Parallel Programming WS 2014/2015 - Assignment 5

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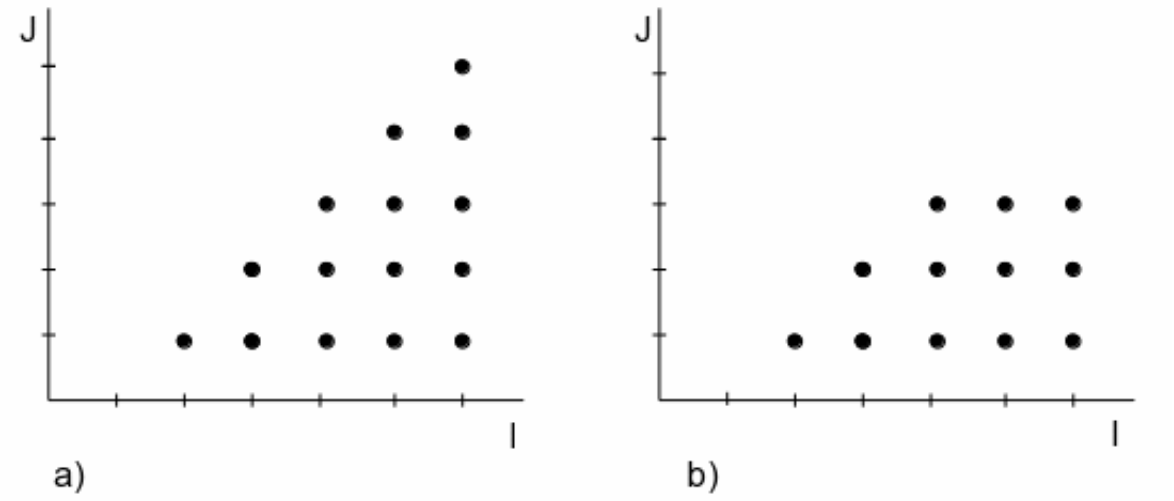
Exercise 1 (Iteration Spaces)

Determine the loops which have the following iteration spaces:



Exercise 2 (Loop Permutation)

```
for I = 1 to 6 do
  for J = 1 to 5 do
    A[I, J] = A[I - 1, J - 2] + 1
  endfor
endfor
```

a) Determine the dependence vector.
b) Can we permute the I and J loops?
c) Show that we cannot permute the I and J loops of the following loop nest:

```
for I = 1 to N do
  for J = 1 to N do
    B[I, J] = B[I - 1, J + 1] + 1
  endfor
endfor
```

Exercise 3 (Loop Reversal)

a) Can we reverse the following loop?

```
for I = 1 to 6 do
    B[I] = B[I - 1] + 1
endfor
```

b) Can we reverse the J loop?

```
for I = 1 to 5 do
  for J = 1 to 6 do
    A[I, J] = A[I - 1, J - 1] + 1
  endfor
endfor
```

Exercise 4 (Loop Skewing)

Original loop:

```
for I = 1 to 3 do
  for J = 1 to 3 do
    A[I, J] = A[I - 1, J + 1] + 1
  endfor
endfor
```

a) Draw the iteration space including a dependence vector.
b) Why is it illegal to permute the I and J loops?
c) Apply a skewing transformation with factor 1.
d) Draw the resulting iteration space including a dependence vector.
e) Permute the I and J loops of the resulting code. Is this a legal transformation?
f) Draw the resulting iteration space including a dependence vector.
g) Derive the loop bounds of the transformed loop from the drawing.
h) Homework: Derive the loop bounds mathematically using the transformation matrix.

Exercise 5 (Homework: Transformation and Parallelization of a Loop)

Apply the transformation steps outlined on Slide 56c to parallelize the loop

```
for I = 0 to N do
  for J = 0 to M do
    A[I + 1, J] = A[I, J - 1] + A[I + 1, J - 2]
  endfor
endfor
```

These are the necessary steps:

- 1. Draw the iteration space.
- 2. Compute the dependence vectors and draw examples of them into the iteration space.
- 3. Apply a skewing transformation with factor 1 and draw the iteration space.
- 4. Apply a permutation transformation and draw the iteration space.
- 5. Compute the matrix of the composed transformation and use it to transform the dependence vectors.
- 6. Compute the inverse of the transformation matrix and use it to transform the index expressions.
- 7. Specify the loop bounds by inequalities and transform them by the inverse of the transformation matrix.
- 8. Write the complete loops with new loop variables ip and jp and new loop bounds.

Check your transformation. Assume `N = M = 2`. The original loop nest computes:

```
s00: A[1, 0] = A[0, -1] + A[1, -2]
s01: A[1, 1] = A[0, 0] + A[1, -1]
s02: A[1, 2] = A[0, 1] + A[1, 0]

s10: A[2, 0] = A[1, -1] + A[2, -2]
s11: A[2, 1] = A[1, 0] + A[2, -1]
s12: A[2, 2] = A[1, 1] + A[2, 0]

s20: A[3, 0] = A[2, -1] + A[3, -2]
s21: A[3, 1] = A[2, 0] + A[3, -1]
s22: A[3, 2] = A[2, 1] + A[3, 0]
```

Compare this to your transformed version. Verify that the inner loop can be executed in parallel.