4$] - $Kill_{BB_4}$) = $\{(a,4)\} \cup (\{(k,2)\} - \emptyset) = \{(k,2),(a,4)\}$

IN[BB$_5$] = OUT[BB$_4$] = $\{(k,2),(a,4)\}$

OUT[BB$_5$] = Gen_{BB_5} ∪ (IN[BB$_5$] - $Kill_{BB_5}$) = $\{(x,5)\} \cup (\{(k,2),(a,4)\} - \emptyset) = \{(k,2),(a,4),(x,5)\}$

IN[BB$_6$] = OUT[BB$_3$] = $\{(k,2)\}$

OUT[BB$_6$] = Gen_{BB_6} ∪ (IN[BB$_6$] - $Kill_{BB_6}$) = $\{(a,4)\} \cup (\{(k,2)\} - \emptyset) = \{(k,2),(a,4)\}$

IN[BB$_7$] = OUT[BB$_6$] = $\{(k,2),(a,4)\}$

OUT[BB$_7$] = Gen_{BB_7} ∪ (IN[BB$_7$] - $Kill_{BB_7}$) = $\{(x,8)\} \cup (\{(k,2),(a,4)\} - \emptyset) = \{(k,2),(a,4),(x,8)\}$

IN[BB$_8$] = OUT[BB$_5$] ∩ OUT[BB$_7$] = $\{(k,2),(a,4),(x,5)\} \cap \{(k,2),(a,4),(x,8)\} = \{(k,2),(a,4)\}$

OUT[BB$_8$] = Gen_{BB_8} ∪ (IN[BB$_8$] - $Kill_{BB_8}$) = $\{(k,4)\} \cup (\{(k,2),(a,4)\} - \{(k,2)\}) = \{(k,4),(a,4)\}$

IN[BB$_9$] = OUT[BB$_8$] ∩ OUT[BB$_{13}$] =$\{(k,4),(a,4)\} \cap U = \{(k,4),(a,4)\}$

OUT[BB$_9$] = Gen_{BB_9} ∪ (IN[BB$_9$] - $Kill_{BB_9}$) = $\emptyset \cup (\{(k,4),(a,4)\} - \emptyset) = \{(k,4),(a,4)\}$

IN[BB$_{10}$] = OUT[BB$_9$] = $\{(k,4),(a,4)\}$

OUT[BB$_{10}$] = $Gen_{BB_{10}}$ ∪ (IN[BB$_{10}$] - $Kill_{BB_{10}}$) = $\{(b,2)\} \cup (\{(k,4),(a,4)\} - \emptyset) = \{(k,4),(a,4),(b,2)\}$

IN[BB$_{11}$] = OUT[BB$_{10}$] = $\{(k,4),(a,4),(b,2)\}$

OUT[BB$_{11}$] = $Gen_{BB_{10}}$ ∪ (IN[BB$_{10}$] - $Kill_{BB_{10}}$) = $\{(x,8)\} \cup (\{(k,4),(a,4),(b,2)\} - \emptyset) = \{(k,4),(a,4),(b,2),(x,8)\}$

IN[BB$_{12}$] = OUT[BB$_{11}$] = $\{(k,4),(a,4),(b,2),(x,8)\}$

OUT[BB$_{12}$] = $Gen_{BB_{12}}$ ∪ (IN[BB$_{12}$] - $Kill_{BB_{12}}$) = $\{(y,8)\} \cup (\{(k,4),(a,4),(b,2),(x,8)\} - \emptyset) = \{(k,4),(a,4),(b,2),(x,8),(y,8)\}$

IN[BB$_{13}$] = OUT[BB$_{12}$] = $\{(k,4),(a,4),(b,2),(x,8),(y,8)\}$

OUT[BB$_{13}$] = $Gen_{BB_{13}}$ ∪ (IN[BB$_{13}$] - $Kill_{BB_{13}}$) = $\{(k,5)\} \cup (\{(k,4),(a,4),(b,2),(x,8)\} - \{(k,4)\}) = \{(k,5),(a,4),(b,2),(x,8),(y,8)\}$

IN[BB$_{14}$] = OUT[BB$_9$] = $\{(k,4),(a,4)\}$

OUT[BB$_{14}$] = $Gen_{BB_{14}}$ ∪ (IN[BB$_{14}$] - $Kill_{BB_{14}}$) = $\emptyset \cup (\{(k,4),(a,4)\} - \emptyset) = \{(k,4),(a,4)\}$

IN[BB$_{15}$] = OUT[BB$_{14}$] = $\{(k,4),(a,4)\}$

OUT[BB$_{15}$] = $Gen_{BB_{15}}$ ∪ (IN[BB$_{15}$] - $Kill_{BB_{15}}$) = $\emptyset \cup (\{(k,4),(a,4)\} - \emptyset) = \{(k,4),(a,4)\}$

Iterazione 2

IN[BB_1] = $\emptyset$

OUT[BB_1] = $\emptyset$

IN[BB_2] = $\emptyset$

OUT[BB_2] = $\{(k, 2)\}$

IN[BB_3] = $\{(k, 2)\}$

OUT[BB_3] = $\{(k, 2)\}$

IN[BB_4] = $\{(k, 2)\}$

OUT[BB_4] = $\{(k, 2), (a, 4)\}$

IN[BB_5] = $\{(k, 2), (a, 4)\}$

OUT[BB_5] = $\{(k, 2), (a, 4), (x, 5)\}$

IN[BB_6] = $\{(k, 2)\}$

OUT[BB_6] = $\{(k, 2), (a, 4)\}$

IN[BB_7] = $\{(k, 2), (a, 4)\}$

OUT[BB_7] = $\{(k, 2), (a, 4), (x, 8)\}$

IN[BB_8] = $\{(k, 2), (a, 4)\}$

OUT[BB_8] = $\{(k, 4), (a, 4)\}$

IN[BB_9] = OUT[BB_8] $\cap$ OUT[BB_{13}] $=\{(k, 4), (a, 4)\} \cap \{(k, 5), (a, 4), (b, 2), (x, 8), (y, 8)\} = \{(a, 4)\}$

OUT[BB_9] = Gen_{BB_9} $\cup$ (IN[BB_9] - $Kill_{BB_9}$) = $\emptyset \cup (\{(a, 4)\} - \emptyset) = \{(a, 4)\}$

IN[BB_{10}] = OUT[BB_9] $= \{(a, 4)\}$

OUT[BB_{10}] = $Gen_{BB_{10}}$ $\cup$ (IN[BB_{10}] - $Kill_{BB_{10}}$) = $\{(b, 2)\} \cup (\{(a, 4)\} - \emptyset) = \{(a, 4), (b, 2)\}$

IN[BB_{11}] = OUT[BB_{10}] $= \{(a, 4), (b, 2)\}$

OUT[BB_{11}] = $Gen_{BB_{10}}$ $\cup$ (IN[BB_{10}] - $Kill_{BB_{10}}$) = $\emptyset \cup (\{(a, 4), (b, 2)\} - \emptyset) = \{(a, 4), (b, 2)\}$

IN[BB_{12}] = OUT[BB_{11}] $= \{(a, 4), (b, 2)\}$

OUT[BB_{12}] = $Gen_{BB_{12}}$ $\cup$ (IN[BB_{12}] - $Kill_{BB_{12}}$) = $\{(y, 8)\} \cup (\{(a, 4), (b, 2)\} - \emptyset) = \{(a, 4), (b, 2), (y, 8)\}$

IN[BB_{13}] = OUT[BB_{12}] $= \{(a, 4), (b, 2), (y, 8)\}$

OUT[BB_{13}] = $Gen_{BB_{13}}$ $\cup$ (IN[BB_{13}] - $Kill_{BB_{13}}$) = $\emptyset \cup (\{(a, 4), (b, 2), (y, 8)\} - \emptyset) = \{(a, 4), (b, 2), (y, 8)\}$

IN[BB_{14}] = OUT[BB_9] $= \{(a, 4)\}$

OUT[BB_{14}] = $Gen_{BB_{14}}$ $\cup$ (IN[BB_{14}] - $Kill_{BB_{14}}$) = $\emptyset \cup (\{(a, 4)\} - \emptyset) = \{(a, 4)\}$

IN[BB_{15}] = OUT[BB_{14}] $= \{(a, 4)\}$

OUT[BB_{15}] = $Gen_{BB_{15}}$ $\cup$ (IN[BB_{15}] - $Kill_{BB_{15}}$) = $\emptyset \cup (\{(a, 4)\} - \emptyset) = \{(a, 4)\}$

Iterazione 3

IN[BB_1] = Ø

OUT[BB_1] = Ø

IN[BB_2] = Ø

OUT[BB_2] = $\{(k, 2)\}$

IN[BB_3] = $\{(k, 2)\}$

OUT[BB_3] = $\{(k, 2)\}$

IN[BB_4] = $\{(k, 2)\}$

OUT[BB_4] = $\{(k, 2), (a, 4)\}$

IN[BB_5] = $\{(k, 2), (a, 4)\}$

OUT[BB_5] = $\{(k, 2), (a, 4), (x, 5)\}$

IN[BB_6] = $\{(k, 2)\}$

OUT[BB_6] = $\{(k, 2), (a, 4)\}$

IN[BB_7] = $\{(k, 2), (a, 4)\}$

OUT[BB_7] = $\{(k, 2), (a, 4), (x, 8)\}$

IN[BB_8] = $\{(k, 2), (a, 4)\}$

OUT[BB_8] = $\{(k, 4), (a, 4)\}$

IN[BB_9] = OUT[BB_8] ∩ OUT[BB_{13}] =$\{(k, 4), (a, 4)\}$ ∩ $\{(a, 4), (b, 2), (y, 8)\} = \{(a, 4)\}$

OUT[BB_9] = $\{(a, 4)\}$

IN[BB_{10}] = $\{(a, 4)\}$

OUT[BB_{10}] = $\{(a, 4), (b, 2)\}$

IN[BB_{11}] = $\{(a, 4), (b, 2)\}$

OUT[BB_{11}] =$\{(a, 4), (b, 2)\}$

IN[BB_{12}] = $\{(a, 4), (b, 2)\}$

OUT[BB_{12}] = $\{(a, 4), (b, 2), (y, 8)\}$

IN[BB_{13}] = $\{(a, 4), (b, 2), (y, 8)\}$

OUT[BB_{13}] = $\{(a, 4), (b, 2), (y, 8)\}$

IN[BB_{14}] = $\{(a, 4)\}$

OUT[BB_{14}] = $\{(a, 4)\}$

IN[BB_{15}] = OUT[BB_{14}] = $\{(a, 4)\}$

OUT[BB_{15}] = $Gen_{BB_{15}}$ ∪ (IN[BB_{15}] - $Kill_{BB_{15}}$) = Ø ∪ $(\{(a, 4)\} - \emptyset) = \{(a, 4)\}$

BitVector = <(a,4),(b,2),(k,2),(k,4),(k,5),(x,5),(x,8),(y,8)>

	Iterazione 1		Iterazione 2		Iterazione 3	
	IN[B]	OUT[B]	IN[B]	OUT[B]	IN[B]	OUT[B]
BB1	<00000000>	<00000000>	<00000000>	<00000000>	<00000000>	<00000000>
BB2	<00000000>	<00100000>	<00000000>	<00100000>	<00000000>	<00100000>
BB3	<00100000>	<00100000>	<00100000>	<00100000>	<00100000>	<00100000>
BB4	<00100000>	<10100000>	<00100000>	<10100000>	<00100000>	<10100000>
BB5	<10100000>	<10100100>	<10100000>	<10100100>	<10100000>	<10100100>
BB6	<00100000>	<10100000>	<00100000>	<10100000>	<00100000>	<10100000>
BB7	<10100000>	<10100010>	<10100000>	<10100010>	<10100000>	<10100010>
BB8	<10100000>	<10010000>	<10100000>	<10010000>	<10100000>	<10010000>
BB9	<10010000>	<10010000>	<10000000>	<10000000>	<10000000>	<10000000>
BB10	<10010000>	<11010000>	<10000000>	<11000000>	<10000000>	<11000000>
BB11	<11010000>	<11010010>	<11000000>	<11000000>	<11000000>	<11010000>
BB12	<11010010>	<11010011>	<11000000>	<11000001>	<11000000>	<11000001>
BB13	<11010011>	<11001011>	<11000001>	<11000001>	<11000001>	<11000001>
BB14	<10010000>	<10010000>	<10000000>	<10000000>	<10000000>	<10000000>
BB15	<10010000>	<10010000>	<10000000>	<10000000>	<10000000>	<10000000>