

CO322: DS & A Parallel Computing

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Why?

World is parallel!

Your phone has few cores in it!!

Can we make use of more than one processing element?

Depends on the algorithm

- ▶ For some algorithms parallel processes are useless
- ▶ For some others you can make use of them

Why?

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Depends on the algorithm

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Example algorithm: Bubble sort Java code

```
public void bubble_sort(int [] data) {  
    int i,j;  
    for(i=0; i < data.length; i++) {  
        for(j = data.length-1; j > i; j--) {  
            if(data[j] < data[j-1]) {  
                int tmp = data[j];  
                data[j] = data[j-1];  
                data[j-1] = tmp;  
            }  
        }  
    }  
}
```

Can you make this implementation parallel?

No. Every loop depends on the previous one(s)!

Example algorithm: Bubble sort Java code

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Example algorithm: Matrix multiplication

For two matrices A_{am} and B_{mb} , if $C = A \times B$ then

$$C_{ij} = \sum_{k=1}^m A_{ik} * B_{kj}$$

```
static int [][] multiply(int [][]A, int [][]B) {  
    /* implement me!  
    * What is/are the preconditions? */  
}
```

Example algorithm: Matrix multiplication Java code

```
static int [][] multiply(int [][]A, int [][]B) {  
  
    int ai = A.length, aj=A[0].length, bi=B.length,  
        bj=B[0].length;  
    int C[][] = new int [ai][bj];  
    int i, j, k, sum;  
    if(aj != bj) /* may be panic */ return C;  
    for(i=0; i < ai; i++) {  
        for(j=0; j < bj; j++) {  
            for(k=0, sum=0; k < aj; k++) sum += (A[i][k] *  
                B[k][j]);  
            C[i][j] = sum;  
        } /* for{i */ } /* for{j= */  
    return C;  
}
```

What is the run-time complexity? ($A_{a \times n}, B_{n \times b}$)

Can you make it parallel? Why?

Example algorithm: Odd-Even sort

Basic idea:

- ▶ Similar to bubble sort
- ▶ Can be implemented in parallel systems (you tell me why :))
- ▶ Compare all odd ones with adjacent element, repeat for even elements.
- ▶ Repeat until array is sorted.

Example algorithm: Odd-Even sort Java code

```
static void oddEvenSort(int [] data) {  
    boolean sorted = false;  
    while(!sorted) {  
        sorted = true;  
        for(int i=0; i< data.length-1; i +=2) {  
            if(data[i] > data[i+1]) {  
                swap(data, i, i+1);  
                sorted = false;  
            } /* if */ } /* for */  
  
        for(int i=1; i< data.length-1; i +=2) {  
            if(data[i] > data[i+1]) {  
                swap(data, i, i+1);  
                sorted = false;  
            } /* if */ } /* for */  
        }  
    }  
}
```

- ▶ What is the worst time complexity?
- ▶ What is the best time complexity?
- ▶ Can use run this parallel? Why?

Exercises

1. Out of bubble, insert, selection, quick and merge sort which ones can be implemented to run parallelly?
2. Can you implement matrix multiplication on parallel system?
 - 2.1 if so, what is the run time complexity on a system with 2 CUP cores for $A_{a \times n}, B_{n \times b}$?
 - 2.2 What if I have $m > n$ number of CPUs? will it help?

Take home point

- ▶ Parallel systems depends on algorithms
- ▶ Some algorithms can make use of parallel cores while other **cannot**
- ▶ Many cores does not make sense without good algorithms
- ▶ Increase the speed by *overlapping* executions