Homework3 – loop transformation

Zewen Hua

1.

C = 64k, B = 128, sizeof(element) = 8 bytes,
number of elements in a cache block = 128/8 = 16
maximum number cache can hold = 64k/8 = 8k
cache k loop needs = 16 + 256 + 16*256 < 8k
consider access pattern of inner loop:
k is iterating;
The stride of A is 1;
The stride of B is 16;
The stride of C is 0;
misses per iteration = A (0.0625) + B (1) + C (0) = 1.0625

2.

C = 64k, B = 64, sizeof(element) = 8 bytes,
number of elements in a cache block = 64/8 = 8
maximum number cache can hold = 64k/8 = 8k
cache k loop needs = 8 + 256 + 8*256 < 8k
consider access pattern of inner loop:
k is iterating;
The stride of A is 1;
The stride of B is 8;
The stride of C is 0;
misses per iteration = A (0.125) + B (1) + C (0) = 1.125

3.

C = 64k, B = 32, sizeof(element) = 8 bytes,
number of elements in a cache block =32/8 = 4
maximum number cache can hold = 64k/8 = 8k
cache k loop needs = 4 + 256 + 4*256 < 8k
consider access pattern of inner loop:
k is iterating;
The stride of A is 1;
The stride of B is 4;
The stride of C is 0;
misses per iteration = A (0.25) + B (1) + C (0) = 1.25

4 – 7: C[i][j] += A[i][k] * B[k][j]

4.

J loop: B and C iterating in row, A not moving

K loop: A iterating in row, B iterating in column, C will be evicted each time

I loop: A, B, C will evict one another during the loop

	A	B	C
I	N	N	N
K	N/B	N	N
J	1	N/B	N/B
	N^2/B	N^3/B	N^3/B

$M = N^2/B + N^3/B + N^3/B$

5.

J loop: B and C iterating in row, A not moving

I loop: A and C iterating in column, B will be evicted each time

K loop: A, B, C will evict one another during the loop

	A	B	C
K	N	N	N
I	N	N	N
J	1	N/B	N/B
	N^2	N^3/B	N^3/B

$M = N^2 + N^3/B + N^3/B$

6.

I loop: A and C iterating in column, B not moving

K loop: A, B, C will evict one another during the loop

J loop: A, B, C will evict one another during the loop

	A	B	C
J	N	N	N
K	N	N	N
I	N	1	N
	N^3	N^2	N^3

$M = N^3 + N^2 + N^3$

7.

I loop: A and C iterating in column, B not moving

J loop: B iterating in row, A and C will be evicted each time

K loop: A, B, C will evict one another during the loop

	A	B	C
K	N	N	N
J	N	N/B	N
I	N	1	N
	N^3	N^2/B	N^3

$M = N^3 + N^2/B + N^3$

8.

	m	*C*	*B*	*E*	*S*	*t*	*s*	*b*
	32	2048	16	2	64	22	6	4

a)

k is iterating;

The stride of a is 0;

The stride of b is 0;

The stride of c is 1;

j is iterating;

The stride of a is 0;

The stride of b is 1;

The stride of c is 1024;

i is iterating;

The stride of a is 1;

The stride of b is 1024;

The stride of c is 1024*1024;

b)

ASK	GET	SET	MISS/HIT
a[0]	a[0-3]	set0	M
b[0]	b[0-3]	set0	M
c[0]	c[0-3]	set1	M
a[0]			H
b[0]			H
c[1]			H
…	…	…	…

hit_rate_a = $1 - \frac{1}{1024*1024*4}$

hit_rate_b = $1 - \frac{1}{1024*4}$

hit_rate_c = $1 - \frac{1}{4} = \frac{3}{4}$

c)

contents after the completion:

set0	c[764-767]
	c[1020-1023]
set1	c[512-515]
	c[768-771]
set2	c[516-519]
	c[772-775]
…	…
set62	c[756-759]
	c[1012-101]
set63	a[1020-1023]
	b[1020-1023]

9.

a)

K loop: A iterating in column, B iterating in column, C not moving

J loop: C iterating in row, A and C will be evicted each time

I loop: A, B, C will evict one another during the loop

	A	B	C
I	N	N	N
J	N	N	N/B
K	N/B	N	1
	N^3/B	N^3	N^2/B

M = $N^3/B + N^3 + N^2/B$

b)

Yes.

Because the index of A, B, C is a loop (i, j -> j, k -> k, i). So, no matter how to change the order for IJK, JKI and KIJ, it will just be like that A, B, C exchange the index one another. It makes no sense for IJK, JKI. And JIK, IKJ and KJI are the same. So, we can take IJK and JIK as the example for each to compare the result.

As shown above in a) question, $M_{IJK} = N^3/B + N^3 + N^2/B$

While for JIK, the result is shown below:

	A	B	C
J	N	N	N
I	N/B	N	N
K	N/B	N	1
	N^3/B^2	N^3	N^2

$M = N^3/B^2 + N^3 + N^2$

So, $M_{JIK} < M_{IJK.}$ JIK, IKJ, KJI will be better than IJK, JKI, KIJ.