

homework 3 - loop transformation

50 pts. – due date: Wed., Sept 26

For exercises 1 - 3, use the following code for square matrix-matrix multiplication:

```

I   for i = 0; i < N; i++
J   for j = 0; j < N; j++
K   for k = 0; k < N; k++
    C[ i ][ j ] = A[ i ][ k ] · B[ k ][ j ]

```

1. **[5 pts.]** Let $N = 256$, $C = 64K$, $\text{sizeof}(\text{element}) = 8$ bytes, $B = 128$, $S = 1$, LRU eviction. Perform an inner loop analysis.
2. **[5 pts.]** Let $N = 256$, $C = 64K$, $\text{sizeof}(\text{element}) = 8$ bytes, $B = 64$, $E = 4$, LRU eviction. Perform an inner loop analysis.
3. **[5 pts.]** Let $N = 256$, $C = 64K$, $\text{sizeof}(\text{element}) = 8$ bytes, $B = 32$, $E = 2$, LRU eviction. Perform an inner loop analysis.

For the following problems 4 - 7, refer to slides 18 - 19 of slide deck 4 – loop analysis:

4. **[5 pts.]** Perform a total miss analysis for loop nest IKJ.
5. **[5 pts.]** Perform a total miss analysis for loop nest KIJ.
6. **[5 pts.]** Perform a total miss analysis for loop nest JKI.
7. **[5 pts.]** Perform a total miss analysis for loop nest KJI.

For the following questions, assume contiguously allocated row major arrays.

8. **[10 pts.]** Given an LRU cache with parameters $C = 2048$, $E = 2$, $B = 16$ and assuming $|\text{element}| = 4$.

Let:

```

@a[1024] = AAAA0000
@b[1024] = AAAA8000
@c[1024] = AAAB0010

```

using the code segment:
 for i = 0 to 1023
 for j = 0 to 1023
 for k = 0 to 1023
 sum_prod += a[i] * b[j] + c[k]

sum_prod, i, j and k are in registers.

- a.) What is the access stride for each loop?.
- b.) What is the overall hit rate for each of a, b, and c?
- c.) What are the cache contents after the completion of the loop nest?

9. **[5 pts.]** Given an LRU cache with parameters $C = 8k$, $E = 512$, $B = 16$ and assuming $|\text{element}| = 4$.

Let:

```

@A[512,512] = AAAA0000
@B[512,512] = AAAA8000
@C[512,512] = AAAB0010

```

using the code segment:
 for i = 0 to 511
 for j = 0 to 511
 for k = 0 to 511
 C[i][j] += A[j][k] - B[k][i]

i, j and k are in registers.

- a.) Perform a total miss analysis.
- b.) Is there a better loop ordering for this problem? If so, state the preferred ordering. If not, why?