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a) 划分块如下:

块0: (1)  $i = m - 1$

(2)  $j = n$

(3)  $t_1 = 4 * n$

(4)  $v = a[t_1]$

块2: (9)  $j = j - 1$

(10)  $t_4 = 4 * j$

(11)  $t_5 = a[t_4]$

(12) if ( $t_5 > v$ ) goto 9

块4: (14)  $t_6 = 4 * i$

(15)  $x = a[t_6]$

(16)  $t_7 = 4 * i$

(17)  $t_8 = 4 * j$

(18)  $t_9 = a[t_8]$

(19)  $a[t_7] = t_9$

(20)  $t_{10} = 4 * j$

(21)  $a[t_{10}] = x$

(22) goto 5

块1: (5) if  $i \neq 1$

(6)  $t_2 = 4 * i$

(7)  $t_3 = a[t_2]$

(8) if ( $t_3 < v$ ) goto 5

块3: (13) if ( $i \neq j$ ) goto 23

块5: (23)  $t_{11} = 4 * i$

(24)  $x = a[t_{11}]$

(25)  $t_{12} = 4 * i$

(26)  $t_{13} = 4 * n$

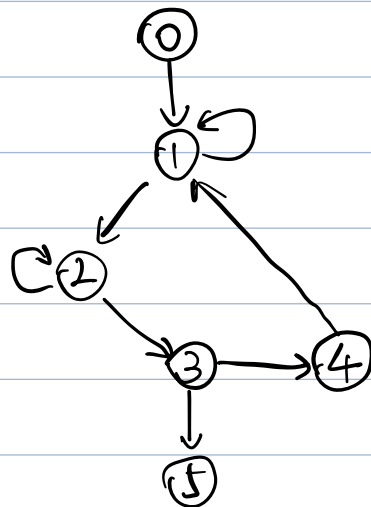
(27)  $t_{14} = a[t_{13}]$

(28)  $a[t_{12}] = t_{14}$

(29)  $t_{15} = 4 * n$

(30)  $a[t_{15}] = x$

程序流程图:



b) 结点 必经结点集

0

$\{0\}$

1

$\{1\} \cup (D(0) \cap D(1) \cap D(4)) = \{0, 1\}$

2

$\{2\} \cup (D(1) \cap D(2)) = \{0, 1, 2\}$

3

$\{3\} \cup D(2) = \{0, 1, 2, 3\}$

4

$\{4\} \cup D(3) = \{0, 1, 2, 3, 4\}$

5

$\{5\} \cup D(3) = \{0, 1, 2, 3, 5\}$

c) 回边 循环

$1 \rightarrow 1$

$\{1\}$

$2 \rightarrow 2$

$\{2\}$

$4 \rightarrow 1$

$\{1, 2, 3, 4\}$

d) 块 gen 集合

kill 集合

0  $\{d_1(i), d_2(j), d_3(t_1), d_4(v)\}$

$\{d_5(i), d_9(j)\}$

1  $\{d_5(i), d_6(t_2), d_7(t_3)\}$

$\{d_1(i)\}$

2  $\{d_9(j), d_{10}(t_4), d_{11}(t_5)\}$

$\{d_2(j)\}$

3  $\emptyset$

$\emptyset$

4  $\{d_{14}(t_6), d_{15}(t), d_{16}(t_1), d_{17}(t_8), d_{18}(t_9), d_{20}(t_{10})\}$

$\emptyset$

5  $\{d_{23}(t_{11}), d_{24}(x), d_{25}(t_{12}), d_{28}(t_{13}), d_{27}(t_{14}), d_{28}(t_{15})\}$

$\emptyset$

e) 对于块 0,  $IN_0 = \emptyset$

对于块 1,  $IN_1 = \{d_1(i), d_2(j), d_3(t_1), d_4(v), d_5(v), d_6(t_2), d_7(t_3), d_9(j), d_{10}(t_4), d_{11}(t_5), d_{14}(t_6), d_{15}(t), d_{16}(t_1), d_{17}(t_8), d_{18}(t_9), d_{20}(t_{10})\}$

对于块 2,  $IN_2 = \{d_2(j), d_3(t_1), d_4(v), d_5(i), d_6(t_2), d_7(t_3), d_9(j), d_{10}(t_4), d_{11}(t_5), d_{14}(t_6), d_{15}(t), d_{16}(t_1), d_{17}(t_8), d_{20}(t_{10})\}$

对于块 3,  $IN_3 = \{d_5(v), d_4(v), d_5(i), d_6(t_2), d_7(t_3), d_9(j), d_{10}(t_4), d_{11}(t_5), d_{14}(t_6), d_{15}(t), d_{16}(t_1), d_{17}(t_8), d_{20}(t_{10})\}$

对于块4,  $IN_4 = IN_3$

对于块5,  $IN_5 = IN_4 = IN_3$

f) 块	DEF 集合	USE 集合
0	$\{i(5, 6, 13, 14, 16, 23, 25), j(9, 10, 13, 17, 20), v(8, 12)\}$	$\{m(1), n(2, 3), a(4)\}$
1	$\{i(13, 14, 16, 23, 25)\}$	$\{i(5), a(7), v(8)\}$
2	$\{j(13, 17, 20)\}$	$\{j(9), a(11), v(12)\}$
3	$\emptyset$	$\{i(13), j(13)\}$
4	$\emptyset$	$\{i(14, 16), j(17, 20), a(15, 18, 19, 21), x(21)\}$
5	$\{x(21)\}$	$\{i(23, 25), n(26, 29), a(24, 27, 28, 30)\}$

g) 块	OUT 集合
0	$\{i(15), j(9), a(7, 11, 15, 18, 19, 21, 24, 27, 28, 30), n(26, 29), v(8, 12), x(21)\}$
1	$\{i(5, 13, 14, 16, 23, 25), j(9), a(7, 11, 15, 18, 19, 21, 24, 27, 28, 30), n(26, 29), v(8, 12), x(21)\}$
2	$\{i(5, 13, 14, 16, 23, 25), j(9, 13, 17, 20), a(7, 11, 15, 18, 19, 21, 24, 27, 28, 30), n(26, 29), v(8, 12), x(21)\}$
3	$\{i(5, 14, 16, 23, 25), j(9, 17, 20), a(7, 11, 15, 16, 19, 21, 24, 27, 28, 30), n(26, 29), v(8, 12), x(21)\}$
4	$\{i(5), j(9), a(7, 11, 15, 18, 19, 21, 24, 27, 28, 30), n(26, 29), v(8, 12), x(21)\}$
5	$\emptyset$

h)  $d_5 - (i)ud = \{d_1, d_5\}$ ,  $d_6 - (i)ud = \{d_5\}$ ,  $d_7 - (a)ud = \emptyset$ ,  $d_7 - (t_5)ud = \{d_6\}$ ,  $d_8 - (t_5)ud = \{d_7\}$ ,  
 $d_8 - (u)ud = \{d_4\}$ ,  $d_9 - (j)ud = \{d_2, d_9\}$ ,  $d_{10} - (j)ud = \{d_9\}$ ,  $d_{11} - (t_4)ud = \{d_{10}\}$ ,  $d_{12} - (t_5)ud = \{d_{11}\}$ ,  
 $d_{13} - (j)ud = \{d_9\}$ ,  $d_{14} - (i)ud = \{d_5\}$ ,  $d_{15} - (a)ud = \emptyset$ ,  $d_{16} - (t_6)ud = \{d_{14}\}$ ,  $d_{16} - (i)ud = \{d_5\}$ ,  
 $d_{17} - (j)ud = \{d_9\}$ ,  $d_{18} - (a)ud = \emptyset$ ,  $d_{18} - (t_8)ud = \{d_{17}\}$ ,  $d_{19} - (t_7)ud = \{d_{16}\}$ ,  $d_{19} - (a)ud = \emptyset$ ,  
 $d_{19} - (t_9)ud = \{d_{18}\}$ ,  $d_{20} - (j)ud = \{d_9\}$ .

i) ①  $i = m - 1$     ②  $j = n$     ③  $t_1 = 4 * n$     ④  $v = a[t_1]$

⑤  $s_1 = 4 * i$     ⑥  $s_2 = 4 * j$     ⑦  $i = i + 1$     ⑧  $s_1 = s_1 + 4$

⑨  $t_2 = s_1$     ⑩  $t_3 = a[t_2]$     ⑪  $\text{if } (t_3 < v) \text{ goto } 7$     ⑫  $j = j - 1$

(13)  $S_2 = S_2 - 4$  (14)  $t_4 = S_2$  (15)  $t_5 = a[t_4]$  (16) if ( $t_5 > 1$ ) goto 12

(17) if ( $i = j$ ) goto 27 (18)  $t_6 = S_1$  (19)  $t_7 = a[t_6]$  (20)  $t_7 = S_1$

(21)  $t_8 = S_2$  (22)  $t_9 = a[t_8]$  (23)  $a[t_7] = t_9$  (24)  $t_{10} = S_2$

(25)  $a[t_{10}] = X$  (26) goto 7 (27)  $t_{11} = 4 * i$  (28)  $X = a[t_{11}]$

(29)  $t_{12} = 4 * i$  (30)  $t_{13} = 4 * n$  (31)  $t_{14} = a[t_{13}]$  (32)  $a[t_{12}] = t_{14}$

(33)  $t_{15} = 4 * n$  (34)  $a[t_{15}] = X$

j) 对循环优化后的基本块局部优化;符.

(仅写了改动部分)

原 (27)  $t_7 = 4 * i$

$t_{12} = t_7$

$t_{13} = 4 * n$

$t_{15} = t_{13}$

$a[t_{15}] = a[t_7]$

$a[t_{12}] = a[t_{13}]$