Very Busy Expression

Domain

Sets of expression

Direction

Backward:
- $In[B] = f_b(Out[B])$
- $Out[B] = \blacksquare\ In[succ(B)]$

Transfer Function

$f_b(x) = Gen[B] \cup (x - Kill[B])$

Meet Operator (■)

$\cap$

Boundary Condition

$In[exit] = \emptyset$

Initial Interior Points

$In[B] = U$

Definizioni:

- **Gen[B]** → le espressioni usate nel blocco B che non hanno operandi definiti nel blocco stesso.
- **Kill[B]** → tutte le espressioni che contengono variabili definite nel blocco B

Tabella Gen-Kill

	Gen	Kill
BB2	-	-
BB3	(b – a)	-
BB4	(a – b)	-
BB5	(b – a)	-
BB6	-	(a – b), (b – a)
BB7	(a – b)	-

Tabella iterazioni

Iterazione 1

	In[B]	Out[B]
BB1	∅	(b – a)
BB2	(b – a)	{(b – a), (a – b)} ∩ {(b – a)} = (b – a)
BB3	(b – a),(a – b)	(a – b)
BB4	(a – b)	∅
BB5	(b – a)	∅
BB6	∅	(a – b)
BB7	(a – b)	∅

Iterazione 2

	In[B]	Out[B]
BB1	∅	(b – a)
BB2	(b – a)	{(b – a), (a – b)} ∩ {(b – a)} = (b – a)
BB3	(b – a),(a – b)	(a – b)
BB4	(a – b)	∅
BB5	(b – a)	∅
BB6	∅	(a – b)
BB7	(a – b)	∅

Passi dell'algoritmo

1° Iterazione

OldIn[B4] = ∅
In[B4] = (a – b) ∪ (∅–∅) = {(a – b)}

OldIn[B3] = ∅
In[B3] = (b – a) ∪ ((a – b) –∅) = {(b – a), (a – b)}

OldIn[B7] = ∅
In[B7] = (a – b) ∪ (∅–∅) = {(a – b)}

OldIn[B6] = ∅
In[B6] = ∅ ∪ ((a – b) – (a – b)) = ∅

OldIn[B5] = ∅
In[B4] = (b – a) ∪ (∅–∅) = {(b – a)}

OldIn[B2] = ∅
In[B2] = ∅ ∪ ({(b – a), (a – b)} ∩ {(b – a)} –∅) = {(b – a)}

OldIn[Entry] = ∅
In[Entry] = ∅ ∪ ({(b – a)} – ∅) = {(b – a)}

2° Iterazione

OldIn[B4] = {(a – b)}
In[B4] = (a – b) ∪ (∅–∅) = {(a – b)}

OldIn[B3] = {(b – a), (a – b)}
In[B3] = (b – a) ∪ ((a – b) –∅) = {(b – a), (a – b)}

OldIn[B7] = {(a – b)}
In[B7] = (a – b) ∪ (∅–∅) = {(a – b)}

OldIn[B6] = ∅
In[B6] = ∅ ∪ ((a – b) – (a – b)) = ∅

$OldIn[B5] = \{(b - a)\}$
$In[B4] = (b - a) \cup (\varnothing - \varnothing) = \{(b - a)\}$

$OldIn[B2] = \{(b - a)\}$
$In[B2] = \varnothing \cup (\{(b - a), (a - b)\} \cap \{(b - a)\} - \varnothing) = \{(b - a)\}$

$OldIn[Entry] = \{(b - a)\}$
$In[Entry] = \varnothing \cup (\{(b - a)\} - \varnothing) = \{(b - a)\}$

Dominator Analysis

Domain

Sets of Basic Block

Direction

Forward:
• $Out[B] = f_b(In[B])$
• $In[B] =$ ■ $Out[pred(B)]$

Transfer Function

$f_b(x) = Gen[B] \cup x$

Meet Operator (■)

$\cap$

Boundary Condition

Out[entry] = entry

Initial Interior Points

Out[B] = Universal Set

Definizioni:

• **Gen[B]** → il blocco stesso

Tabella Gen-Kill

Ogni blocco genera solo sé stesso e non uccide niente.

Passi dell'algoritmo

$In[A] = \varnothing$
$Out[A] = A$

$In[B] = A$
$Out[B] = B \cup A = A, B$

$In[C] = A$
$Out[C] = C \cup A = A, C$

$In[D] = A, C$
$Out[D] = D \cup \{A, C\} = A, C, D$

$In[E] = A, C$
$Out[E] = E \cup \{A, C\} = A, C, E$

$In[F] = Out[D] \cap Out[E] = \{A, C, D\} \cap \{A, C, E\} = \{A, C\}$

$Out[F] = F \cup (\{A, C, D\} \cap \{A, C, E\}) = \{A, C, F\}$

$In[G] = Out[B] \cap Out[F] = \{A, C, F\} \cap \{A, B\} = \{A\}$
$Out[G] = G \cup (\{A, C, F\} \cap \{A, B\}) = \{A, G\}$

Tabella iterazioni

	In[B]	Out[B]
A	/	A
B	A	A, B
C	A	A, C
D	A, C	A, C, D
E	A, C	A, C, E
F	$\{A, C, D\} \cap \{A, C, E\} = A, C$	A, C, F
G	$\{A, C, F\} \cap \{A, B\} = A$	A, G

(Iterazione 2 analoga)

Constant Propagation

Domain

Sets of [x, c]

Direction

Forward:
• $Out[B] = f_b(In[B])$
• In[B] = ■ Out[pred(B)]

Transfer Function

$f_b(x) = Gen[B] \cup (x – Kill[B])$

Meet Operator (■)

∩

Boundary Condition

Out[entry] = ∅

Initial Interior Points

Out[B] = Universal Set

Definizioni:

• **Gen[B]** → le definizioni che hanno uno o entrambi gli operandi costanti in B
• **Kill[B]** → tutte le coppie che contengono le variabili definite nuovamente nel blocco B

Tabella Gen-Kill

	Gen	Kill
BB1	[k,2]	-
BB2	-	-
BB3	-	-
BB4	[x,5]	[x,8]
BB5	-	-
BB6	[x,8]	[x,5]
BB7	-	[k,2]
BB8	-	-
BB9	[b,2]	-

BB10	-	[x,5], [x,8]
BB11	-	-
BB12	-	[k,2]

Tabella iterazioni

Iterazione 1

	In[B]	Out[B]
BB1	∅	[k, 2]
BB2	[k, 2]	[k, 2]
BB3	[k, 2]	[k, 2]
BB4	[k, 2]	[k, 2], [x, 5]
BB5	[k, 2]	[k, 2]
BB6	[k, 2]	[k, 2], [x, 8]
BB7	[k, 2]	∅
BB8	∅	∅
BB9	∅	[b, 2]
BB10	[b, 2]	[b, 2]
BB11	[b, 2]	[b, 2]
BB12	[b, 2]	[b, 2]
BB13	∅	∅

Iterazione 2

	In[B]	Out[B]
BB1	∅	[k, 2]
BB2	[k, 2]	[k, 2]
BB3	[k, 2]	[k, 2]
BB4	[k, 2]	[k, 2], [x, 5]
BB5	[k, 2]	[k, 2]
BB6	[k, 2]	[k, 2], [x, 8]
BB7	[k, 2]	∅
BB8	∅	∅
BB9	∅	[b, 2]
BB10	[b, 2]	[b, 2]
BB11	[b, 2]	[b, 2]
BB12	[b, 2]	[b, 2]
BB13	∅	∅

Passi dell'algoritmo

1° Iterazione

OldOut[BB1] = U
In[BB1] = ∅
Out[BB1] = [k, 2] ∪ (∅–∅) = [k, 2]

OldOut[BB2] = U
In[BB2] = [k, 2]
Out[BB2] = ∅ ∪ ([k, 2] –∅) = [k, 2]

OldOut[BB3] = U
In[BB3] = [k, 2]
Out[BB3] = ∅ ∪ ([k, 2] –∅) = [k, 2]

OldOut[BB4] = U
In[BB4] = [k, 2]
Out[BB4] = [x, 5] ∪ ([k, 2] – [x, 8]) = {[x, 5], [k, 2]}

OldOut[BB5] = U
In[BB5] = [k, 2]
Out[BB5] = ∅ ∪ ([k, 2] –∅) = [k, 2]

OldOut[BB6] = U
In[BB6] = [k, 2]
Out[BB6] = [x, 8] ∪ ([k, 2] – [x, 5]) = {[x, 8], [k, 2]}

OldOut[BB7] = U
In[BB7] = Out[BB4] ∩ Out[BB6] = {[x, 8], [k, 2]} ∩ {[x, 5], [k, 2]} = [k, 2]
Out[BB7] = ∅ ∪ ([k, 2] – [k, 2]) = ∅

OldOut[BB8] = U
In[BB8] = Out[BB12] ∩ Out[BB7] = ∅
Out[BB8] = ∅ ∪ (∅–∅) = ∅

OldOut[BB9] = U
In[BB9] = ∅
Out[BB9] = [b, 2] ∪ (∅–∅) = [b, 2]

OldOut[BB10] = U
In[BB10] = [b, 2]
Out[BB10] = ∅ ∪ ([b, 2] – [x, 5], [x, 8]) = [b, 2]

OldOut[BB11] = U
In[BB11] = [b, 2]
Out[BB11] = ∅ ∪ ([b, 2] –∅) = [b, 2]

OldOut[BB12] = U
In[BB12] = [b, 2]
Out[BB12] = ∅ ∪ ([b, 2] – [k, 2]) = [b, 2]

OldOut[BB13] = U
In[BB13] = ∅
Out[BB13] = ∅ ∪ (∅–∅) = ∅

2° Iterazione

OldOut[BB1] = [k, 2]
In[BB1] = ∅
Out[BB1] = [k, 2] ∪ (∅–∅) = [k, 2]

OldOut[BB2] = [k, 2]
In[BB2] = [k, 2]
Out[BB2] = ∅ ∪ ([k, 2] –∅) = [k, 2]

OldOut[BB3] = [k, 2]
In[BB3] = [k, 2]
Out[BB3] = ∅ ∪ ([k, 2] –∅) = [k, 2]

OldOut[BB4] = {[x, 5], [k, 2]}
In[BB4] = [k, 2]

$\text{Out}[BB4] = [x, 5] \cup ([k, 2] - [x, 8]) = \{[x, 5], [k, 2]\}$

$\text{OldOut}[BB5] = [k, 2]$
$\text{In}[BB5] = [k, 2]$
$\text{Out}[BB5] = \varnothing \cup ([k, 2] - \varnothing) = [k, 2]$

$\text{OldOut}[BB6] = \{[x, 8], [k, 2]\}$
$\text{In}[BB6] = [k, 2]$
$\text{Out}[BB6] = [x, 8] \cup ([k, 2] - [x, 5]) = \{[x, 8], [k, 2]\}$

$\text{OldOut}[BB7] = \varnothing$
$\text{In}[BB7] = \text{Out}[BB4] \cap \text{Out}[BB6] = \{[x, 8], [k, 2]\} \cap \{[x, 5], [k, 2]\} = [k, 2]$
$\text{Out}[BB7] = \varnothing \cup ([k, 2] - [k, 2]) = \varnothing$

$\text{OldOut}[BB8] = \varnothing$
$\text{In}[BB8] = \text{Out}[BB12] \cap \text{Out}[BB7] = \varnothing$
$\text{Out}[BB8] = \varnothing \cup (\varnothing - \varnothing) = \varnothing$

$\text{OldOut}[BB9] = [b, 2]$
$\text{In}[BB9] = \varnothing$
$\text{Out}[BB9] = [b, 2] \cup (\varnothing - \varnothing) = [b, 2]$

$\text{OldOut}[BB10] = [b, 2]$
$\text{In}[BB10] = [b, 2]$
$\text{Out}[BB10] = \varnothing \cup ([b, 2] - [x, 5], [x, 8]) = [b, 2]$

$\text{OldOut}[BB11] = [b, 2]$
$\text{In}[BB11] = [b, 2]$
$\text{Out}[BB11] = \varnothing \cup ([b, 2] - \varnothing) = [b, 2]$

$\text{OldOut}[BB12] = [b, 2]$
$\text{In}[BB12] = [b, 2]$
$\text{Out}[BB12] = \varnothing \cup ([b, 2] - [k, 2]) = [b, 2]$

$\text{OldOut}[BB13] = \varnothing$
$\text{In}[BB13] = \varnothing$
$\text{Out}[BB13] = \varnothing \cup (\varnothing - \varnothing) = \varnothing$