Loop skewing

Used with loop interchange to exploit parallelism in wavefront computations.

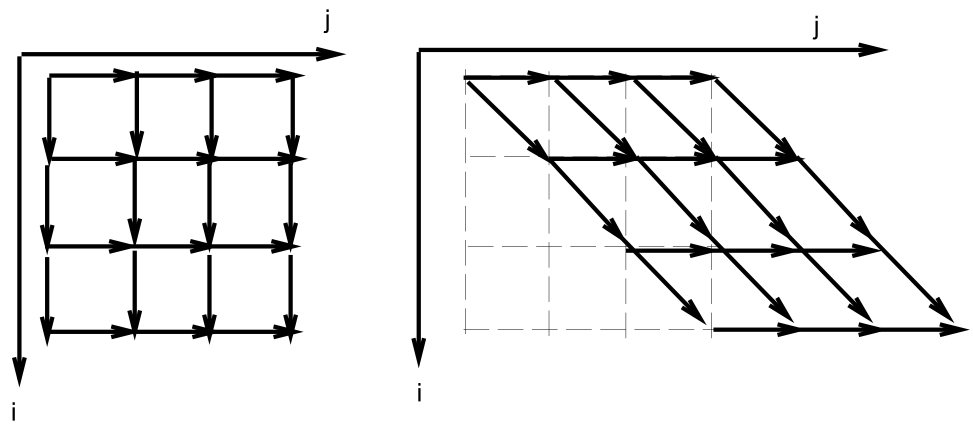
```
do i = 2, n-1
 do j=2, m-1
   a[i,j]=a[i-1,j]+a[i,j-1]+a[i+1,j]+a[i,j+1];
 enddo
enddo
```

Dependence (1,0), (0,1)

```
do i = 2, n-1
 do j=i+2, i+m-1
  j'=j-i;
  a[i,j']=a[i-1,j']+a[i,j'-1]+a[i+1,j']+a[i,j'+1];
 enddo
enddo
```

Skewed code: Dependence (1,1), (0,1)

Original iteration space **Skewed space**




```
do j=4, m+n-2
 do i = max(2,j-m+1), min(n-1,j-2)
  j'=j-i;
  a[i,j']=a[i-1,j']+a[i,j'-1]+a[i+1,j']+a[i,j'+1];
 enddo
enddo
```

Skewed and interchanged code: Dependence (1,0), (1,1). Inner loop can be executed in parallel.

Strip mining

Adjust the granularity of an operation.

```
do i = 1, n
   a[i]=a[i]+c
enddo
```

```
TN=(n/64)*64
do TI=1, TN, 64
   a[TI:TI+63]=a[TI:TI+63]+c
enddo
do i = TN, n
   a[i]=a[i]+c
enddo
```

Loop tiling

For i=1 to n

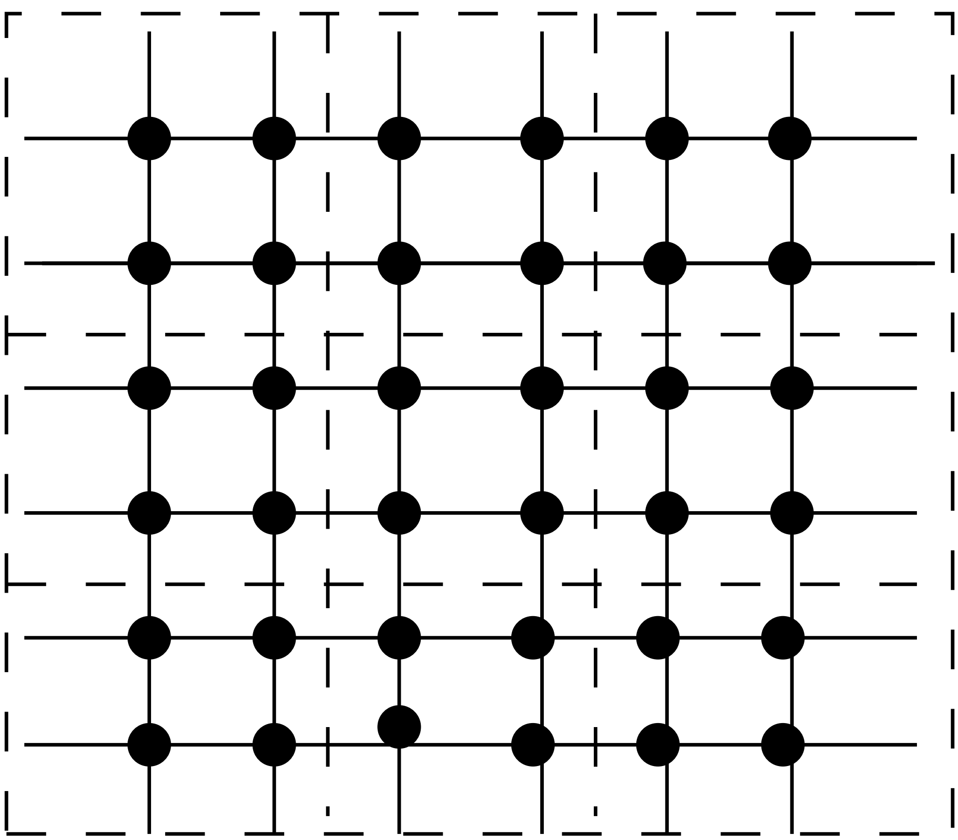
For j=1 to n

$u^{new}_{i,j} = 0.25(u_{i+1,j} + u_{i-1,j} + u_{i,j+1} + u_{i,j-1})$.

EndFor

EndFor

Iteration space partitioning



Transformation process

Step 1. Introduce control variables.

For $bi = 1$ to p
  For $i = (b_i - 1)\gamma + 1$ to $b_i\gamma$
    For $bj = 1$ to p
      For $j = (b_j - 1)\gamma + 1$ to $b_j\gamma$
        $u_{i,j}^{new} = 0.25(u_{i+1,j} + u_{i-1,j} + u_{i,j+1} + u_{i,j-1})$.
      EndFor
    EndFor
  EndFor
EndFor

Step 2. Interchange loops.

For $bi = 1$ to p
  For $bj = 1$ to p
    For $i = (b_i - 1)\gamma + 1$ to $b_i\gamma$
      For $j = (b_j - 1)\gamma + 1$ to $b_j\gamma$
        $u_{i,j}^{new} = 0.25(u_{i+1,j} + u_{i-1,j} + u_{i,j+1} + u_{i,j-1})$.
      EndFor
    EndFor
  EndFor
EndFor

Tiling for matrix multiplication

for $i = 1$ **to** n **do**

  for $j = 1$ **to** n **do**

    for $k = 1$ to n **do**

      $c(i,j) = c(i,j) + a(i,k) * b(k,j);$

    Endfor

  Endfor

Endfor