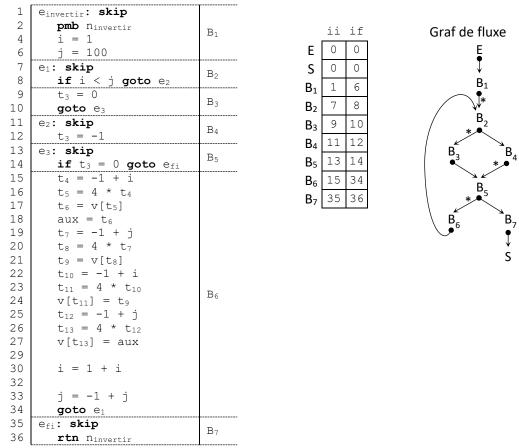
Pels programes proposats per l'exercici dels dies anteriors i a partir dels algorismes vists, identifica-hi:

- les invariants
- les variables d'inducció
- per a les variables d'inducció com s'aplicaria la reducció de força

Programa 1

Partint dels blocs bàsics ja identificats (la numeració encara es correspon amb el codi original sense optimitzar, per això falten alguns valors a les línies del c3@). S'afegeix una optimització, de manera que les línies 29 i 30 i les 32 i 33 s'ajunten. Així dóna més joc:



Només hi ha un bucle: $BLC[1] = \{ B_6, B_2, B_5, B_3, B_4 \}$

Invariants:

Totes les variables tenen una sola assignació al bucle, excepte t₃ que en té dues. Per tant

```
f(x) = 1 \ \forall \ x \in \{t_4, t_5, t_6, aux, t_7, t_8, t_9, t_{10}, t_{11}, t_{12}, t_{13}, i, j\}
f(t_3) = 2.
```

Càlcul de m:

			Avaluació esquerra ¹				ió			
	línia		a	b	С	1	a	b	С	m
B ₂	7	e ₁ : skip								
D2	8	<pre>if i < j goto e2</pre>								
B_3	9	t3 = 0								
D3	10	goto e3								
B ₄	11	e2: skip								
D4	12	t3 = -1								
B_5	13	e3: skip								
D5	14	<pre>if t3 = 0 goto efi</pre>								
	15	t4 = -1 + i	✓			×	×	×	×	-1
	16	t5 = 4 * t4	✓			×	×	×	×	-1
	17	t6 = v[t5]	×	×	×	✓				-2
	18	aux = t6	×	×	×	✓				-2
	19	t7 = -1 + j	✓			×	×	×	×	-1
	20	t8 = 4 * t7	✓			×	×	×	×	-1
	21	t9 = v[t8]	×	×	×	✓				-2
	22	t10 = -1 + i	✓			×	×	×	×	-1
B ₆	23	t11 = 4 * t10	✓			×	×	×	×	-1
₽6	24	v[t11] = t9	×	×	×	✓				-2
	25	t12 = -1 + j	✓			×	×	×	×	-1
	26	t13 = 4 * t12	✓			×	×	×	×	-1
	27	v[t13] = aux	×	×	×	✓				-2
	29									
	30	i = 1 + i	✓			×	×	×	×	-1
	32									
	33	j = −1 + j	✓			×	×	×	×	-1
	34	goto e_1								

Per tant no hi ha invariants

¹ 1 indica que l'operació és unària (és a dir, no hi ha part dreta, i òbviament només s'aplica a la part dreta), a, b, c indiquen l'apartat de l'algorisme de classificació que s'aplica en cada cas

Variables d'inducció:

Totes les variables tenen una sola assignació al bucle, excepte $t_3\,$ que en té dues.

Variables d'inducció bàsiques:

variable	f pos	R(x)
i	1 (B ₆ , 30)	(i, 1, 1)
j	1 (B ₆ , 33)	(j, 1, -1)

A partir de les variables d'inducció bàsiques es poden obtenir les variables d'inducció derivades. Analitzant cada una de les possibilitats:

variable	f	pos	R(x)	R(x) final	increment
t ₃	2	(B ₃ , 9)(B ₄ , 12)			
t ₄	1	(B ₆ , 15)	(i, 1, -1)	(i, 1, -1)	1
t ₅	1	(B ₆ , 16)	(t ₄ , 4, 0)	(i, 4, -4)	4
t ₆	1	(B ₆ , 17)			
aux	1	(B ₆ , 18)			
t ₇	1	(B ₆ , 19)	(j, 1, -1)	(j, 1, -1)	-1
t ₈	1	(B ₆ , 20)	$(t_7, 4, 0)$	(j, 4, -4)	-4
t ₉	1	(B ₆ , 21)			
t ₁₀	1	(B ₆ , 22)	(i, 1, -1)	(i, 1, -1)	1
t ₁₁	1	(B ₆ , 23)	$(t_{10}, 4, 0)$	(i, 4, -4)	4
t ₁₂	1	(B ₆ , 25)	(j, 1, -1)	(j, 1, -1)	-1
t ₁₃	1	(B ₆ , 26)	$(t_{12}, 4, 0)$	(j, 4, -4)	-4

El codi que en resulta seria el següent:

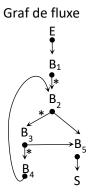
1	e _{invertir} : skip	
2	pmb n _{invertir}	B ₁
4	i = 1	D1
6	j = 100	
	$t_{15} = i * 1$	
	$t_{16} = t_{15} - 1$	
	s ₁₄ = t ₁₆	
	$t_{18} = i * 4$	
	$t_{19} = t_{18} - 4$	
	$s_{17} = t_{19}$	
	$t_{21} = j * 1$	
	$t_{22} = t_{21} - 1$	
	$s_{20} = t_{21}$ $s_{20} = t_{22}$	ď
	$t_{24} = j * 4$	0
	$t_{25} = t_{24} - 4$	LA
	$s_{23} = t_{25}$	SA
	$t_{27} = i * 1$	ΑP
	$t_{28} = t_{27} - 1$	NG.
	$s_{26} = t_{28}$	园
		PREENCAPSALADOR
	$t_{30} = i * 4$ $t_{31} = t_{30} - 4$	
	$s_{29} = t_{31}$ $t_{33} = j * 1$	
	$t_{34} = t_{33} - 1$	
	$s_{32} = t_{34}$ $t_{36} = j * 4$	
	$t_{37} = t_{36} - 4$	
7	$s_{35} = t_{37}$	
8	e1: skip	B_2
9	$\mathbf{if} \ i < j \ \mathbf{goto} \ \mathbf{e}_2$ $\mathbf{t}_3 = 0$	
10	goto e ₃	B ₃
	goto e ₃	
11	e ₂ : skip	B ₄
11 12	e_2 : skip $t_3 = -1$	B ₄
11 12 13	e ₂ : skip t ₃ = -1 e ₃ : skip	B ₄
11 12 13 14	e ₂ : skip t ₃ = -1 e ₃ : skip if t ₃ = 0 goto e _{fi}	
11 12 13	e ₂ : skip t ₃ = -1 e ₃ : skip if t ₃ = 0 goto e _{fi} t ₄ = s ₁₄	
11 12 13 14 15	e ₂ : skip t ₃ = -1 e ₃ : skip if t ₃ = 0 goto e _{fi} t ₄ = s ₁₄ s ₁₄ = s ₁₄ + 1	
11 12 13 14	e ₂ : skip t ₃ = -1 e ₃ : skip if t ₃ = 0 goto e _{fi} t ₄ = s ₁₄ s ₁₄ = s ₁₄ + 1 t ₅ = s ₁₇	
11 12 13 14 15	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \end{array}$	
11 12 13 14 15 16	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v[t_5] \\ \end{array}$	
11 12 13 14 15 16	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v(t_5) \\ \\ \textbf{aux} &= t_6 \\ \end{array}$	
11 12 13 14 15 16	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v(t_5) \\ \\ \textbf{aux} &= t_6 \\ \end{array}$	
11 12 13 14 15 16 17 18 19	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v(t_5) \\ \\ \textbf{aux} &= t_6 \\ \\ t_7 &= s_{20} \\ \\ s_{20} &= s_{20} - 1 \\ \end{array}$	
11 12 13 14 15 16	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v [t_5] \\ \\ aux &= t_6 \\ \\ t_7 &= s_{20} \\ \\ s_{20} &= s_{20} - 1 \\ \\ t_8 &= s_{23} \end{array}$	
11 12 13 14 15 16 17 18 19	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v [t_5] \\ \\ aux &= t_6 \\ \\ t_7 &= s_{20} \\ \\ s_{20} &= s_{20} - 1 \\ \\ t_8 &= s_{23} \\ \\ s_{23} &= s_{23} - 4 \end{array}$	
11 12 13 14 15 16 17 18 19 20 21	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v[t_5] \\ \\ aux &= t_6 \\ \\ t_7 &= s_{20} \\ \\ s_{20} &= s_{20} - 1 \\ \\ t_8 &= s_{23} \\ \\ s_{23} &= s_{23} - 4 \\ \\ t_9 &= v[t_8] \\ \end{array}$	
11 12 13 14 15 16 17 18 19	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v[t_5] \\ \\ aux &= t_6 \\ \\ t_7 &= s_{20} \\ \\ s_{20} &= s_{20} - 1 \\ \\ t_8 &= s_{23} \\ \\ s_{23} &= s_{23} - 4 \\ \\ t_9 &= v[t_8] \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22	$\begin{array}{l} e_2 \colon \mathbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \mathbf{skip} \\ \mathbf{if} \ t_3 &= 0 \ \mathbf{goto} \ e_{\mathrm{fi}} \\ t_4 &= s_{14} \\ s_{14} &= s_{14} + 1 \\ t_5 &= s_{17} \\ s_{17} &= s_{17} + 4 \\ t_6 &= v[t_5] \\ \mathbf{aux} &= t_6 \\ t_7 &= s_{20} \\ s_{20} &= s_{20} - 1 \\ t_8 &= s_{23} \\ s_{23} &= s_{23} - 4 \\ t_9 &= v[t_8] \\ t_{10} &= s_{26} \\ s_{26} &= s_{26} + 1 \end{array}$	
11 12 13 14 15 16 17 18 19 20 21	$\begin{array}{l} e_2 \colon \mathbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \mathbf{skip} \\ \mathbf{if} \ t_3 &= 0 \ \mathbf{goto} \ e_{\mathrm{fi}} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v[t_5] \\ \\ \mathbf{aux} &= t_6 \\ \\ t_7 &= s_{20} \\ \\ s_{20} &= s_{20} - 1 \\ \\ t_8 &= s_{23} \\ \\ s_{23} &= s_{23} - 4 \\ \\ t_9 &= v[t_8] \\ \\ t_{10} &= s_{26} \\ \\ s_{26} &= s_{26} + 1 \\ \\ t_{11} &= s_{29} \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23	$\begin{array}{l} e_2 \colon \mathbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \mathbf{skip} \\ \mathbf{if} \ t_3 &= 0 \ \mathbf{goto} \ e_{\mathrm{fi}} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v[t_5] \\ \\ \mathbf{aux} &= t_6 \\ \\ t_7 &= s_{20} \\ \\ s_{20} &= s_{20} - 1 \\ \\ t_8 &= s_{23} \\ \\ s_{23} &= s_{23} - 4 \\ \\ t_9 &= v[t_8] \\ \\ t_{10} &= s_{26} \\ \\ s_{26} &= s_{26} + 1 \\ \\ t_{11} &= s_{29} \\ \\ s_{29} &= s_{29} + 4 \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23	$\begin{array}{l} e_2 \colon \mathbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \mathbf{skip} \\ \mathbf{if} \ t_3 &= 0 \ \mathbf{goto} \ e_{\mathrm{fi}} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v[t_5] \\ \\ \mathbf{aux} &= t_6 \\ \\ t_7 &= s_{20} \\ \\ s_{20} &= s_{20} - 1 \\ \\ t_8 &= s_{23} \\ \\ s_{23} &= s_{23} - 4 \\ \\ t_9 &= v[t_8] \\ \\ t_{10} &= s_{26} \\ \\ s_{26} &= s_{26} + 1 \\ \\ t_{11} &= s_{29} \\ \\ s_{29} &= s_{29} + 4 \\ \\ v[t_{11}] &= t_9 \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23	$\begin{array}{l} e_2 \colon \mathbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \mathbf{skip} \\ \mathbf{if} \ t_3 &= 0 \ \mathbf{goto} \ e_{\mathrm{fi}} \\ \\ t_4 &= s_{14} \\ \\ s_{14} &= s_{14} + 1 \\ \\ t_5 &= s_{17} \\ \\ s_{17} &= s_{17} + 4 \\ \\ t_6 &= v[t_5] \\ \\ \mathbf{aux} &= t_6 \\ \\ t_7 &= s_{20} \\ \\ s_{20} &= s_{20} - 1 \\ \\ t_8 &= s_{23} \\ \\ s_{23} &= s_{23} - 4 \\ \\ t_9 &= v[t_8] \\ \\ t_{10} &= s_{26} \\ \\ s_{26} &= s_{26} + 1 \\ \\ t_{11} &= s_{29} \\ \\ s_{29} &= s_{29} + 4 \\ \\ v[t_{11}] &= t_9 \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \\ e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \hline t_4 &= s_{14} \\ \hline s_{14} &= s_{14} + 1 \\ \hline t_5 &= s_{17} \\ \hline s_{17} &= s_{17} + 4 \\ \hline t_6 &= v[t_5] \\ \hline \textbf{aux} &= t_6 \\ \hline t_7 &= s_{20} \\ \hline s_{20} &= s_{20} - 1 \\ \hline t_8 &= s_{23} \\ \hline s_{23} &= s_{23} - 4 \\ \hline t_9 &= v[t_8] \\ \hline t_{10} &= s_{26} \\ \hline s_{26} &= s_{26} + 1 \\ \hline t_{11} &= s_{29} \\ \hline s_{29} &= s_{29} + 4 \\ \hline v[t_{11}] &= t_9 \\ \hline t_{12} &= s_{32} \\ \hline s_{32} &= s_{32} - 1 \\ \hline \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23	$\begin{array}{l} \textbf{e_2: skip} \\ \textbf{t_3} &= -1 \\ \\ \textbf{e_3: skip} \\ \textbf{if } \textbf{t_3} &= 0 \textbf{ goto } \textbf{e}_{fi} \\ \textbf{t_4} &= \textbf{s}_{14} \\ \textbf{s}_{14} &= \textbf{s}_{14} + 1 \\ \textbf{t_5} &= \textbf{s}_{17} \\ \textbf{s}_{17} &= \textbf{s}_{17} + 4 \\ \textbf{t_6} &= \textbf{v}(\textbf{t_5}) \\ \textbf{aux} &= \textbf{t_6} \\ \textbf{t_7} &= \textbf{s}_{20} \\ \textbf{s}_{20} &= \textbf{s}_{20} - 1 \\ \textbf{t_8} &= \textbf{s}_{23} \\ \textbf{s}_{23} &= \textbf{s}_{23} - 4 \\ \textbf{t_9} &= \textbf{v}(\textbf{t_8}) \\ \textbf{t_{10}} &= \textbf{s}_{26} \\ \textbf{s}_{26} &= \textbf{s}_{26} + 1 \\ \textbf{t_{11}} &= \textbf{s}_{29} \\ \textbf{s}_{29} &= \textbf{s}_{29} + 4 \\ \textbf{v}(\textbf{t_{11}}) &= \textbf{t_9} \\ \textbf{t_{12}} &= \textbf{s}_{32} \\ \textbf{s}_{32} &= \textbf{s}_{32} - 1 \\ \textbf{t_{13}} &= \textbf{s}_{35} \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26	$\begin{array}{l} \textbf{e_2: skip} \\ \textbf{t_3} &= -1 \\ \\ \textbf{e_3: skip} \\ \textbf{if } \textbf{t_3} &= 0 \textbf{ goto } \textbf{e}_{fi} \\ \textbf{t_4} &= \textbf{s}_{14} \\ \textbf{s}_{14} &= \textbf{s}_{14} + 1 \\ \textbf{t_5} &= \textbf{s}_{17} \\ \textbf{s}_{17} &= \textbf{s}_{17} + 4 \\ \textbf{t_6} &= \textbf{v}(\textbf{t_5}) \\ \textbf{aux} &= \textbf{t_6} \\ \textbf{t_7} &= \textbf{s}_{20} \\ \textbf{s}_{20} &= \textbf{s}_{20} - 1 \\ \textbf{t_8} &= \textbf{s}_{23} \\ \textbf{s}_{23} &= \textbf{s}_{23} - 4 \\ \textbf{t_9} &= \textbf{v}(\textbf{t_8}) \\ \textbf{t_{10}} &= \textbf{s}_{26} \\ \textbf{s}_{26} &= \textbf{s}_{26} + 1 \\ \textbf{t_{11}} &= \textbf{s}_{29} \\ \textbf{s}_{29} &= \textbf{s}_{29} + 4 \\ \textbf{v}(\textbf{t_{11}}) &= \textbf{t_9} \\ \textbf{t_{12}} &= \textbf{s}_{32} \\ \textbf{s}_{32} &= \textbf{s}_{32} - 1 \\ \textbf{t_{13}} &= \textbf{s}_{35} \\ \textbf{s}_{35} &= \textbf{s}_{35} - 4 \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27	$\begin{array}{l} \textbf{e_2: skip} \\ \textbf{t_3} &= -1 \\ \\ \textbf{e_3: skip} \\ \textbf{if } \textbf{t_3} &= 0 \textbf{ goto } \textbf{e}_{fi} \\ \textbf{t_4} &= \textbf{s}_{14} \\ \textbf{s}_{14} &= \textbf{s}_{14} + 1 \\ \textbf{t_5} &= \textbf{s}_{17} \\ \textbf{s}_{17} &= \textbf{s}_{17} + 4 \\ \textbf{t_6} &= \textbf{v}(\textbf{t_5}) \\ \textbf{aux} &= \textbf{t_6} \\ \textbf{t_7} &= \textbf{s}_{20} \\ \textbf{s}_{20} &= \textbf{s}_{20} - 1 \\ \textbf{t_8} &= \textbf{s}_{23} \\ \textbf{s}_{23} &= \textbf{s}_{23} - 4 \\ \textbf{t_9} &= \textbf{v}(\textbf{t_8}) \\ \textbf{t_{10}} &= \textbf{s}_{26} \\ \textbf{s}_{26} &= \textbf{s}_{26} + 1 \\ \textbf{t_{11}} &= \textbf{s}_{29} \\ \textbf{s}_{29} &= \textbf{s}_{29} + 4 \\ \textbf{v}(\textbf{t_{11}}) &= \textbf{t_9} \\ \textbf{t_{12}} &= \textbf{s}_{32} \\ \textbf{s}_{32} &= \textbf{s}_{32} - 1 \\ \textbf{t_{13}} &= \textbf{s}_{35} \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 29	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \end{array}$ $\begin{array}{l} e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \end{array}$ $\begin{array}{l} t_4 &= s_{14} \\ s_{14} &= s_{14} + 1 \\ \end{array}$ $\begin{array}{l} t_5 &= s_{17} \\ s_{17} &= s_{17} + 4 \\ \end{array}$ $\begin{array}{l} t_6 &= v(t_5) \\ \text{aux} &= t_6 \\ \end{array}$ $\begin{array}{l} t_7 &= s_{20} \\ s_{20} &= s_{20} - 1 \\ \end{array}$ $\begin{array}{l} t_8 &= s_{23} \\ s_{23} &= s_{23} - 4 \\ \end{array}$ $\begin{array}{l} t_9 &= v(t_8) \\ \end{array}$ $\begin{array}{l} t_{10} &= s_{26} \\ \end{array}$ $\begin{array}{l} s_{26} &= s_{26} + 1 \\ \end{array}$ $\begin{array}{l} t_{11} &= s_{29} \\ \end{array}$ $\begin{array}{l} s_{29} &= s_{29} + 4 \\ v(t_{11}) &= t_9 \\ \end{array}$ $\begin{array}{l} t_{12} &= s_{32} \\ \end{array}$ $\begin{array}{l} s_{32} &= s_{32} - 1 \\ \end{array}$ $\begin{array}{l} t_{13} &= s_{35} \\ \end{array}$ $\begin{array}{l} s_{35} &= s_{35} - 4 \\ v(t_{13}) &= aux \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 29 30	$\begin{array}{l} \textbf{e_2: skip} \\ \textbf{t_3} &= -1 \\ \\ \textbf{e_3: skip} \\ \textbf{if } \textbf{t_3} &= 0 \textbf{ goto } \textbf{e}_{fi} \\ \textbf{t_4} &= \textbf{s}_{14} \\ \textbf{s}_{14} &= \textbf{s}_{14} + 1 \\ \textbf{t_5} &= \textbf{s}_{17} \\ \textbf{s}_{17} &= \textbf{s}_{17} + 4 \\ \textbf{t_6} &= \textbf{v}(\textbf{t_5}) \\ \textbf{aux} &= \textbf{t_6} \\ \textbf{t_7} &= \textbf{s}_{20} \\ \textbf{s}_{20} &= \textbf{s}_{20} - 1 \\ \textbf{t_8} &= \textbf{s}_{23} \\ \textbf{s}_{23} &= \textbf{s}_{23} - 4 \\ \textbf{t_9} &= \textbf{v}(\textbf{t_8}) \\ \textbf{t_{10}} &= \textbf{s}_{26} \\ \textbf{s}_{26} &= \textbf{s}_{26} + 1 \\ \textbf{t_{11}} &= \textbf{s}_{29} \\ \textbf{s}_{29} &= \textbf{s}_{29} + 4 \\ \textbf{v}(\textbf{t_{11}}) &= \textbf{t_9} \\ \textbf{t_{12}} &= \textbf{s}_{32} \\ \textbf{s}_{32} &= \textbf{s}_{32} - 1 \\ \textbf{t_{13}} &= \textbf{s}_{35} \\ \textbf{s}_{35} &= \textbf{s}_{35} - 4 \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 29 30 32	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \end{array}$ $\begin{array}{l} e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \end{array}$ $\begin{array}{l} t_4 &= s_{14} \\ s_{14} &= s_{14} + 1 \\ \end{array}$ $\begin{array}{l} t_5 &= s_{17} \\ s_{17} &= s_{17} + 4 \\ \end{array}$ $\begin{array}{l} t_6 &= v(t_5) \\ \text{aux} &= t_6 \\ \end{array}$ $\begin{array}{l} t_7 &= s_{20} \\ s_{20} &= s_{20} - 1 \\ \end{array}$ $\begin{array}{l} t_8 &= s_{23} \\ s_{23} &= s_{23} - 4 \\ \end{array}$ $\begin{array}{l} t_9 &= v(t_8) \\ \end{array}$ $\begin{array}{l} t_{10} &= s_{26} \\ s_{26} &= s_{26} + 1 \\ \end{array}$ $\begin{array}{l} t_{11} &= s_{29} \\ s_{29} &= s_{29} + 4 \\ \end{array}$ $\begin{array}{l} v(t_{11}) &= t_9 \\ \end{array}$ $\begin{array}{l} t_{12} &= s_{32} \\ s_{32} &= s_{32} - 1 \\ \end{array}$ $\begin{array}{l} t_{13} &= s_{35} \\ s_{35} &= s_{35} - 4 \\ \end{array}$ $v(t_{13}) &= aux$ $\begin{array}{l} i &= 1 + i \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 29 30 32 33	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \end{array}$ $\begin{array}{l} e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \end{array}$ $\begin{array}{l} t_4 &= s_{14} \\ s_{14} &= s_{14} + 1 \\ t_5 &= s_{17} \\ \end{array}$ $\begin{array}{l} s_{17} &= s_{17} + 4 \\ t_6 &= v(t_5] \\ \end{array}$ $\begin{array}{l} \textbf{aux} &= t_6 \\ t_7 &= s_{20} \\ s_{20} &= s_{20} - 1 \\ \end{array}$ $\begin{array}{l} t_8 &= s_{23} \\ s_{23} &= s_{23} - 4 \\ \end{array}$ $\begin{array}{l} t_9 &= v(t_8] \\ \end{array}$ $\begin{array}{l} t_{10} &= s_{26} \\ s_{26} &= s_{26} + 1 \\ \end{array}$ $\begin{array}{l} t_{11} &= s_{29} \\ s_{29} &= s_{29} + 4 \\ v(t_{11}] &= t_9 \\ \end{array}$ $\begin{array}{l} t_{12} &= s_{32} \\ s_{32} &= s_{32} - 1 \\ \end{array}$ $\begin{array}{l} t_{13} &= s_{35} \\ s_{35} &= s_{35} - 4 \\ v(t_{13}) &= aux \\ \end{array}$ $\begin{array}{l} \vdots &= 1 + i \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 29 30 32 33 34	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \end{array}$ $\begin{array}{l} e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \end{array}$ $\begin{array}{l} t_4 &= s_{14} \\ s_{14} &= s_{14} + 1 \\ t_5 &= s_{17} \\ \end{array}$ $\begin{array}{l} s_{17} &= s_{17} + 4 \\ t_6 &= v[t_5] \\ \end{aligned}$ $\begin{array}{l} aux &= t_6 \\ t_7 &= s_{20} \\ s_{20} &= s_{20} - 1 \\ \end{cases}$ $\begin{array}{l} t_8 &= s_{23} \\ s_{23} &= s_{23} - 4 \\ \end{aligned}$ $\begin{array}{l} t_9 &= v[t_8] \\ \end{cases}$ $\begin{array}{l} t_{10} &= s_{26} \\ s_{26} &= s_{26} + 1 \\ \end{cases}$ $\begin{array}{l} t_{11} &= s_{29} \\ s_{29} &= s_{29} + 4 \\ v[t_{11}] &= t_9 \\ \end{cases}$ $\begin{array}{l} t_{12} &= s_{32} \\ s_{32} &= s_{32} - 1 \\ \end{cases}$ $\begin{array}{l} t_{13} &= s_{35} \\ s_{35} &= s_{35} - 4 \\ v[t_{13}] &= aux \\ \end{array}$ $\begin{array}{l} \vdots &= 1 + i \\ \end{array}$	B ₅
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 29 30 32 33	$\begin{array}{l} e_2 \colon \textbf{skip} \\ t_3 &= -1 \\ \end{array}$ $\begin{array}{l} e_3 \colon \textbf{skip} \\ \textbf{if} \ t_3 &= 0 \ \textbf{goto} \ e_{fi} \\ \end{array}$ $\begin{array}{l} t_4 &= s_{14} \\ s_{14} &= s_{14} + 1 \\ t_5 &= s_{17} \\ \end{array}$ $\begin{array}{l} s_{17} &= s_{17} + 4 \\ t_6 &= v(t_5] \\ \end{array}$ $\begin{array}{l} \textbf{aux} &= t_6 \\ t_7 &= s_{20} \\ s_{20} &= s_{20} - 1 \\ \end{array}$ $\begin{array}{l} t_8 &= s_{23} \\ s_{23} &= s_{23} - 4 \\ \end{array}$ $\begin{array}{l} t_9 &= v(t_8] \\ \end{array}$ $\begin{array}{l} t_{10} &= s_{26} \\ s_{26} &= s_{26} + 1 \\ \end{array}$ $\begin{array}{l} t_{11} &= s_{29} \\ s_{29} &= s_{29} + 4 \\ v(t_{11}] &= t_9 \\ \end{array}$ $\begin{array}{l} t_{12} &= s_{32} \\ s_{32} &= s_{32} - 1 \\ \end{array}$ $\begin{array}{l} t_{13} &= s_{35} \\ s_{35} &= s_{35} - 4 \\ v(t_{13}) &= aux \\ \end{array}$ $\begin{array}{l} \vdots &= 1 + i \\ \end{array}$	B ₅

Programa 2

Partint dels blocs bàsics ja identificats (la numeració encara es correspon amb el codi original sense optimitzar, per això falten alguns valors a les línies del c3@)

		r
1	e _{cercar} : skip	
2	pmb n _{cercar}	B_1
4	i = 1	
5	e ₁ : skip	
6	$t_2 = -1 + i$	
7	$t_3 = 4 * t_2$	B ₂
8	$t_4 = v[t_3]$	
9	if $t_4 = x$ goto e_3	
12	$t_5 = 100$	ъ
13	if $x \ge t_5$ goto e_3	B ₃
17		
18	i = 1 + i	B ₄
19	goto e ₁	
20	e ₃ : skip	B ₅
21	rtn n _{cerca} , x	D5

	ii	if
Ε	0	0
S	0	0
B_1	1	4
B_2	5	9
B_3	12	13
B_4	17	19
B_5	20	21



S'ajunten les instruccions 17 i 18.

Només hi ha un bucle: $BLC[1] = \{ B_4, B_2, B_3 \}$

Totes les variables tenen una sola assignació al bucle, excepte t_3 que en té dues. Per tant

$$f(x) = 1 \ \forall \ x \in \{t_2, t_3, t_4, t_5, i\}.$$

Càlcul de m:

			Avaluació esquerra ¹				ió			
			esc	-		areta-				
	línia		а	b	С	1	a	b	С	m
	5	e ₁ : skip								
	6	$t_2 = -1 + i$	✓			×	×	×	×	-1
B_2	7	$t_3 = 4 * t_2$	✓			×	×	×	×	-1
	8	$t_4 = v[t_3]$	×	×	×	✓				-2
	9	if $t_4 = x$ goto e_3								
D	12	$t_5 = 100$	✓			✓				1
B ₃	13	if $x \ge t_5$ goto e_3								
	17									
B_4	18	i = 1 + i	✓			×	×	×	×	-1
	19	goto e ₁		,						·

Per tant hi ha una invariants: $t_5 = 100$. Aleshores amb el preencapçalador i el desplaçament de la instrucció el codi queda de la següent manera:

1	ecercar: skip	
2	<pre>pmb n_{cercar}</pre>	B_1
4	i = 1	
	$t_5 = 100$	PRE
5	e ₁ : skip	
6	$t_2 = -1 + i$	
7	$t_3 = 4 * t_2$	B_2
8	$t_4 = v[t_3]$	
9	if $t_4 = x$ goto e_3	
13	if $x \ge t_5$ goto e_3	Вз
18	i = 1 + i	Б
19	goto e ₁	B ₄
20	e3: skip	Б
21	rtn n _{cerca} , x	B ₅

Variables d'inducció:

Totes les variables tenen una sola assignació al bucle.

Variables d'inducció bàsiques:

variable	f pos	R(x)
i	1 (B ₄ , 18)	(i, 1, 1)

A partir de les variables d'inducció bàsiques es poden obtenir les variables d'inducció derivades. Analitzant cada una de les possibilitats:

variable	f pos	R(x)	R(x) final	increment
t ₂	1 (B ₂ , 6)	(i, 1, -1)	(i, 1, -1)	1
t ₃	1 (B ₂ , 7)	$(t_2, 4, 0)$	(i, 4, -4)	4
t ₄	1 (B ₂ , 8)			

El codi que en resulta seria el següent:

1 2	e _{cercar} : skip	ъ
	pmb n _{cercar}	B ₁
4	i = 1	
	$t_5 = 100$	
	$t_6 = i * 1$	O.R.
	$t_7 = t_6 - 1$	PΓ
	s ₆ = t ₇	SAI
	$t_8 = i * 4$	AP
	$t_9 = t_8 - 4$	PREENCAPSALADOR
	$s_7 = t_9$	ŒE
	27 39	H
5	e ₁ : skip	
6	$t_2 = s_6$	
O	$s_6 = s_6 + 1$	
7		ъ
/	$t_3 = s_7$	B ₂
_	$s_7 = s_7 + 4$	
8	$t_4 = v[t_3]$	
9	if $t_4 = x$ goto e_3	
13	if $x \ge t_5$ goto e_3	В3
18	i = 1 + i	Ъ
19	goto e ₁	B ₄
20	e ₃ : skip	Б
21	rtn n _{cerca} , x	B ₅
	·	L