ASSIGNMENT

ADA Lab

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Minimum Spanning Trees

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Contents

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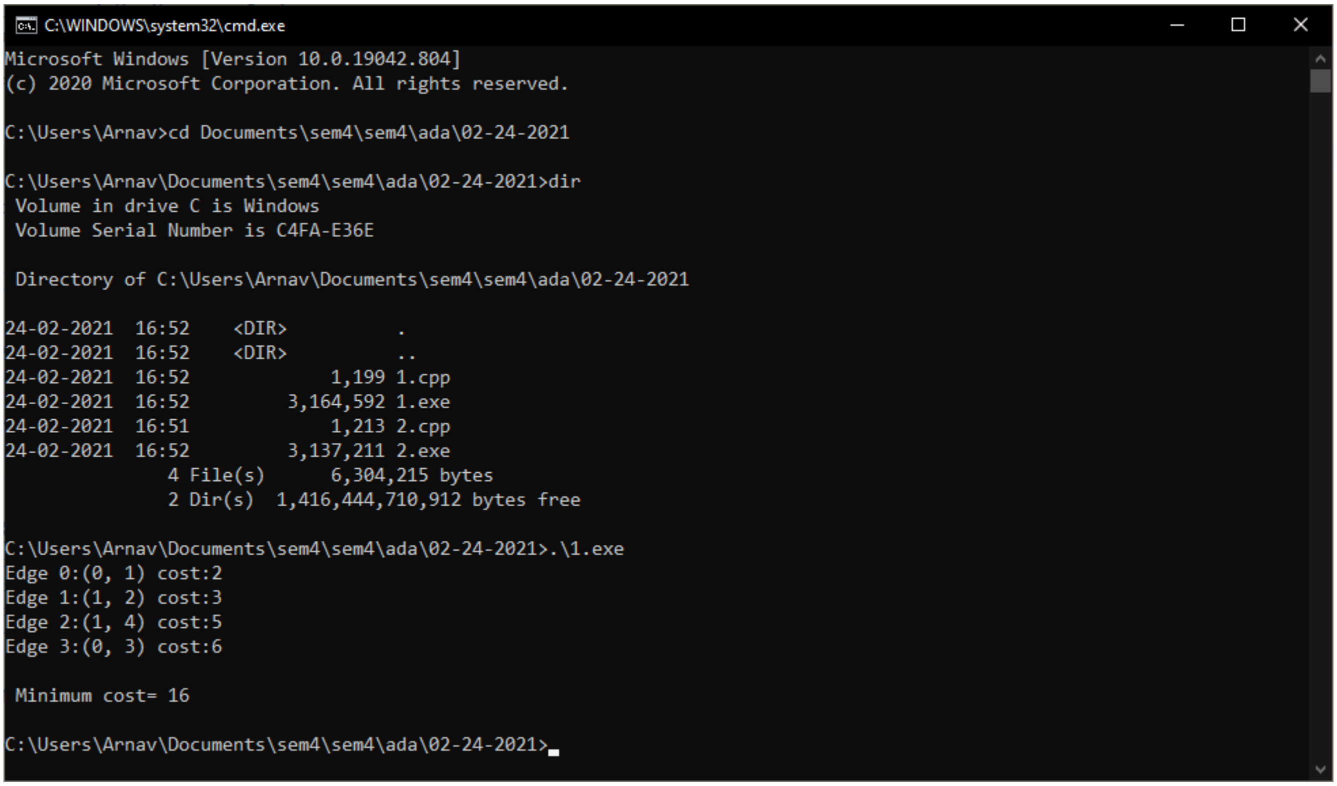
1. Kruskal’s Minimum Spanning Tree

Implement Kruskal’s Minimum Spanning Tree

1.1 Source Code

```
#include <bits/stdc++.h>
using namespace std;

#define V 5
int parent[V];

int find(int i)
{
    while (parent[i] != i)
        i = parent[i];
    return i;
}

void uni(int i, int j)
{
    int a = find(i);
    int b = find(j);
    parent[a] = b;
}

void kruskalMST(int cost[][V])
{
    int mincost = 0;


    for (int i = 0; i < V; i++)
        parent[i] = i;

    int edge_count = 0;
    while (edge_count < V - 1)
    {
        int min = INT_MAX, a = -1, b = -1;
        for (int i = 0; i < V; i++)
        {
            for (int j = 0; j < V; j++)
            {
                if (find(i) != find(j) && cost[i][j] < min)
                {
                    min = cost[i][j];
                    a = i;
                    b = j;
                }
            }
        }

        uni(a, b);
        printf("Edge %d:(%d, %d) cost:%d \n",
               edge_count++, a, b, min);
        mincost += min;
    }
    printf("\nMinimum cost= %d \n", mincost);
}


int main()
{
    /*
          2    3
      (0)--(1)--(2)
       |   / \   |
      6| 8/   \5 |7
       | /     \ |
      (3)-------(4)
            9          */
    int cost[][V] =
    {
        { INT_MAX, 2, INT_MAX, 6, INT_MAX },
        { 2, INT_MAX, 3, 8, 5 },
        { INT_MAX, 3, INT_MAX, INT_MAX, 7 },
        { 6, 8, INT_MAX, INT_MAX, 9 },
        { INT_MAX, 5, 7, 9, INT_MAX },
    };

    kruskalMST(cost);
    return 0;
}
```

1.2 Output



```
Microsoft Windows [Version 10.0.19042.804]
(c) 2020 Microsoft Corporation. All rights reserved.

C:\Users\Arnav>cd Documents\sem4\sem4\ada\02-24-2021

C:\Users\Arnav\Documents\sem4\sem4\ada\02-24-2021>dir
 Volume in drive C is Windows
 Volume Serial Number is C4FA-E36E

 Directory of C:\Users\Arnav\Documents\sem4\sem4\ada\02-24-2021

24-02-2021  16:52    <DIR>          .
24-02-2021  16:52    <DIR>          ..
24-02-2021  16:52             1,199 1.cpp
24-02-2021  16:52         3,164,592 1.exe
24-02-2021  16:51             1,213 2.cpp
24-02-2021  16:52         3,137,211 2.exe
               4 File(s)      6,304,215 bytes
               2 Dir(s)  1,416,444,710,912 bytes free

C:\Users\Arnav\Documents\sem4\sem4\ada\02-24-2021>.\1.exe
Edge 0:(0, 1) cost:2
Edge 1:(1, 2) cost:3
Edge 2:(1, 4) cost:5
Edge 3:(0, 3) cost:6

 Minimum cost= 16

C:\Users\Arnav\Documents\sem4\sem4\ada\02-24-2021>
```

Figure 1: Kruskal MST

1.3 Complexity Analysis

Time Complexity: *O*(V^2)
As we have to compare all the possible vertex pairs in the matrix, to find the minimum cost edges, the time complexity is *O*(V^2).
If the graph was implemented as an adjacency list, the complexity would be *O(ElogV)* as we will have to sort the edges and look for minimum cost edges.

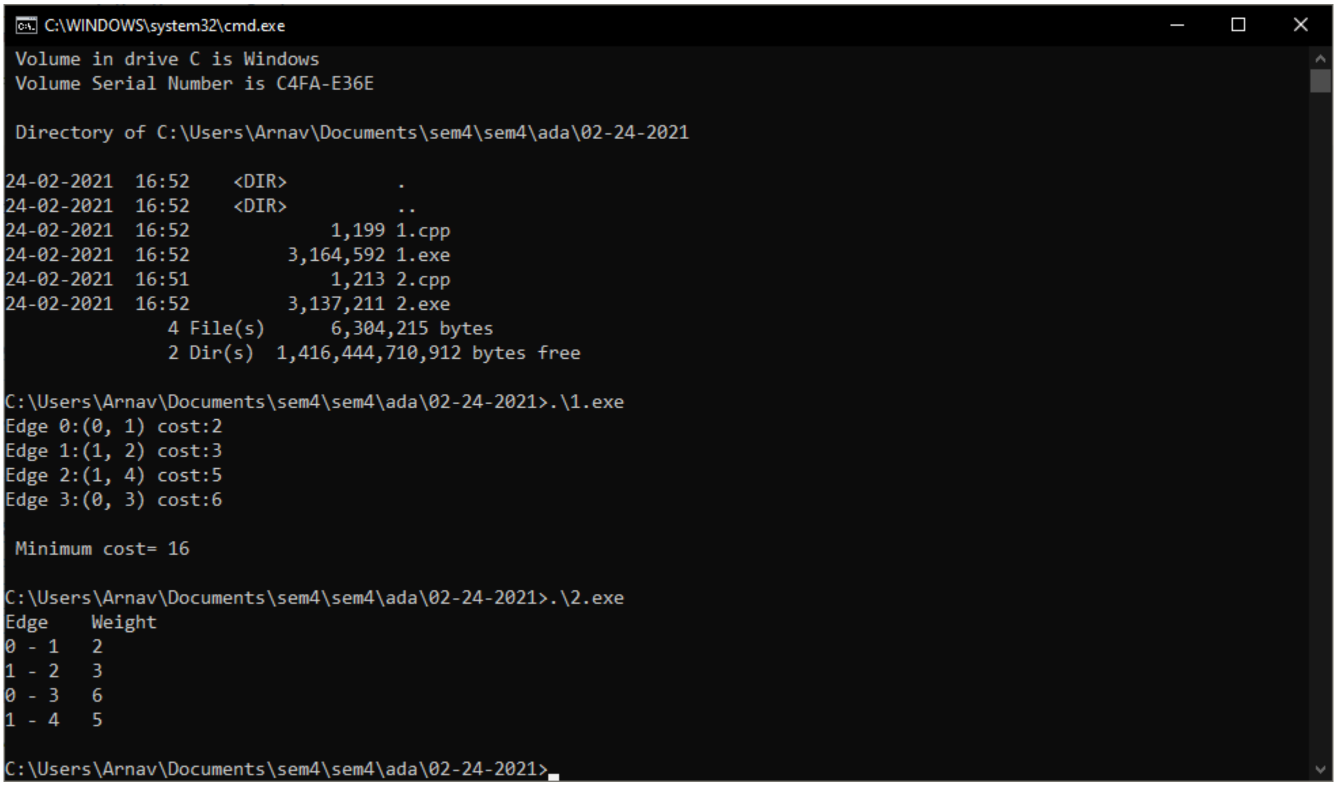
2. Prim's Minimum Spanning Tree

Implement Prim's Minimum Spanning Tree

2.1 Source Code

```
#include <bits/stdc++.h>
using namespace std;

#define V 5

int minKey(int key[], bool mstSet[])
{
    int min = INT_MAX, min_index;

    for (int v = 0; v < V; v++)
        if (mstSet[v] == false && key[v] < min)
            min = key[v], min_index = v;

    return min_index;
}

void printMST(int parent[], int graph[V][V])
{
    cout<<"Edge \tWeight\n";
    for (int i = 1; i < V; i++)
        cout<<parent[i]<<" - "<<i<<" \t"<<graph[i][parent[i]]<<" \n";
}

void primMST(int graph[V][V])
{
    int parent[V];
    int key[V];
    bool mstSet[V];
    for (int i = 0; i < V; i++)
        key[i] = INT_MAX, mstSet[i] = false;
    key[0] = 0;
    parent[0] = -1;
    for (int count = 0; count < V - 1; count++)
    {
        int u = minKey(key, mstSet);
        mstSet[u] = true;

        for (int v = 0; v < V; v++)
            if (graph[u][v] && mstSet[v] == false && graph[u][v] < key[v])
                parent[v] = u, key[v] = graph[u][v];
    }

    printMST(parent, graph);
}

int main()
{
    /*
        2    3
    (0)--(1)--(2)
    |    / \   |
    6| 8/   \5 |7
    | /      \ |
    (3)-------(4)
          9    */
    int graph[V][V] = { { 0, 2, 0, 6, 0 },
        { 2, 0, 3, 8, 5 },
        { 0, 3, 0, 0, 7 },
        { 6, 8, 0, 0, 9 },
        { 0, 5, 7, 9, 0 }
    };

    primMST(graph);

    return 0;
}
```

2.2 Output



```
 Volume in drive C is Windows
 Volume Serial Number is C4FA-E36E

 Directory of C:\Users\Arnav\Documents\sem4\sem4\ada\02-24-2021

24-02-2021  16:52    <DIR>          .
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24-02-2021  16:51             1,213 2.cpp
24-02-2021  16:52         3,137,211 2.exe
               4 File(s)      6,304,215 bytes
               2 Dir(s)  1,416,444,710,912 bytes free

C:\Users\Arnav\Documents\sem4\sem4\ada\02-24-2021>.\1.exe
Edge 0:(0, 1) cost:2
Edge 1:(1, 2) cost:3
Edge 2:(1, 4) cost:5
Edge 3:(0, 3) cost:6

 Minimum cost= 16

C:\Users\Arnav\Documents\sem4\sem4\ada\02-24-2021>.\2.exe
Edge    Weight
0 - 1   2
1 - 2   3
0 - 3   6
1 - 4   5

C:\Users\Arnav\Documents\sem4\sem4\ada\02-24-2021>
```

Figure 2: Prim MST

2.3 Complexity Analysis

Time Complexity: $O(V^2)$
As we have to compare all the possible vertex pairs in the matrix, to find the minimum cost edges, the time complexity is $O(V^2)$.
If the graph was implemented as an adjacency list, the complexity would be $O(ElogV)$ as we will have to sort the edges and look for minimum cost edges.