Activity : Extracting Parallelism (2D cases)

Extracting dependency from code is an almost automatic process. You need to choose a granularity. But once that is chosen, the entire analysis follows.

In the whole activity, you should express the metrics in complexity notation as a function of the parameters of the functions.

1 Coin Collection (from Midterm Spring 2018)

The Coin Collection problem is defined as follows:

Several coins are placed on an $n \times m$ board with at most one coin per cell of the board. A robot is initially located at the upper left cell of the board. The robot can only move to the right or down; it can not move up or left. When the robot visits a cell where a coin is located, it picks it up. At most, how many coins can the robot collect?

This problem can be solved by the following method:

```
void RobotCoin(int n, int m, //size of the board
               int C[n][m] //Is there a coin in (i,j)
               ) {

  int F[n][m]; //How many coins can be collected while on (i,j)

  F[0][0] = C[0][0];                                        Task A

  for (int k=1; k<m; ++k) {
    F[0][k] = F[0][k-1] + C[0][k];                          Task Bk
  }

  for (int i=1; i<n; ++i) {
    F[i][0] = F[i-1][0] + C[i][0];
    for (int j=1; j<m; ++j) {                               Task Ci
      F[i][j] = max (F[i-1][j], F[i][j-1]) + C[i][j];
    }
  }

  return F[n-1][m-1];
}
```

Question: What is the complexity of this function? O(m+nm)=O(nm)
Question: Extract the dependencies.
Question: What is the width? m+1
Question: What is the work? m+nm
Question: What is the critical path? What is its length? A->B1->...->Bm->C1->...->Cn; 1+m+n

2 Knapsack

The Knapsack problem aims at finding the best set of objects to pack in a bag. Often the following dynamic programming algorithm is used to solve the problem.

```
void knapsack (int n, int W, int value[], int weight[], int val[][]) {
  for (int a = 0; a<=W; ++a) {
    val[0][a] = 0;                          Task Aa
  }

  for (int i=1; i<=n; ++i) {
    for (int j=0; j<=W; ++j) {
      val[i][j] = val[i-1][j];              Task Bi
      if (weight[i-1] <= j) {
        val[i][j] = max (val[i-1][j], value[i-1]+val[i-1][j-weight[i-1]]);
      }
    }
  }
}
```

(You can assume weight is positive.)

Question: What is the complexity of this function? O(nW)
Question: Extract the dependencies.
Question: What is the width? W+1
Question: What is the work? W+1+n(W+1)
Question: What is the critical path? What is its length? A0->B10->…->Bn0->Cn0; n+2

3 Bubble Sort

The bubble sort algorithm can be written like this:

```
void bubblesort(int* A, int n) {
  for (int i=0; i<n; ++i) {
    for (int j=1; j<n; ++j) {
      if (A[j] < A[j-1]) {
        int temp = A[j];
        A[j] = A[j-1];
        A[j-1] = temp;
      }
    }
  }
}
```

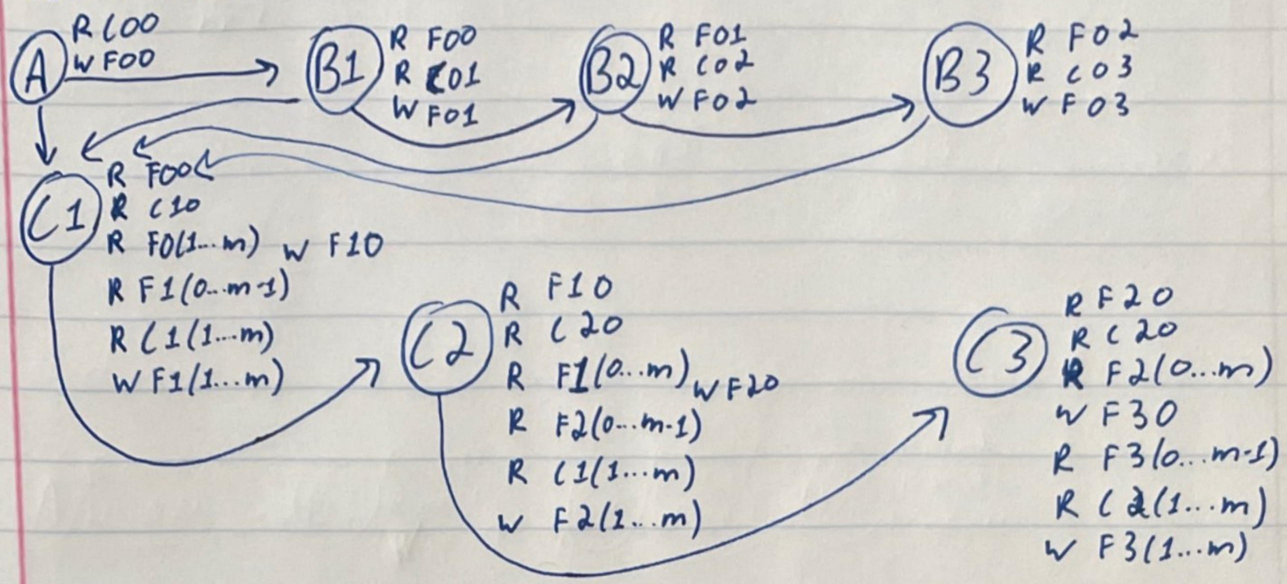
Task Aij

Task Aij

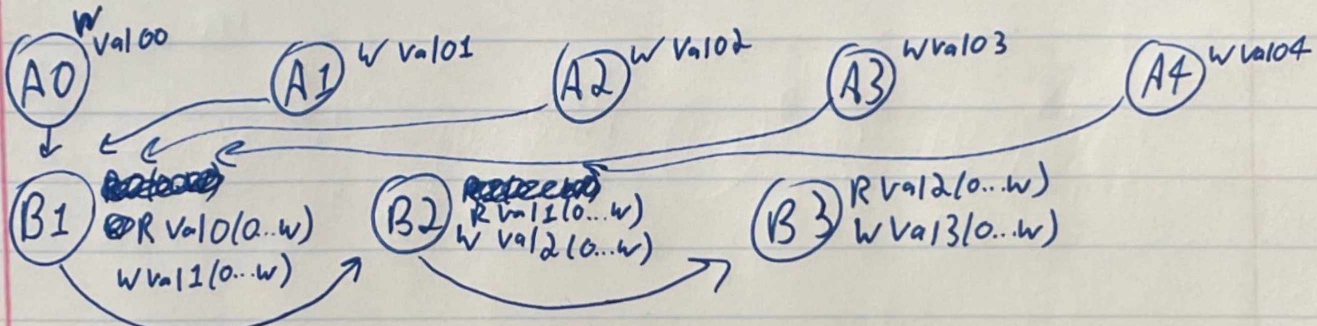
Question: What is the complexity of this function? A(n^2)
Question: Extract the dependencies.
Question: What is the width? 2
Question: What is the work? n^2
Question: What is the critical path? What is its length? A01->…->A0n->A1n-1->A1n->A2n-1->…->Ann-1->Ann; n^2

extracting 2, try 2

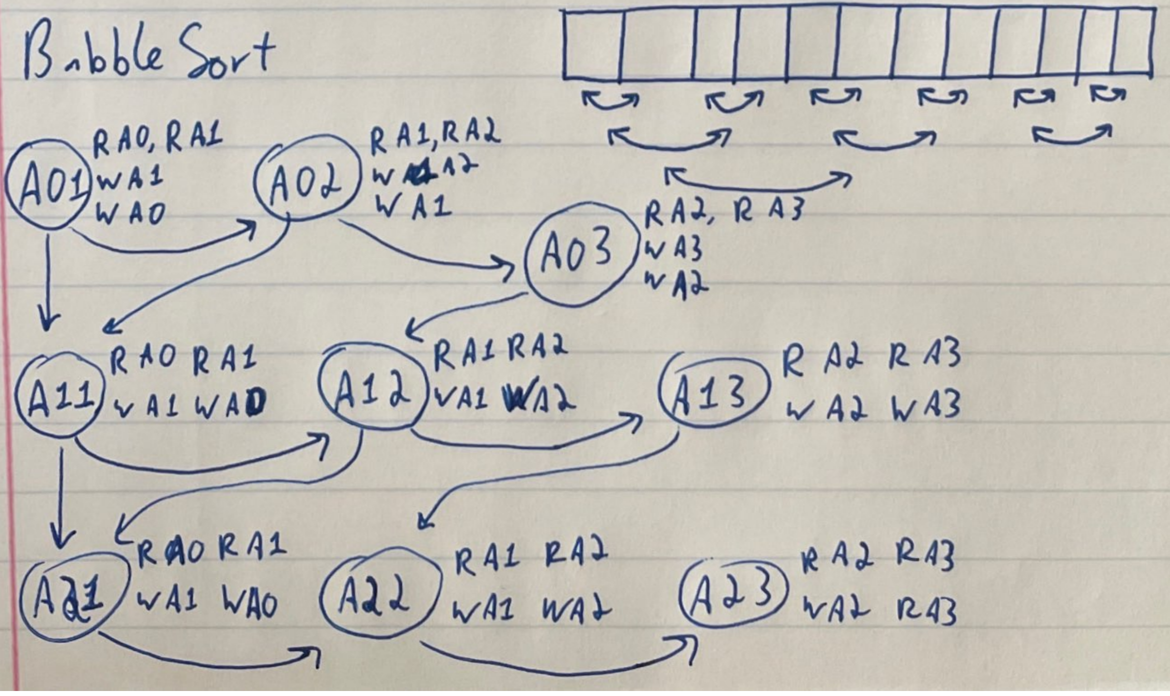
1 Coin collection



2 Knapsack



3 Bubble Sort


A01
RA0, RA1
WA1
WA0
A02
RA1, RA2
WA2
WA1
A03
RA2, RA3
WA3
WA2
A11
RA0 RA1
WA1 WA0
A12
RA1 RA2
WA1 WA2
A13
RA2 RA3
WA2 WA3
A21
RA0 RA1
WA1 WA0
A22
RA1 RA2
WA1 WA2
A23
RA2 RA3
WA2 RA3