

imperatif va (iterativo) ←
fungsi onel (recursivo) ←

Programmazione imperativa

basate su
cambiamenti
dello stato

Stato

stato è un insieme
finito di coppie

$\langle \text{nome}, \text{valore} \rangle$

$$S_1 = \{ \langle x, 5 \rangle, \langle y, 7 \rangle \}$$

$$S_2 = \{ \langle pippo, 10 \rangle, \langle x, 9 \rangle, \langle w, 10 \rangle \}$$

Nelle prog. imperativa i
cambiamenti di stato
non effetto dell'esecuzione
di

COMMANDI

Comando di base

Assegnamento

nome ← espressione
||
||

$$\{ \langle x, 3 \rangle, \langle y, 5 \rangle \}$$

$$x \leftarrow 3 + 5$$

$$\{ \langle x, 8 \rangle, \langle y, 5 \rangle \}$$

$$\left\{ \langle x, 5 \rangle, \langle y, 5 \rangle \right\} \leftarrow$$

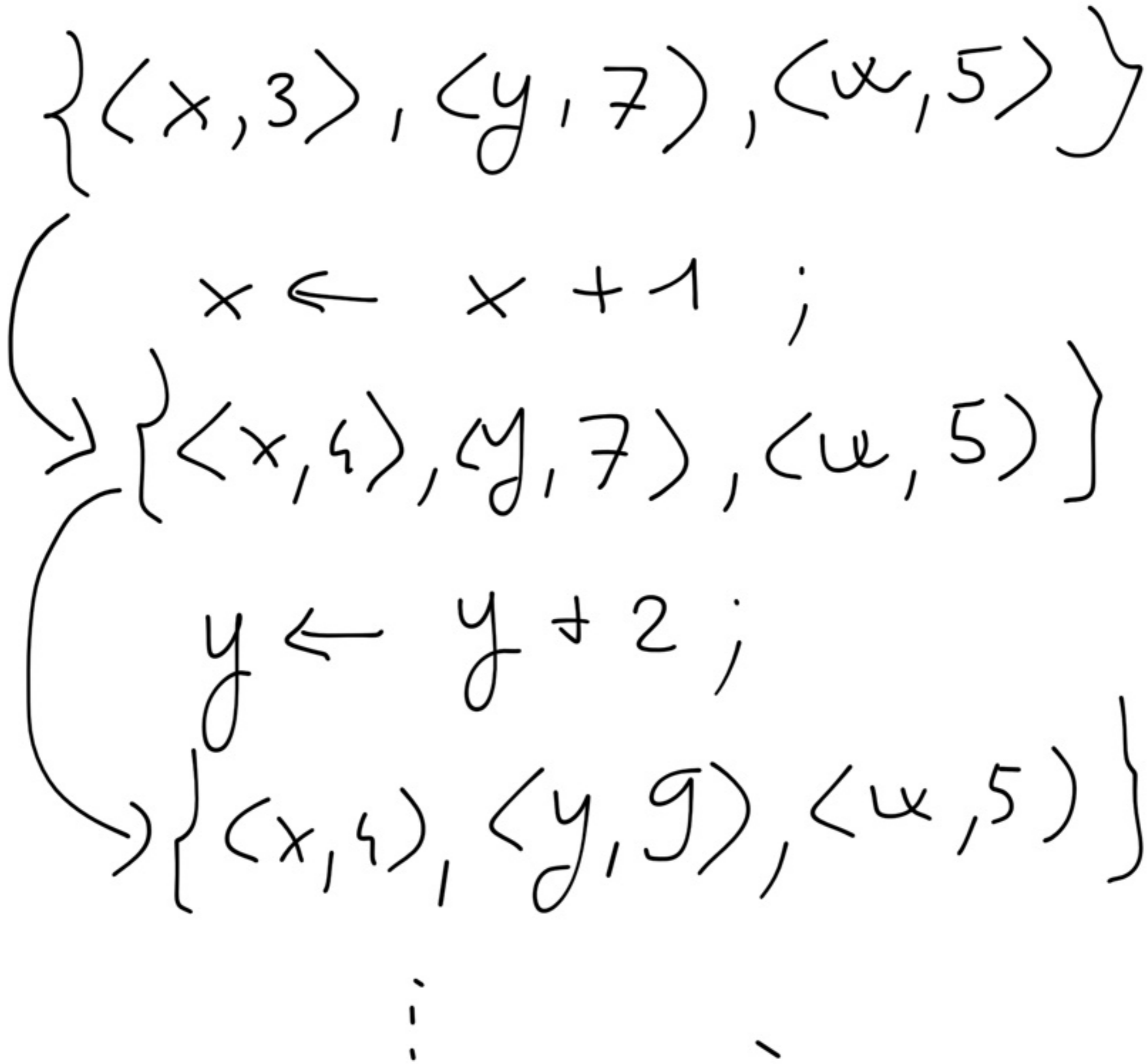
$$\begin{array}{c} \textcircled{x} \leftarrow \textcircled{\underline{\underline{x+5}}} \end{array}$$

$$\left\{ \langle x, 10 \rangle, \langle y, 5 \rangle \right\}$$

Sequenza di comandi

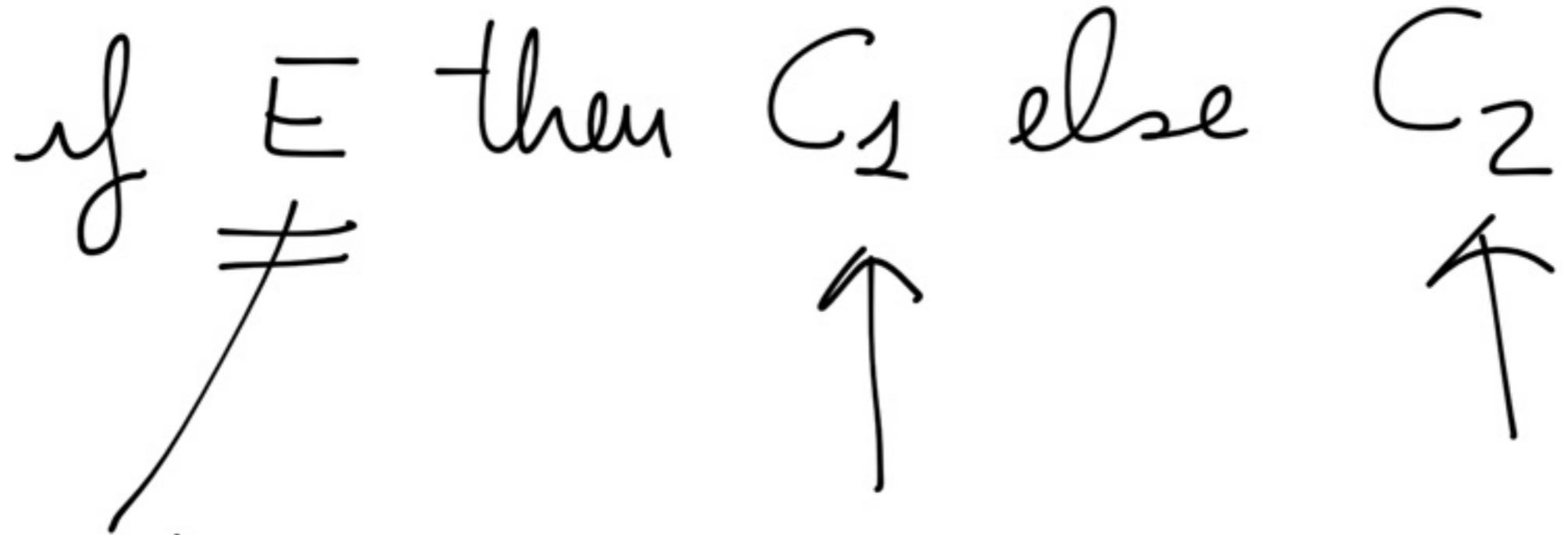
C_1 ; C_2





Condizionale

if E then C_1 else C_2



espressioni
logice

dè risultato vero o falso
true false

$\{ \langle x, 3 \rangle, \langle y, 5 \rangle \}$

if $x > y$ then $x \leftarrow x - 1$
else $y \leftarrow y - 2$

$\{ \langle x, 3 \rangle, \langle y, 7 \rangle \}$

$\{ \langle x, 5 \rangle, \langle y, 3 \rangle, \langle w, 7 \rangle \}$

if $x > y$ then $x \leftarrow x - 1$

else $y \leftarrow y - 2;$

$w \leftarrow w - 3$

$\{ \langle x, 4 \rangle, \langle y, 3 \rangle, \langle w, 7 \rangle \}$

$\{ \langle x, 5 \rangle, \langle y, 3 \rangle, \langle w, 7 \rangle \}$

if $x > y$ then $x \leftarrow x - 1$

else $y \leftarrow y - 2;$

$w \leftarrow w - 3$

$\{ \langle x, 4 \rangle, \langle y, 3 \rangle, \langle w, 4 \rangle \}$

Comando iterativo

while E do C

esprimere logica
condizioni
guardie

while E do C

- si valute E
- se E è falsa il comando
termina
- se E è vera si esegue
 C (si ottiene un nuovo
stato) e si esegue
nuovamente
while E do C

$\{ \langle x, 2 \rangle, \langle y, 0 \rangle \}$

while

$x > 0$

do {

$x \leftarrow x - 1$
 $y \leftarrow y + 2$

$\{ \langle x, 1 \rangle, \langle y, 2 \rangle \}$ ←

$\{ \langle x, 0 \rangle, \langle y, 4 \rangle \}$

$\{ \langle x, 0 \rangle, \langle y, 4 \rangle \}$

$$\{(x, 2), (y, 0)\}$$


while $x > 0$ do

$$\left\{ \begin{array}{l} x \leftarrow x + 1; \\ y \leftarrow y + 2 \end{array} \right.$$

$$\{(x, 3), (y, 2)\}$$

$$\{(x, 4), (y, 4)\}$$

...

for condition 

C viene eseguita
un numero finito
di volte

iterazione

MCD x y

$\{ \langle x, v_1 \rangle, \langle y, v_2 \rangle \}$

⋮

$\{ \langle x, \text{MCD}(v_1, v_2) \rangle, \dots \}$

proprietà di MCD

$$\text{MCD}(m, m) = m \quad \leftarrow$$

$$\text{MCD}(m, m) = \text{MCD}(m - m, m) \quad \left. \begin{array}{l} \\ \text{se } m > m \end{array} \right\}$$

$$\text{MCD}(m, m) = \text{MCD}(m, m - m) \quad \left. \begin{array}{l} \\ \text{se } m > m \end{array} \right\}$$

$\{ \langle x, v_1 \rangle, \langle y, v_2 \rangle \} \quad x, y > 0$

while $x \neq y$ do

if $x > y$ then $x \leftarrow x - y$

else $y \leftarrow y - x$

$\{ \langle x, \text{MCD}(v_1, v_2) \rangle, \langle y, \text{MCD}(v_1, v_2) \rangle \}$

Programmarion funktione

$$f(x) = x^2 \quad \underline{\underline{\text{def}}}$$

$$\left. \begin{array}{l} f(3) = 9 \\ f(5) = 25 \end{array} \right\} \text{applicoz.}$$

$$f(x) = x^2$$

$$g(x, y) = x + y$$

$$f(g(3, 2)) = 25$$

espressioni condizionali

if E then E_1 else E_2

expr. logice

espressioni

if $(3 > 2)$ then $3+5$ else 7
 $\equiv 8$ espressione

$f(x) \equiv$ espressione
(che contiene x)

$$f(x) = x^2$$

esperi'one

$f(x) = \begin{cases} x+1 & \text{if } x > 0 \\ x+2 & \text{else} \end{cases}$

$$f(-2) = \emptyset$$

$$f(2) = 3$$

$$f(x) = \begin{cases} x+1 & \text{if } x > 0 \\ x+2 & \text{if } x \leq 0 \end{cases}$$

Ricorsione

definizioni di funzioni
ricorsive

$$f(x) = \dots f \dots$$

$f(x) =$ if $x > 0$ then $2 + f(x-1)$
 else \emptyset

$$\begin{array}{l}
 f(2) \\
 = \left\{ \begin{array}{l} \text{def. } f, \text{ then} \\ 2 + f(1) \end{array} \right\} \\
 = \left\{ \begin{array}{l} \text{def. } f, \text{ then} \\ 2 + 2 + f(0) \end{array} \right\}
 \end{array}
 \quad \Bigg| \quad
 \begin{array}{l}
 = \left\{ \begin{array}{l} \text{def. } f, \\ \text{then else} \end{array} \right\} \\
 2 + 2 + \emptyset \\
 = \left\{ \text{calculated} \right\} \\
 4
 \end{array}$$

$$f(x) = 2 + f(x+1)$$

$$f(2) = \{ \text{def } f \}$$

$$2 + f(3) = \{ \text{def } f \}$$

$$2 + 2 + f(4) = \{ \text{def } f \}$$

$$2 + 2 + 2 + f(5) \\ \dots$$

$$\text{MCD}(m, m) = m$$

$$\text{MCD}(m, m) = \text{MCD}(m - m, m)$$

$$\text{se } m > m$$

$$\text{MCD}(m, m) = \text{MCD}(m, m - m)$$

$$\text{se } m > m$$

$$\text{mcd}(m, m) =$$

if $m = m$ then m

else if $m > m$

then $\text{mcd}(m - m, m)$

else $\text{mcd}(m, m - m)$

①

②

③

$$\text{mcd}(35, 21)$$

$$= \{ \text{def mcd, caso 2} \}$$

$$\text{mcd}(14, 21)$$

$$= \{ \text{def mcd, caso 3} \}$$

$$\text{mcd}(14, 7)$$

$$= \{ \text{def mcd, caso 2} \}$$

$$\text{mcd}(7, 7)$$

$$= \{ \text{def mcd, caso 1} \}$$

$$7$$

$$f(x) = \begin{cases} 2 + f(x-1) & \text{if } x > 0 \\ \emptyset & \text{else} \end{cases}$$

|||

$$f(x) = \begin{cases} 2 \cdot x & \text{if } x > 0 \\ \emptyset & \text{else} \end{cases}$$

$$n! \quad n \in \mathbb{N}$$

$$0! = 1$$

$$n! = n * (n-1) * \dots * 1$$

$$4! = 4 \cdot 3 \cdot 2 \cdot 1 = 24$$

$\{ \langle m, v_n \rangle, \langle \text{fact}, - \rangle, \dots \}$

$\text{fact} \leftarrow 1; \quad m \geq \emptyset$

while $m > 0$ do

$\{ \text{fact} \leftarrow \text{fact} * m;$
 $m \leftarrow m - 1 \}$

$\{ \langle m, - \rangle, \langle \text{fact}, v_n! \rangle, \dots \}$

$$m \geq 0$$

$$\text{fact}(m) =$$

if $m = 0$ then 1

else $m * \text{fact}(m-1)$