

并行程序设计作业

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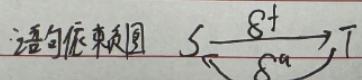
1 ex1

1.1 ex1.1

1. 找出以下循环中的存在依赖关系(包括依赖类型), 画出语句依赖图。

```
for I = 0 to 100 do
    A(I) = C(I)+2;
    B(I) = A(I-1)-A(2*I-5);
end for
```

EX1 1. S^{8t} T 因为对 A(I) 进行写 T 对 A(I-1) 进行读有先写后读的串流依赖
当 I=5 时 T 对 A(2*I-5) 进行读 S 对 A(I) 进行写存在 T^{8a}S



1.2 ex1.2

2. 找出以下循环中的存在依赖关系(包括依赖类型、依赖向量), 画出迭代依赖图(注意: 要“窥一斑而知全豹”)。

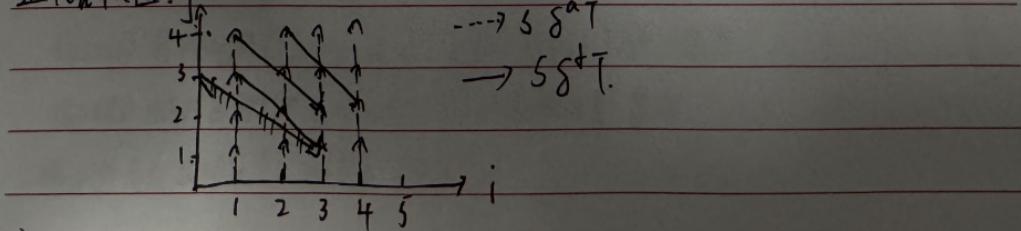
```
for I = 1 to 100 do
    for J = 1 to 50 do
        A(I+2,J) = B(2*I,J) - 5;
        B(2*I,J-1) = A(I,J+2) + 4;
    end for
end for
```

2. S 对 $A(I, J)$ 写 T 对 $A(I, J+2)$ 进行读，对数组 A 先写后读的存储依赖。

$$S \delta^T \text{ 依赖向量 } D = \begin{pmatrix} 2 \\ -2 \end{pmatrix} \quad d = \begin{pmatrix} 1 \\ -1 \end{pmatrix}$$

对数组 B ， S 中读 $B(I, J)$ T 写 $B(J, J-1)$ 存在读写冲突。 $S \delta^a T$ 依赖向量 $D = \begin{pmatrix} 0 \\ 1 \end{pmatrix} \quad d = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$

迭代依赖图：



1.3 ex1.3

3. 向量化以下循环。如果不能，请说明原因。

(1) for $I = 1$ to N do

S : $A(I) = B(I) + C(I+1);$
 T : $C(I) = A(I) * D(I);$
end for

(2) for $I = 1$ to N do

S : $A(I) = A(I-1) + 1$
end for

→ 距离为0

↑ 距离大

3 (1). 存在依赖向量(1) 的依赖 $S \delta^a T$ 和 依赖向量(2) 的 依赖 $S \delta^T T$ 不存向量化

TSS 可向量化。

$S' A(1:N) = B(1:N) + C(2:N+1)$

$T' C(1:N) = A(1:N) * D(1:N)$

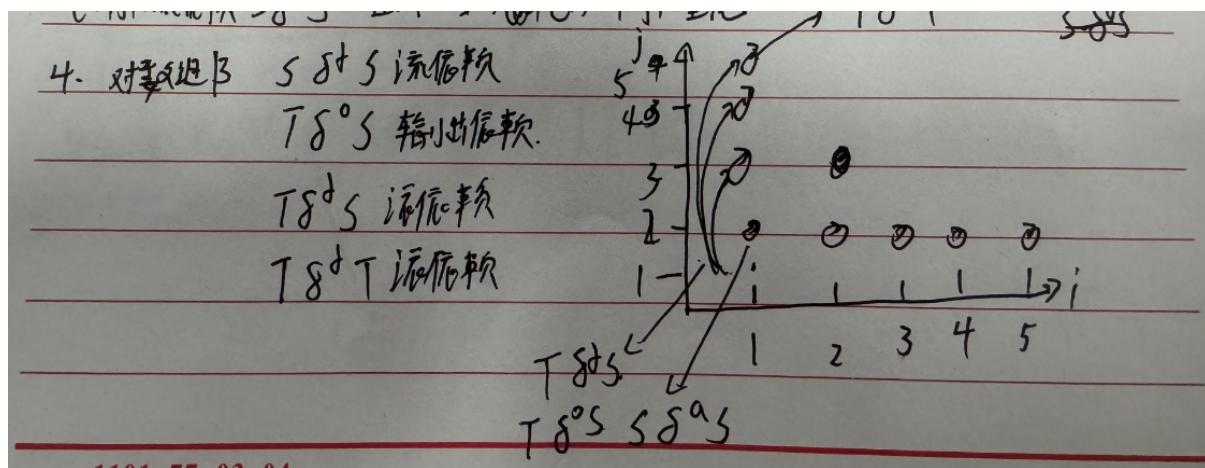
(2) 存在流依赖 $S \delta^T S$ 且方向向量为(1) (1)不可向量化 $\rightarrow T \delta^T T$

~~SSS~~

1.4 ex1.4

4. 分析以下循环中的存在依赖关系(包括依赖类型), 画出迭代依赖图。

```
for I = 1 to 5 do
S:   B(I) = B(I) / A(I,I);
      for J = I+1 to 5 do
T:       B(J) = B(J) - A(I,J) * B(I);
      end for
end for
```



2 EX2

2.1 ex2.1

1. 描述以下循环中的存在依赖关系(包括迭代对、依赖类型、依赖向量和距离向量)

```
for I = 1 to 100 do
  for J = 1 to 100 do
    A(I,J) = B(I+4,J-2) - B(I-2,J+1) + B(I,J+3);
    B(I,J) = D(I,J-1) - C(I+2,J)
  endfor
endfor
```

EX2:

1. ① $S \otimes^a T \{ \langle S(j_1, j_2), T(j_1, j_2) \rangle \mid j_1 = i_1 + 4, j_2 = i_2 - 2, 1 \leq i_1 \leq 96, 3 \leq i_2 \leq 100 \}$

$$d = (1, -1) \quad D = (4, -2)$$

② $S \otimes^a T \{ \langle T(i_1, i_2), S(j_1, j_2) \rangle \mid j_1 = i_1 + 2, j_2 = i_2 - 10, 1 \leq i_1 \leq 98, 2 \leq i_2 \leq 100 \}$

$$d = (1, -1) \quad D = (2, -1)$$

③ $S \otimes^a T \{ \langle S(j_1, j_2), T(j_1, j_2) \rangle \mid j_1 = i_1, j_2 = i_2 + 3, 1 \leq i_1 \leq 100, 1 \leq i_2 \leq 97 \}$

$$d = (0, 1) \quad D = (0, 3)$$

2.2 ex2.2

2. 分析循环②是否分别与循环③、④和⑤等价？

循环②:

```

for I = 1 to 100 do
  for J = 4 to 100 do
    S: A(I, J) = A(I-1, J+1)
    endfor
  endfor

```

循环③:

```

for J = 4 to 100 do
  for I = 1 to 100 do
    S: A(I, J) = A(I-1, J+1)
    endfor
  endfor

```

循环④:

```

for I = 1 to 100 do
  doall J = 4 to 100 do
    S: A(I, J) = A(I-1, J+1)
    enddoall
  endfor

```

循环⑤:

```

doall I = 1 to 100 do
  for J = 4 to 100 do
    S: A(I, J) = A(I-1, J+1)
    endfor
  enddoall

```

2. 循环② 有在 $S \otimes^a T \quad d = (1, -1)$

循环③ 置换矩阵 $\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \quad d \cdot \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} = (-1, 1)$ 为不等价

循环④ 因不存在形如 $(\alpha, \alpha, \dots, \alpha)$ 的依赖向量 等价

循环⑤ 有在 $d = (1, -1)$ 由主导 不等价

2.3 ex2.3

3 (1) 给出下面循环中的依赖关系描述和迭代依赖图。

```

for I = 1 to 8 do
    for J = max(I-3, 1) to min(I, 5) do
        S:   A(I+1, J+1) = A(I, J) + B(I, J)
        endfor
    endfor

```

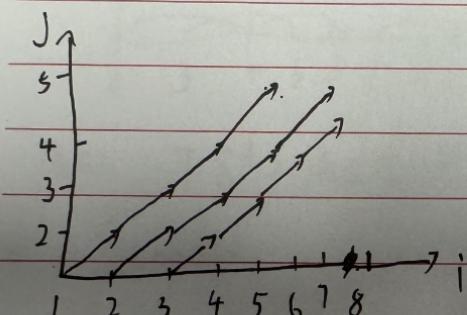
(2) 分析下面循环中存在的数据依赖关系。

```

for I = 2 to 9 do
    if A(I) > 0 then
        S:   A(I) = B(I-1) + 1
    else
        T:   B(I) = A(I) * 2
    endif
endfor

```

3. (1) S 的 S[i][j] d=(1,1)



(2) T 的 S[i][j] $\{S(i), S(j)\} \mid i = i+1, A(i) \leq 0, A(j) \geq 0, 2 \leq i \leq 8\}$

3 EX3

3.1 ex3.1

一、 分析以下循环中的依赖关系，并给出相应的迭代依赖图：

```
for i = 2 to 10 do // 循环 1
    for j = 2 to 10
        S: A[i,j] = ( A[i-1,j-1] + A[i+1,j+1] ) * 0.5;
        endfor
    endfor
```

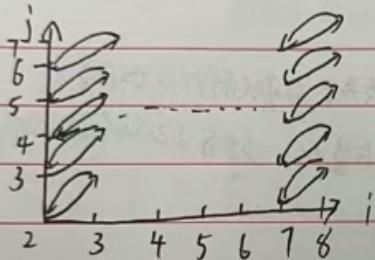
```
for i = 2 to 20 do // 循环 2
    S: A[2*i+2] = A[2*i-2] + B[i];
    endfor
```

```
for i = 2 to 20 do // 循环 3
    if A[i] > 0 then
        S: B[i] = C[i-1] + 1
    else
        T: C[i] = B[i] - 1
    endif
endfor
```

Ex3:

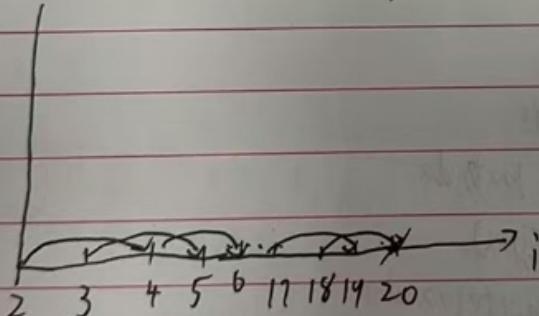
1. 循环1: $S_1^d S$ 和 $S_1^a S$ 的依赖关系

向量 $(1,1)$ 和 $(1,1)$

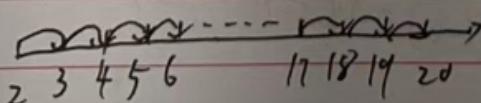


循环2: $S_1^d S$ 向量 (1,1) 非常向量 (4,4) (2,0)

(1)



循环3: $T_1^d S$ 满足偶数的 $T_1^d S$ (i) // $A[i] \leq 0$ $A[j] > 0$, $j = i+1, 2 \leq i \leq 20$
 $2 \leq i \leq 20$



3.2 ex3.2

二、 针对以下两个循环:

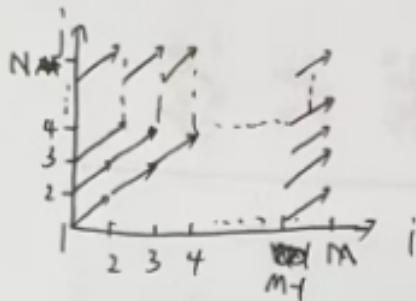
```
for i = 1 to M do    // 循环1 M, N, C 均是常量
  for j = 1 to N
    S: A[i+1, j+1] = A[i, j] + C;
  endfor
endfor
```

- (1) 给出迭代依赖示意图。
- (2) 简述能否逆转外层的 i 循环? 能否交换内外循环次序?

```
for i = 1 to 100 do // 循环2 N 是常量
  X[i] = Y[i] + 10; // 语句 S1
  for j = 1 to 100 do
    B[j] = A[j, N]; // 语句 S2
    for k = 1 to 100 do
      A[j+1, k] = B[j] + C[j, k]; // 语句 S3
    endfor // loop-k
    Y[i+j] = A[j+1, N]; // 语句 S4
  endfor // loop-j
endfor // loop-i
```

- (1) 给出此循环的语句依赖图。
- (2) 尝试向量化/并行化此循环。

②. 1. $S_8^t S$ 伸展向量 $(1,1)$ 距离向量 $(1,1)$



不可逆循环 循环向量 $(1,1)$ 通过后为 $(1,1)$ 伸展

$$(1,1) \cdot \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} = (1,1) \text{ 可以可逆}$$

2. S_1
 S_2
 S_3
 S_4
 S_5 不在大括号内，不能向量化
 S_1, S_2, S_3 在大括号内，可以向量化
 S_1, S_2, S_3, S_4 可以向量化， S_5 不可以向量化

对于 $i=1, S_1, S_2, S_3, S_4$ 有相同的倍数，不可向量化，平行化

综上：

for $i=1 \text{ to } 100$ do

$$X[i] = [C_i] + 10$$

for $j=1 \text{ to } 100$ do

$$B[j] = A[j, N];$$

do double $k=1 \text{ to } 100$ do

$$A[j+1, k] = B[j] + C[j, k];$$

end do all

end for

$$Y[i+1 : i+100] = A[2 : 101, N],$$

end for.

3.3 ex3.3

三、 针对以下循环/程序：

```
for i = 1 to 100 do //循环1
    for j = 1 to 50 do
        S1: A[3*i+2,2*j-1] = A[5*j,i+3] + 2;
    endfor
endfor
```

- (1) 给出满足依赖方向向量(1,1)的迭代依赖对集合的描述。
(2) 找出与迭代(i=11, j=11)相依赖的迭代(m,n)并指出是哪种依赖?
(3) 能否向量化最内层的j循环?如不行,简述理由。

```
S1: x = y * 2
    for i = 1 to 100 do
        S2: C[i] = B[i] + x
        S3: A[i] = C[i-1] + z
        S4: C[i+1] = A[i] * B[i]
            for j = 1 to 50 do
                S5: D[i,j] = D[i,j-1] + x
            endfor
        endfor
S6: z = y + 4
```

给出上述程序的语句依赖图。

偏微向量为 $(\frac{1}{n} \otimes \chi_{1,1}) =$

$$3. \text{ 令 } \begin{cases} s_1(i_1, j_1) > s_2(i_2, j_2) \\ 3i_1 + 2 = 5j_2 \\ 2j_1 - 1 = i_2 + 3 \\ 1 \leq i_1, i_2 \leq 100 \\ 1 \leq j_1, j_2 \leq 50 \end{cases} \Rightarrow \begin{cases} i_2 = 2j_1 - 4 \\ j_2 = \frac{3i_1 + 2}{5} \end{cases}$$

遍历所有向量 (i_1, j_1)

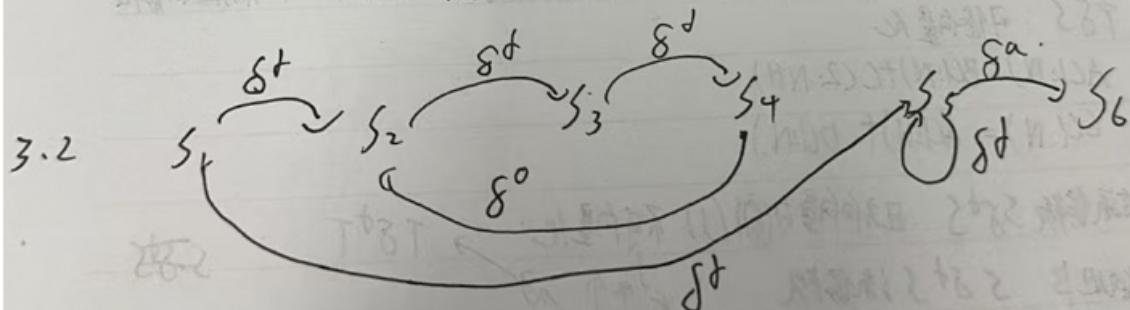
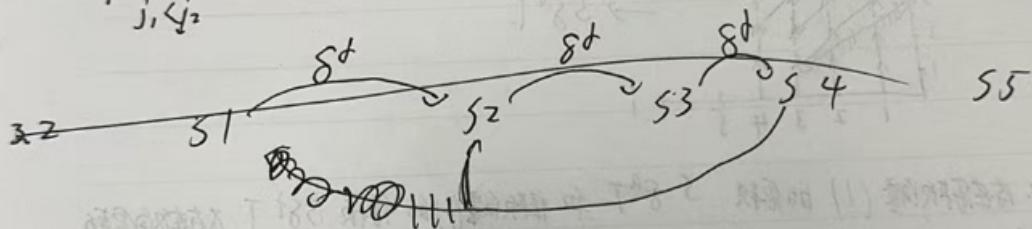
$$s_1 \otimes s_2 \{s_1(i_1, j_1), s_2(i_2, j_2) \mid 2j_1 - 4 \geq i_2, \frac{3i_1 + 2}{5} \geq j_1, 1 \leq i_1, i_2 \leq 100, 1 \leq j_1, j_2 \leq 50\}$$

$$s_2 \otimes s_1 \{s_2(i_2, j_2), s_1(i_1, j_1) \mid 2j_1 - 4 < i_2, \frac{3i_1 + 2}{5} < j_1, 1 \leq i_1, i_2 \leq 100, 1 \leq j_1, j_2 \leq 50\}$$

$$\text{E1 } (18, 7) \text{ S1} = S(11, 11) \text{ S2} = S(18, 7)$$

(3) 若向量化不存依赖项由主子

$$\begin{cases} 3i_1 + 2 = 5j_2 \\ 2j_1 - 1 = i_2 + 3 \\ j_1 < j_2 \end{cases} \Rightarrow i_1 = 26, j_1 = 15, j_2 = 16 \text{ 不向量化}$$



3.4 ex3.4

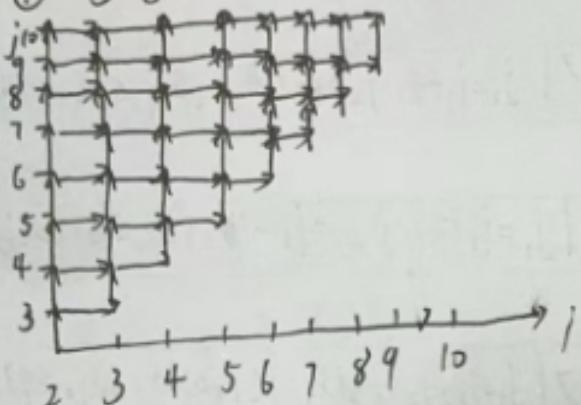
```
for i = 2 to 10 do    //循环1
    for j = i to 10
        S A[i,j] = ( A[i,j-1] + A[i-1,j] )* 0.5;
    endfor
endfor
```

```
for i = 1 to 16 do    // 循环2
    S A[i+3] = A[i] + B[i];
endfor
```

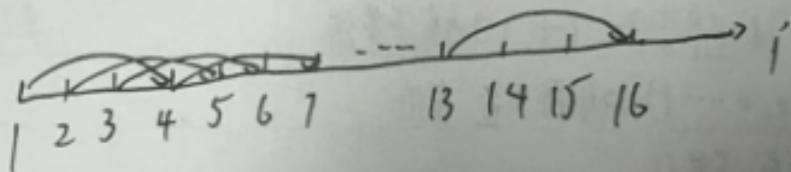
```
for k = 1 to 16 step 5 do    // 循环3 ,k 的循环步长为 5
    for i = k to min(16,i+4) do //设 min 为求最小值函数
        S A[i+3] = A[i] + B[i]
    endfor
endfor
```

34

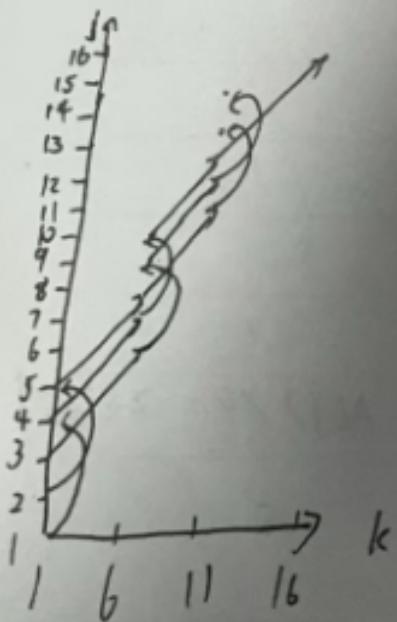
① $S^{\dagger}S (0,1), (1,0)$



② $S^{\dagger}S (3)$



③. $S^{\dagger}S$



3.5 ex3.5

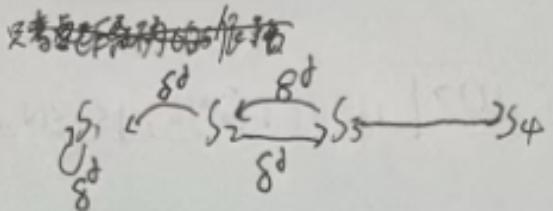
```
for i = 1 to 100 do // 循环 1
  S1 A[i] = A[i] + B[i-1];
  S2 B[i] = C[i-1] * 2 ;
  S3 C[i] = 1 / B[i] ;
  S4 D[i] = C[i] * C[i] ;
endfor
```

```
for i = 1 to 999 do // 循环 2
  S A[i] = B[i] + C[i];
  T D[i] = ( A[i] + A[ 999-i+1 ] ) / 2 ;
endfor
```

```
for i = 1 to 100 do // 循环 3
  for j = 1 to 100 do
    S  A[3*i+2*j, 2*j] = C[i,j] * 2      ;
    T  D[i,j]           = A[i-j+6, i+j] ;
  endfor
endfor
```

$$① S_1 S^{\dagger} S_2 D=0 \quad S_2 S^{\dagger} S_3 D=0 \quad S_3 S^{\dagger} S_4 D=0$$

$$S_3 S^{\dagger} S_2 D=1 \quad S_2 S^{\dagger} S_1 D=1$$



将 S_1, S_4 移到最后此时 S_1, S_4 可向量化

for $i = 1 \text{ to } 100$,

$$BC[i] = [i-1]*2, 1, S_2$$

$$CD[i] = 1/BC[i], 1, S_3$$

and for

$$AC[i:100] = AC[i:100] + BC[i:99]; 1, S_1$$

$$DC[i:100] = CD[i:100] * AC[i:100]; 1, S_4$$

$$② S S^{\dagger} T T^{\dagger} S$$

$$S' = AC[1:99] = BC[1:99] + CD[1:99];$$

$$T' = DC[1:99] = (AC[1:99] + CD[1:99])/2$$

$$S'' = AC[500:999] = BC[500:999] + CD[500:999];$$

$$T'' = DC[500:999] = (AC[500:999] + CD[500:999])/2$$

③ 确定函数关系

forall $i = 1 \text{ to } 100$ do

$$S' = AC[3i+2:3i+200, 2:200] = CD[i, 1:100] * 2;$$

$$T' = DC[i, 1:100] = AC[i+5:i-94, i+1:i+100];$$

$$T'' = DC[500, 999] = (AC[500:999] + CD[500:999])/2$$

odd forall

4 EX4

4.1 ex4.1

1. 针对以下循环 1:

```
for I = 0 to 3 do
    for J = 0 to 3 do
        S A(I,J) = (A(I-1,J) + A(I,J-1)) / 2;
    endfor
endfor
```

1.1 描述以下循环中的存在依赖关系(包括迭代依赖图、依赖类型、依赖向量和距离向量等)

1.2 令 $K_1 = I + J$ 和 $K_2 = J$ 变换上述循环 1，并给出新循环 2 的迭代依赖图:

```
for K1 = ...
for K2 = ...
A(..., ...) = ...
```

1.3 令 $K_1 = I + J$ 和 $K_2 = I + 2J$ 变换上述循环 1，并给出新循环 3 的迭代依赖图:

```
for K1 = ...
for K2 = ...
A(..., ...) = ...
```

1.4 令 $K_1 = 2I + J$ 和 $K_2 = 3I + 2J$ 变换上述循环 1，并给出新循环 4 的迭代依赖图:

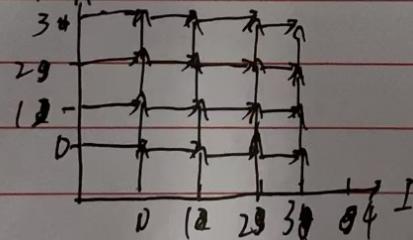
```
for K1 = ...
for K2 = ...
A(..., ...) = ...
```

ex-4,

$$\text{令 } S: A(I,J) = (A(I-1,J) + A(I,J-1)) / 2$$

1.1 $S \rightarrow^+ S$ 和 $S \rightarrow^- S$ 都是流依赖.

迭代依赖图



依赖向量 $(1,0), (0,1)$ 距离向量 $(1,0), (0,1)$ 同是流依赖.

$$1.2. \quad \begin{pmatrix} k_1 \\ k_2 \end{pmatrix} = \begin{pmatrix} I \\ J \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 \\ 1 & 1 \end{pmatrix}$$

依赖向量为 $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 1 & 1 \end{pmatrix}$ 均为正

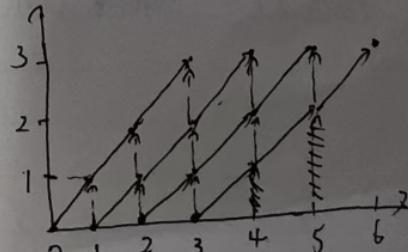
$$\left\{ \begin{array}{l} 0 \leq I \leq 3 \\ 0 \leq J \leq 3 \end{array} \right. \Rightarrow \left\{ \begin{array}{l} 0 \leq \boxed{k_1 - k_2} \leq 3 \\ 0 \leq k_2 \leq 3 \end{array} \right. \Rightarrow \left\{ \begin{array}{l} k_2 \leq k_1 \\ k_2 \geq |k_1| - 3 \\ k_2 \geq 0 \\ k_2 \leq 3 \end{array} \right.$$

$$\max(0, k_1 - 3) \leq k_2 \leq \min(3, k_1).$$

$$6 \geq k_1 \geq 0$$

```

    源上： for k1 = 0 to 6 do
        for k2 = max(0, k1-3) to min(3, k1) do
            i = k1 - k2
            j = k2
            H(i, j)
        endfor
    endfor
  
```



$$I_3 \begin{pmatrix} k_1 \\ k_2 \end{pmatrix} = \begin{pmatrix} I \\ J \end{pmatrix} I \cdot \begin{pmatrix} 1 & 1 \\ 1 & 2 \end{pmatrix}$$

低频向量: $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 1 & 1 \\ 1 & 2 \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ 1 & 2 \end{pmatrix}$ 均值.

$$\begin{cases} 0 \leq I \leq 3 \\ 0 \leq J \leq 3 \end{cases} \Rightarrow \begin{cases} 0 \leq 2k_1 - k_2 \leq 3 \\ 0 \leq k_2 - k_1 \leq 3 \end{cases} \Rightarrow \begin{cases} k_2 \leq 2k_1 \\ k_2 \geq 2k_1 - 3 \\ k_1 \leq k_2 \\ k_2 \leq 3 + k_1 \end{cases} \Rightarrow \begin{cases} \max(2k_1 - 3, k_1) \leq k_2 \\ \min(3 + k_1, 2k_1) \geq k_2 \end{cases}$$

$$\begin{cases} 2k_1 \geq k_1 \\ 2k_1 \geq 2k_1 - 3 \\ 3 + k_1 \geq k_1 \\ 3 + k_1 \geq 2k_1 - 3 \end{cases} \Rightarrow \begin{cases} k_1 \geq 0 \\ k_1 \leq 6 \end{cases}$$

综上

for $k_1 = 0$ to 6 do

for $k_2 = \max(2k_1 - 3, k_1)$ to $\min(3 + k_1, 2k_1)$ do

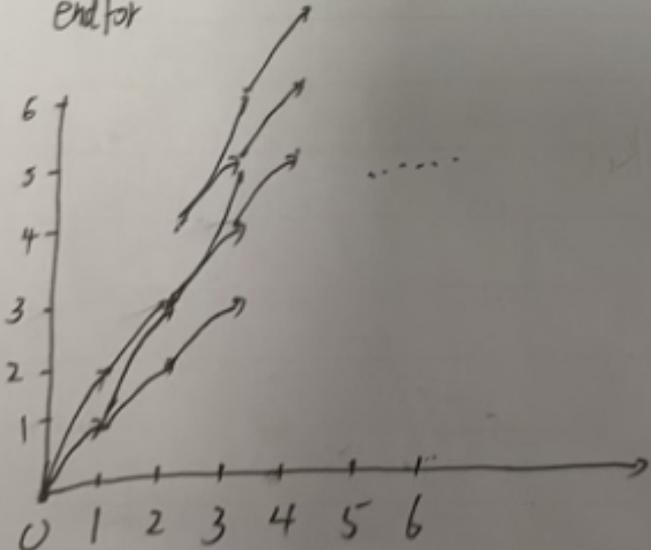
$$J = 2k_1 - k_2$$

$$J = k_2 - k_1$$

$$A(I, J) = (A(I-1, J) + A(I, J-1)) / 2$$

end for

end for



4

$$\begin{aligned}
 & \text{for } 0 \leq j \leq 3 \Rightarrow \left\{ \begin{array}{l} 0 \leq 2k_1 - k_2 \leq 3 \\ 0 \leq 2k_2 - 3k_1 \leq 3 \end{array} \right. \Rightarrow \left\{ \begin{array}{l} k_2 \leq 2k_1 \\ k_2 \geq 2k_1 - 3 \\ k_2 \geq \frac{3}{2}k_1 \\ k_2 \leq \frac{3+3k_1}{2} \end{array} \right. \\
 & \quad \left\{ \begin{array}{l} k_2 \leq \min(2k_1, \frac{3+3k_1}{2}) \\ k_2 \geq \max(2k_1 - 3, \frac{3}{2}k_1) \end{array} \right. \quad 0 \leq k_1 \leq 4
 \end{aligned}$$

for上: for $k_1 = 0$ to 4 do

for $k_2 = \max(2k_1 - 3, \frac{3}{2}k_1)$ to $\min(2k_1, \frac{3+3k_1}{2})$ do

$$I = 2k_1 - k_2$$

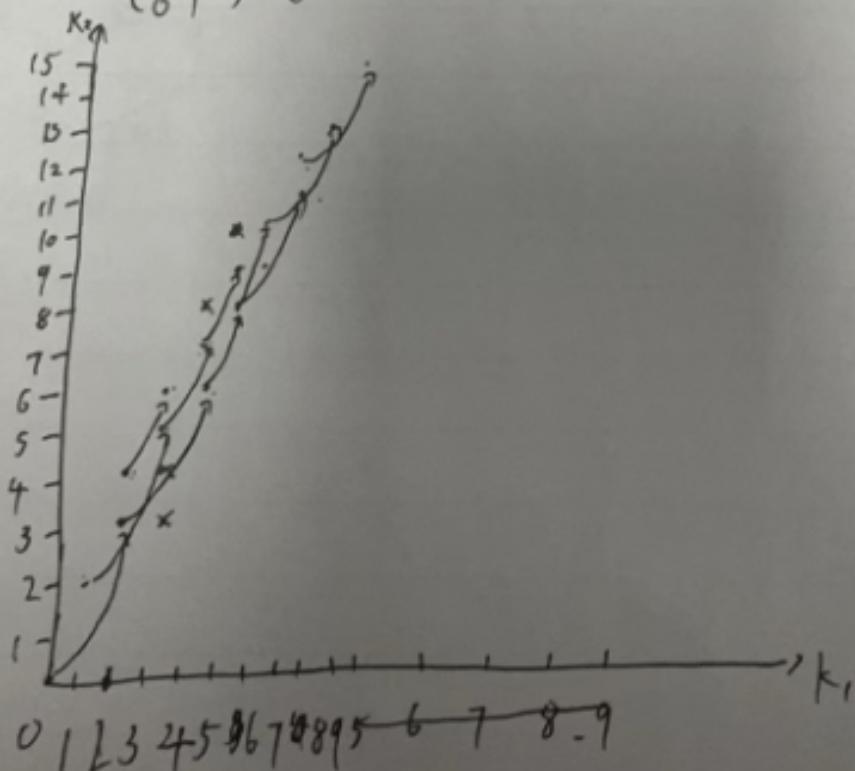
$$J = 2k_2 - 3k_1$$

$H(I, J)$:

endfor

endfor

依赖向量 H $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 2 & 3 \\ 1 & 2 \end{pmatrix} = \begin{pmatrix} 2 & 3 \\ 1 & 2 \end{pmatrix}$



4.2 ex4.2

2. 尝试交换以下循环 5 的内外层循环。

```
for I = 1 to 8 do
    for J = max(I-3,1) to min(I,5) do
        S A(I+1, J+1) = A(I,J) + B(I,J)
    endfor
endfor
```

2.

```
for J=1 to 5 do
    for I = J to J+3 do
        A(I+1, J+1) = A(I,J) + B(I,J)
    endfor
endfor
```

$P = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ 依赖向量 $(1,1)$ $(1,1) \cdot P = (1,1)$ 可行

5 EX5

5.1 ex5.1

```
for i = 1 to N do    //循环 1
    for j = 1 to N/2 do
        S1:   B[ i, j ] = A[ i, j ] + C;
        endfor
        for j = 1 to N do
            S2:   A[ i, j+1 ] = B[ i, j ] + D;
        endfor
    endfor
```

- (1) 描述循环中存在的依赖关系。
- (2) 尝试对循环 1 进行并行化/向量化

EX5. 37

1. (1) $S1 \rightarrow S2 \left(\{S1(i_1, j_1), S2(i_2, j_2)\} \mid i_1 = j_1, i_2 = j_2, 1 \leq i_1 \leq N, 1 \leq j_1 \leq N, 1 \leq i_2 \leq \frac{N}{2}, 1 \leq j_2 \leq \frac{N}{2}\} \right)$

(2) $\begin{array}{l} \text{for } i=1 \text{ to } N \text{ do} \\ \quad \text{for } j=1 \text{ to } N/2 \text{ do} \\ \quad \quad \overline{B[i]} \end{array}$

(2): ~~do all~~ $i=1 \text{ to } N$

$$B[i, 1 : \frac{N}{2}] = B[i, 1 : \frac{N}{2}] + C$$

$$A[i, j+1] = B[i]$$

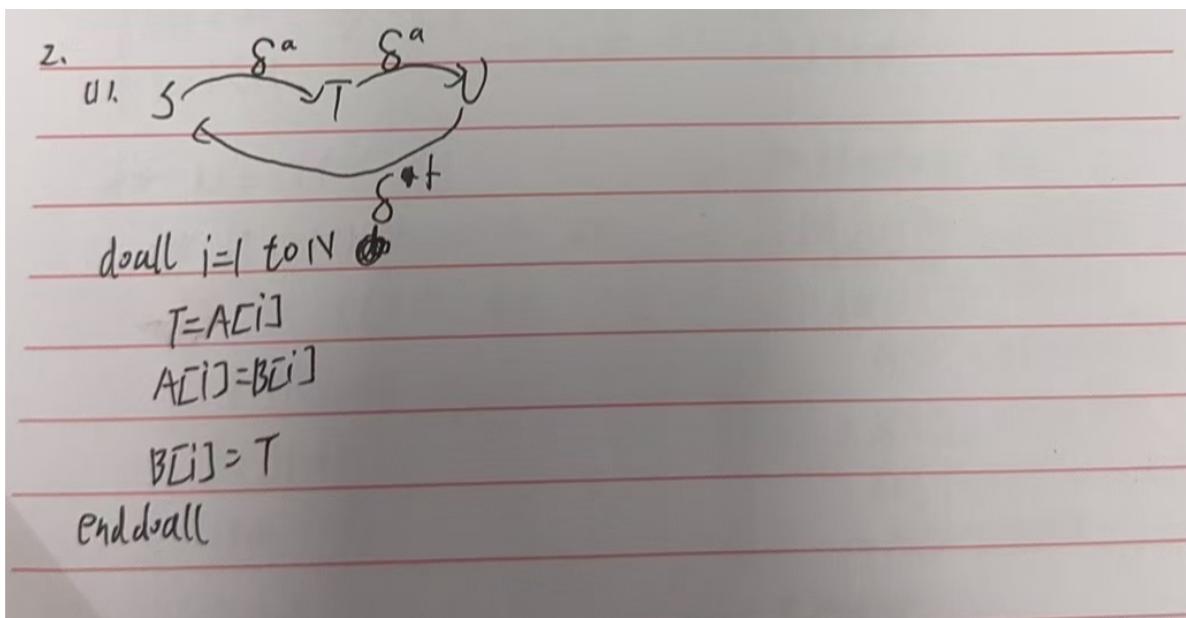
$$A[i, 2 : N+1] = B[i, 1 : N] + D$$

end do all

5.2 ex5.2

```
for i = 1 to N do    //循环 2
    S:  T = A[ i ]
    T:  A[ i ] = B[ i ]
    U:  B[ i ] = T
endfor
```

- (1) 给出该循环的语句依赖图。
(2) 尝试对循环 2 并行化/向量化。



5.3 ex5.3

```
for k = 1 to L do    //循环 3
    for j = 1 to M do
        for i = 1 to N
S:   A[ i+1,j+1,k+1 ] = A[ i,j,k+1 ] + A[ i,j+1,k ] +
            A[ i+1,j+1,k ]
        endfor
    endfor
endfor
```

(1) 给出循环 3 的依赖方向向量。

(2) 令 $k_1 = k$ 、 $j_1 = j + k$ 和 $i_1 = i$ 变换如下，

```
for k1 = ...
    for j1 = ...
        for i1 = ...
            A[..., ...] = ... ...
```

● 给出变换后的循环，及其新的依赖方向向量。

● 尝试 OpenMP 并行化变换后的循环。

3

11. $58\ddot{3}$ $58\ddot{3}$ $58\ddot{3}$

$$(1, 0, 0) \quad (1, 0, 1) \quad (0, 0, 1)$$

$$\begin{array}{ccc} (0,1,1) & (1,0,1) & (1,0,0) \\ \downarrow & \downarrow & \downarrow \\ 1 & 1 & 0 \end{array}$$

$$\begin{pmatrix} 1 & 0 \\ 1 & 1 \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{pmatrix}$$

$$[2] \begin{pmatrix} 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 0 & 1 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \end{pmatrix}$$

单力场单向量 $(0, 1, 1)$ $(1, 1, 1)$ ~~$(1, 1, 2)$~~ $(1, 1, 0)$.

$$\left| \begin{array}{l} 1 \leq k \leq L \\ 1 \leq j \leq M \\ 1 \leq i \leq N \end{array} \right\} \Rightarrow \left| \begin{array}{l} 1 \leq k_1 \leq L \\ 1 \leq j_1 - k_1 \leq M \\ 1 \leq i_1 \leq N \end{array} \right\} \Rightarrow \left| \begin{array}{l} 1 + k_1 \leq j_1 \leq M + k_1 \\ 1 \leq i_1 \leq N \end{array} \right\}$$

for $k_1 = 1 \text{ to } L$ do

for $j = l+k$ to $m+k$ do

for i=1 to N do

$k=k_1$

$$d = d|-k|$$

$\hat{y} = 1$

H(j,l,k)

endfor

endfor

Chadfor.

1101-77-03-04

(2) for $|K|=1$ to L do

for $j = 1 \text{ to } n$ k do

for i = 1 to N do

$A[i:i+1] \in [H-K]^{DKH}$

三周口市-项城市

+AC[1]E[1]+K[1]EK[1]

~~+AEIiit+UERH+U[ei]+t+k]DKL~~

e endfor

and for

endor