

| Very Busy Expression    |  |
|-------------------------|--|
| Domain                  | L'insieme delle espressioni  |
| Direction               | Backward<br>$in[b] = f_b(out[b])$<br>$out[b] = \wedge in[succ(b)]$ |
| Transfer function       | $f_b(x) = Gen_b \cup (x - Kill_b)$                                 |
| Meet operation          | $\cap$   |
| Boundary condition      | $in[exit] = \emptyset$   |
| Initial interior points | $in[b] = u$ (universal set)  |

|     | GEN[]       | KILL[]      |
|-----|-------------|-------------|
| BB1 | $\emptyset$ | $\emptyset$ |
| BB2 | $\emptyset$ | $\emptyset$ |
| BB3 | b-a         | $\emptyset$ |
| BB4 | a-b         | $\emptyset$ |
| BB5 | b-a         | $\emptyset$ |
| BB6 | $\emptyset$ | a-b         |
| BB7 | a-b         | $\emptyset$ |
| BB8 | $\emptyset$ | $\emptyset$ |

|     | IN  | OUT                                   |
|-----|---|---------------------------------------|
| BB1 | $\emptyset \cup (\{b-a\} - \emptyset) = \{b-a\}$    | $\{b-a\}$                             |
| BB2 | $\emptyset \cup (\{b-a\} - \emptyset) = \{b-a\}$    | $\{b-a, a-b\} \cap \{b-a\} = \{b-a\}$ |
| BB3 | $\{b-a\} \cup (\{a-b\} - \emptyset) = \{b-a, a-b\}$ | $\{a-b\}$                             |
| BB4 | $\{a-b\} \cup (\emptyset - \emptyset) = \{a-b\}$    | $\emptyset$                           |
| BB5 | $\{b-a\} \cup (\emptyset - \emptyset) = \{b-a\}$    | $\emptyset$                           |
| BB6 | $\emptyset \cup (\{a-b\} - \{a-b\}) = \emptyset$    | $\{a-b\}$                             |
| BB7 | $\{a-b\} \cup (\emptyset - \emptyset) = \{a-b\}$    | $\emptyset$                           |
| BB8 | $\emptyset$   | $\emptyset$                           |

| Dominator Analys        |   |
|-------------------------|---|
| Domain                  | L'insieme dei blocchi   |
| Direction               | Forward<br>$out[b] = f_b(in[b])$<br>$in[b] = \wedge out[pred(b)]$ |
| Transfer function       | $f_b(x) = Gen_b \cup (x - Kill_b)$                                |
| Meet operation          | $\cap$  |
| Boundary condition      | $out[entry] = \emptyset$  |
| Initial interior points | $out[b] = u$ (universal set)                                      |

$GEN[b] = B$  (ogni blocco genera se stesso)

$KILL[b] = \emptyset$  (non sono presenti operazioni di kill)

|   | IN  | OUT   |
|---|---|---|
| A | $\emptyset$                               | $A \cup (\emptyset - \emptyset) = \{A\}$      |
| B | A   | $B \cup (A - \emptyset) = \{A, B\}$           |
| C | A   | $C \cup (A - \emptyset) = \{A, C\}$           |
| D | $\{A, C\}$                                | $D \cup (\{A, C\} - \emptyset) = \{A, C, D\}$ |
| E | $\{A, C\}$                                | $E \cup (\{A, C\} - \emptyset) = \{A, C, E\}$ |
| F | $\{A, C, D\} \cap \{A, C, E\} = \{A, C\}$ | $F \cup (\{A, C\} - \emptyset) = \{A, C, F\}$ |
| G | $\{A, B\} \cap \{A, C, F\} = \{A\}$       | $G \cup (A - \emptyset) = \{A, G\}$           |

| Constant Propagation    |   |
|-------------------------|---|
| Domain                  | L'insieme delle coppie <variabile, valore costante>               |
| Direction               | Forward<br>$out[b] = f_b(in[b])$<br>$in[b] = \wedge out[pred(b)]$ |
| Transfer function       | $f_b(x) = Gen_b \cup (x - Kill_b)$                                |
| Meet operation          | $\cap$  |
| Boundary condition      | $out[entry] = \emptyset$  |
| Initial interior points | $out[b] = u$ (universal set)                                      |

|                | GEN[]                  | KILL[]                 |
|----------------|------------------------|------------------------|
| BB1<br>(entry) | $\emptyset$            | $\emptyset$            |
| BB2            | $\langle k, 2 \rangle$ | $\emptyset$            |
| BB3<br>(if)    | $\emptyset$            | $\emptyset$            |
| BB4            | $\langle a, 4 \rangle$ | $\emptyset$            |
| BB5            | $\langle x, 5 \rangle$ | $\emptyset$            |
| BB6            | $\langle a, 4 \rangle$ | $\emptyset$            |
| BB7            | $\langle x, 8 \rangle$ | $\emptyset$            |
| BB8            | $\langle k, 4 \rangle$ | $\langle k, 2 \rangle$ |
| BB9<br>(while) | $\emptyset$            | $\emptyset$            |
| BB10           | $\langle b, 2 \rangle$ | $\emptyset$            |
| BB11           | $\langle x, 8 \rangle$ | $\emptyset$            |
| BB12           | $\langle y, 8 \rangle$ | $\emptyset$            |
| BB13           | $\langle k, 5 \rangle$ | $\langle k, 4 \rangle$ |
| BB14           | $\emptyset$            | $\emptyset$            |
| BB15           | $\emptyset$            | $\emptyset$            |

ITER 1

|                | IN  | OUT  |
|----------------|---|--|
| BB1<br>(entry) | $\emptyset$   | $\emptyset$  |
| BB2            | $\emptyset$   | $\langle k, 2 \rangle \cup (\emptyset - \emptyset) = \langle k, 2 \rangle$   |
| BB3<br>(if)    | $\langle k, 2 \rangle$  | $\emptyset \cup (\langle k, 2 \rangle - \emptyset) = \langle k, 2 \rangle$   |
| BB4            | $\langle k, 2 \rangle$  | $\langle a, 4 \rangle \cup (\langle k, 2 \rangle - \emptyset) = \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB5            | $\langle a, 4 \rangle, \langle k, 2 \rangle$  | $\langle x, 5 \rangle \cup (\langle a, 4 \rangle, \langle k, 2 \rangle - \emptyset) = \langle x, 5 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB6            | $\langle k, 2 \rangle$  | $\langle a, 4 \rangle \cup (\langle k, 2 \rangle - \emptyset) = \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB7            | $\langle a, 4 \rangle, \langle k, 2 \rangle$  | $\langle x, 8 \rangle \cup (\langle a, 4 \rangle, \langle k, 2 \rangle - \emptyset) = \langle x, 8 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB8            | $\langle x, 5 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle \cap \langle x, 8 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle = \langle a, 4 \rangle, \langle k, 2 \rangle$ | $\langle k, 4 \rangle \cup (\langle a, 4 \rangle, \langle k, 2 \rangle - \langle k, 2 \rangle) = \langle k, 4 \rangle, \langle a, 4 \rangle$   |
| BB9<br>(while) | $\langle k, 4 \rangle, \langle a, 4 \rangle$  | $\emptyset \cup (\langle k, 4 \rangle, \langle a, 4 \rangle - \emptyset) = \langle k, 4 \rangle, \langle a, 4 \rangle$   |
| BB10           | $\langle k, 4 \rangle, \langle a, 4 \rangle$  | $\langle b, 2 \rangle \cup (\langle k, 4 \rangle, \langle a, 4 \rangle - \emptyset) = \langle k, 4 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle$  |
| BB11           | $\langle k, 4 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle$  | $\langle x, 8 \rangle \cup (\langle k, 4 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle - \emptyset) = \langle x, 8 \rangle, \langle k, 4 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle$  |
| BB12           | $\langle x, 8 \rangle, \langle k, 4 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle$  | $\langle y, 8 \rangle \cup (\langle x, 8 \rangle, \langle k, 4 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle - \emptyset) = \langle x, 8 \rangle, \langle k, 4 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle$                                  |
| BB13           | $\langle x, 8 \rangle, \langle k, 4 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle$  | $\langle k, 5 \rangle \cup (\langle x, 8 \rangle, \langle k, 4 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle - \langle k, 4 \rangle) = \langle x, 8 \rangle, \langle k, 5 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle$ |
| BB14           | $\langle k, 4 \rangle, \langle a, 4 \rangle$  | $\emptyset \cup (\langle k, 4 \rangle, \langle a, 4 \rangle - \emptyset) = \langle k, 4 \rangle, \langle a, 4 \rangle$   |
| BB15           | $\langle k, 4 \rangle, \langle a, 4 \rangle$  | $\langle k, 4 \rangle, \langle a, 4 \rangle$   |

ITER 2

|                | IN  | OUT  |
|----------------|---|--|
| BB1<br>(entry) | $\emptyset$   | $\emptyset$  |
| BB2            | $\emptyset$   | $\langle k, 2 \rangle \cup (\emptyset - \emptyset) = \langle k, 2 \rangle$   |
| BB3<br>(if)    | $\langle k, 2 \rangle$  | $\emptyset \cup (\langle k, 2 \rangle - \emptyset) = \langle k, 2 \rangle$   |
| BB4            | $\langle k, 2 \rangle$  | $\langle a, 4 \rangle \cup (\langle k, 2 \rangle - \emptyset) = \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB5            | $\langle a, 4 \rangle, \langle k, 2 \rangle$  | $\langle x, 5 \rangle \cup (\langle a, 4 \rangle, \langle k, 2 \rangle - \emptyset) = \langle x, 5 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB6            | $\langle k, 2 \rangle$  | $\langle a, 4 \rangle \cup (\langle k, 2 \rangle - \emptyset) = \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB7            | $\langle a, 4 \rangle, \langle k, 2 \rangle$  | $\langle x, 8 \rangle \cup (\langle a, 4 \rangle, \langle k, 2 \rangle - \emptyset) = \langle x, 8 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB8            | $\langle x, 5 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle \cap \langle x, 8 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle = \langle a, 4 \rangle, \langle k, 2 \rangle$ | $\langle k, 4 \rangle \cup (\langle a, 4 \rangle, \langle k, 2 \rangle - \langle k, 2 \rangle) = \langle k, 4 \rangle, \langle a, 4 \rangle$   |
| BB9<br>(while) | $\langle k, 4 \rangle, \langle a, 4 \rangle \cap \langle x, 8 \rangle, \langle k, 5 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle = \langle a, 4 \rangle$ | $\emptyset \cup (\langle a, 4 \rangle - \emptyset) = \langle a, 4 \rangle$   |
| BB10           | $\langle a, 4 \rangle$  | $\langle b, 2 \rangle \cup (\langle a, 4 \rangle - \emptyset) = \langle a, 4 \rangle, \langle b, 2 \rangle$  |
| BB11           | $\langle a, 4 \rangle, \langle b, 2 \rangle$  | $\langle x, 9 \rangle \cup (\langle a, 4 \rangle, \langle b, 2 \rangle - \emptyset) = \langle x, 9 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle$  |
| BB12           | $\langle x, 9 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle$  | $\langle y, 8 \rangle \cup (\langle x, 9 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle - \emptyset) = \langle x, 9 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle$  |
| BB13           | $\langle x, 9 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle$  | $\langle k, 6 \rangle \cup (\langle x, 9 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle - \langle k, 5 \rangle) = \langle x, 9 \rangle, \langle k, 6 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle$ |
| BB14           | $\langle a, 4 \rangle$  | $\emptyset \cup (\langle a, 4 \rangle - \emptyset) = \langle a, 4 \rangle$   |
| BB15           | $\langle a, 4 \rangle$  | $\langle a, 4 \rangle$   |

### ITER 3

|                | IN  | OUT  |
|----------------|---|--|
| BB1<br>(entry) | $\emptyset$   | $\emptyset$  |
| BB2            | $\emptyset$   | $\langle k, 2 \rangle \cup (\emptyset - \emptyset) = \langle k, 2 \rangle$   |
| BB3<br>(if)    | $\langle k, 2 \rangle$  | $\emptyset \cup (\langle k, 2 \rangle - \emptyset) = \langle k, 2 \rangle$   |
| BB4            | $\langle k, 2 \rangle$  | $\langle a, 4 \rangle \cup (\langle k, 2 \rangle - \emptyset) = \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB5            | $\langle a, 4 \rangle, \langle k, 2 \rangle$  | $\langle x, 5 \rangle \cup (\langle a, 4 \rangle, \langle k, 2 \rangle - \emptyset) = \langle x, 5 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB6            | $\langle k, 2 \rangle$  | $\langle a, 4 \rangle \cup (\langle k, 2 \rangle - \emptyset) = \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB7            | $\langle a, 4 \rangle, \langle k, 2 \rangle$  | $\langle x, 8 \rangle \cup (\langle a, 4 \rangle, \langle k, 2 \rangle - \emptyset) = \langle x, 8 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle$  |
| BB8            | $\langle x, 5 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle \cap \langle x, 8 \rangle, \langle a, 4 \rangle, \langle k, 2 \rangle = \langle a, 4 \rangle, \langle k, 2 \rangle$ | $\langle k, 4 \rangle \cup (\langle a, 4 \rangle, \langle k, 2 \rangle - \langle k, 2 \rangle) = \langle k, 4 \rangle, \langle a, 4 \rangle$   |
| BB9<br>(while) | $\langle k, 4 \rangle, \langle a, 4 \rangle \cap \langle x, 9 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle = \langle a, 4 \rangle$                       | $\emptyset \cup (\langle a, 4 \rangle - \emptyset) = \langle a, 4 \rangle$   |
| BB10           | $\langle a, 4 \rangle$  | $\langle b, 2 \rangle \cup (\langle a, 4 \rangle - \emptyset) = \langle a, 4 \rangle, \langle b, 2 \rangle$  |
| BB11           | $\langle a, 4 \rangle, \langle b, 2 \rangle$  | $\langle x, 10 \rangle \cup (\langle a, 4 \rangle, \langle b, 2 \rangle - \emptyset) = \langle x, 10 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle$  |
| BB12           | $\langle x, 10 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle$   | $\langle y, 8 \rangle \cup (\langle x, 10 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle - \emptyset) = \langle x, 10 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle$  |
| BB13           | $\langle x, 10 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle$   | $\langle k, 7 \rangle \cup (\langle x, 10 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle - \langle k, 6 \rangle) = \langle x, 10 \rangle, \langle k, 7 \rangle, \langle a, 4 \rangle, \langle b, 2 \rangle, \langle y, 8 \rangle$ |
| BB14           | $\langle a, 4 \rangle$  | $\emptyset \cup (\langle a, 4 \rangle - \emptyset) = \langle a, 4 \rangle$   |
| BB15           | $\langle a, 4 \rangle$  | $\langle a, 4 \rangle$   |