

# C++ Programming Work

## Graph Coloring Algorithm Program Code Description

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### 1. Pseudocode

- Begin Program
- First it reads the XML graph file to get the Vertices and Edges and sets those vertices and edges ID number serially.
- Detects and sets total color by counting total vertices and then it sets Edges to a Graph list to find the Vertices color.
- Process first vertices and first color ID using its default value.
- Process rest of the vertices to color it by using Greedy Coloring algorithm.
- Finally, shows the Vertex coloring result.
- End Program

### 2. Source Code

#### 2.1 Global Declarations

The following code are global declarations of headers, variables, and functions markers.

```
#include <iostream>
#include <fstream>
#include <string>
#include <vector>
#include <cstdlib>
#include <stdio.h>

using namespace std;

struct edge {
    string src;
    string dst;
};

// Function prototypes
string get_file(string fileName);
int get_vertices_edges(string xml, vector<string> &vertices, vector<edge> &edges);
int get_vertice_id(string vertice, vector<string> vertices);
string get_vertice_Name(size_t id, vector<string> vertices);
void greedyColoring(int maxnum, vector<int> &color, vector<vector<int>> graph);
```

#### 2.2 Main

The following code is the main function for the entry point of the program.

The code starts the program and reads the XML file to process Greedy Color Graph.

```
int main()
{
    int n = 0;
    int e = 0;
    string fileName = "greedy_color_graph.xml";
    vector<string> vertices;
    vector<edge> edges;
    vector<vector<int>> graph;
    vector<int> color;
    string text = {};
    int nReply = 0;

    text = get_file(fileName);
    if (text == "") goto CANCEL;

    nReply = get_vertices_edges(text, vertices, edges);
    if (nReply == -1) goto CANCEL;

    cout << "Total Number of Vertices: " << vertices.size() << endl;
    cout << "Total Number of Edges: " << edges.size() << endl;

    if (vertices.size() < 2) { cout << "Vertices must be more than one." << endl; goto CANCEL; }

    if (edges.size() < 1) { cout << "Edges cannot be zero." << endl; goto CANCEL; }

    n = vertices.size();
    e = edges.size();
    graph.resize(n);
    color.resize(n);

    for (int i = 0; i < e; i++)
    {
        int x = get_vertice_id(edges[i].src, vertices);
        if (x == -1) { cout << "id not found of vertice " << edges[i].src << endl; goto
CANCEL; }

        int y = get_vertice_id(edges[i].dst, vertices);
        if (x == -1) { cout << "id not found of vertice " << edges[i].dst << endl; goto
CANCEL; }

        graph[x].push back(y);
        graph[y].push_back(x);
    }

    for (size_t i = 0; i < graph.size(); i++)
    {
        for (size_t j = 0; j < graph[i].size(); j++)
        {
            cout << "Vertex " << get_vertice_Name(i,vertices) << " or " << i << " is
connected with " << "Vertex " << get_vertice_Name(graph[i][j],vertices)
<< " or " << graph[i][j] << endl;
        }
    }

    greedyColoring(n, color, graph);

    for (int i = 0; i<n; i++)
    {
        cout << "Vertex " << get_vertice_Name(i,vertices) << " is coloured " << color[i] +
1 << "\n";
    }
CANCEL:
    system("PAUSE");
    return 0;
}
```

## 2.3 Greedy Coloring Process

The following code is for Greedy Coloring process.

It uses the minimum color for coloring the graph vertices.

```
void greedyColoring(int maxnum, vector<int> &color, vector<vector<int>> graph)
{
    int i = 0;
    size_t j = 0;
    int n = maxnum;
    bool* unused;
    unused = new bool[n];

    color[0] = 0;
    for (i = 1; i<n; i++)
        color[i] = -1;

    for (i = 0; i<n; i++)
        unused[i] = 0;

    for (i = 1; i < n; i++)
    {
        for (j = 0; j<graph[i].size(); j++)
            if (color[graph[i][j]] != -1)
                unused[color[graph[i][j]]] = true;

        int cr;
        for (cr = 0; cr<n; cr++)
            if (unused[cr] == false)
                break;

        color[i] = cr;

        for (j = 0; j<graph[i].size(); j++)
            if (color[graph[i][j]] != -1)
                unused[color[graph[i][j]]] = false;
    }
}
```

## 2.4 Vertex ID

The following code retrieves vertices ID from vertices list.

```
int get_vertex_id(string vertice, vector <string> vertices){
    for (size_t i = 0; i < vertices.size(); i++)
    {
        if (vertices[i] == vertice) return i;
    }
    return -1;
}
```

## 2.5 Vertex Name

The following code retrieves the vertices Name from vertices list.

```
string get_vertex_Name(size_t id, vector <string> vertices) {
    if (id < vertices.size()) return vertices[id];
    return "";
}
```

## 2.6 Vertex and Edge List

The following code retrieves vertices and edges list from XML text file.

```
int get_vertices_edges(string xml, vector<string> &vertices, vector<edge> &edges) {
    string tagGraph = "<graph>";
    string tagGraphEnd = "</graph>";
    string tagNodes = "<nodes>";
    string tagNodesEnd = "</nodes>";
    string tagNode = "<node>";
    string Node = {};
    string Edge = {};
    string tagEdges = "<edges>";
    string tagEdgesEnd = "</edges>";
    string tagEdge = "<edge>";
    string tagEnd = ">";
    string atbName = "name=";
    string atbSrc = "src=";
    string atbDst = "dst=";
    string Src = {};
    string Dst = {};
    size_t nStart = 0;
    size_t nEnd = 0;
    size_t nOffset = 0;
    bool isValid = false;

    // scan for valid graph xml node
    isValid = false;
    nStart = xml.find(tagGraph);
    if (nStart != string::npos)
    {
        nStart = xml.find(tagGraphEnd, tagGraph.length());
        if (nStart != string::npos) isValid = true;
    }
    if (isValid == false)
    {
        cout << "Invalid graph xml node found." << endl;
        return -1;
    }

    // scan for valid nodes xml node
    isValid = false;
    nStart = xml.find(tagNodes);
    if (nStart != string::npos)
    {
        nStart = xml.find(tagNodesEnd, tagNodes.length());
        if (nStart != string::npos) isValid = true;
    }
    if (isValid == false)
    {
        cout << "Invalid nodes xml node found." << endl;
        return -1;
    }

    // scan for valid edges xml node
    isValid = false;
    nStart = xml.find(tagEdges);
    if (nStart != string::npos)
    {
        nStart = xml.find(tagEdgesEnd, tagEdges.length());
        if (nStart != string::npos) isValid = true;
    }
    if (isValid == false)
    {
        cout << "Invalid edges xml node found." << endl;
        return -1;
    }

    // find Nodes
    nStart = xml.find(tagGraph);
    if (nStart != string::npos)
    {
        nOffset = tagGraph.length();
        nStart = xml.find(tagNodes, nOffset);
        if (nStart != string::npos)
```

```

{
    nOffset = nStart + tagNodes.length();
    nStart = xml.find(tagNode, nOffset);
    while (nStart != string::npos)
    {
        nOffset = nStart + tagNode.length();
        nStart = xml.find(atbName, nOffset);
        if (nStart != string::npos)
        {
            nOffset = nStart + atbName.length();
            nEnd = xml.find(tagEnd, nOffset);
            if (nEnd != string::npos)
            {
                Node = xml.substr(nOffset, nEnd - nOffset);
                Node = Node.substr(1, Node.length() - 2);
                vertices.push_back(Node);
                cout << "Vertex " << Node << " is " <<
                    get_vertice_id(Node, vertices) << endl;
                nOffset = nEnd + tagEnd.length();
                nStart = xml.find(tagNode, nOffset);
            }
            else
            {
                cout << "Invalid end of node." << endl;
                return -1;
            }
        }
        else
        {
            cout << "Attribute 'Name' not found." << endl;
            return -1;
        }
    }
}

// find Edges
nStart = xml.find(tagGraph);
if (nStart != string::npos)
{
    nOffset = tagGraph.length();
    nStart = xml.find(tagEdges, nOffset);
    if (nStart != string::npos)
    {
        nOffset = nStart + tagEdges.length();
        nStart = xml.find(tagEdge, nOffset);
        while (nStart != string::npos)
        {
            nOffset = nStart + tagEdge.length();
            nStart = xml.find(atbSrc, nOffset);
            if (nStart != string::npos)
            {
                nOffset = nStart + atbSrc.length();
                nEnd = xml.find(atbDst, nOffset);
                if (nEnd != string::npos)
                {
                    Src = xml.substr(nOffset, nEnd - nOffset);
                    Src = Src.substr(1, Src.length() - 3);
                    //cout << "edge source " << Src << endl;
                    nStart = nEnd;
                    nOffset = nEnd + atbDst.length();
                    nEnd = xml.find(tagEnd, nOffset);
                    if (nEnd != string::npos)
                    {
                        Dst = xml.substr(nOffset, nEnd - nOffset);
                        Dst = Dst.substr(1, Dst.length() - 3);
                        //cout << "edge destination " << Dst << endl;
                    }
                    else
                    {
                        cout << "Invalid end of edge node." << endl;
                        return -1;
                    }
                }
                edge e;
                e.src = Src; e.dst = Dst;
                edges.push_back(e);
                cout << "Edge " << Src << "--" << Dst << endl;
            }
        }
    }
}

```

```

        nOffset = nEnd + tagEnd.length();
        nStart = xml.find(tagEdge, nOffset);
    }
    else
    {
        cout << "Invalid end of attribute 'Dst'." << endl;
        return -1;
    }
}
else
{
    cout << "Attribute 'Src' not found." << endl;
    return -1;
}
}
}
return 0;
}

```

## 2.6 XML Data

The following code read all XML text from the XML file.

```

string get_file(string fileName)
{
    string buffer;
    char c;

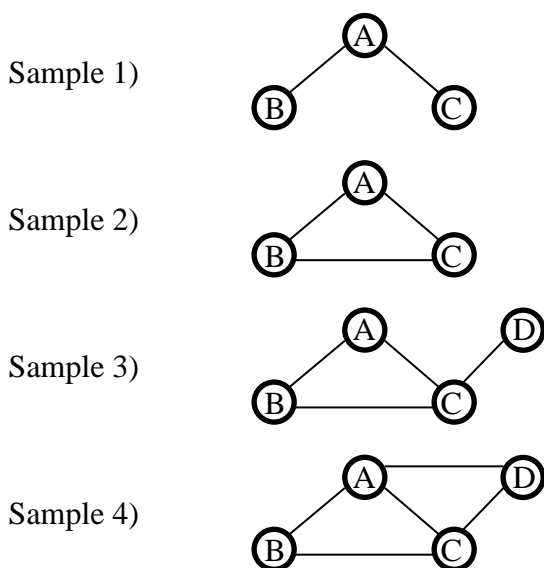
    ifstream in(fileName);    if (!in) { cout << fileName << " not found \n";
}
    while (in.get(c)) buffer += c;
    in.close();

    return buffer;
}

```

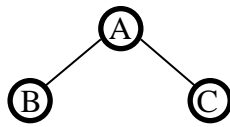
## 3. Execution of Source Code

See execution screenshots using the following sample graphs:



### 3.1 Execution #1

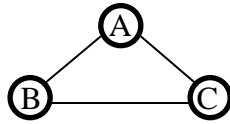
Sample 1)



```
main.cpp | greedy_color_grap...  
1 <graph>  
2   <nodes>  
3     <node name="A"/>  
4     <node name="B"/>  
5     <node name="C"/>  
6   </nodes>  
7   <edges>  
8     <edge src="A" dst="B" />  
9     <edge src="A" dst="C" />  
10  </edges>  
11 </graph>  
12  
  
Vertex A is 0  
Vertex B is 1  
Vertex C is 2  
Edge A--B  
Edge A--C  
Total Number of Vertices: 3  
Total Number of Edges: 2  
Vertex A or 0 is connected with Vertex B or 1  
Vertex A or 0 is connected with Vertex C or 2  
Vertex B or 1 is connected with Vertex A or 0  
Vertex C or 2 is connected with Vertex A or 0  
Vertex A is coloured 1  
Vertex B is coloured 2  
Vertex C is coloured 2  
sh: 1: PAUSE: not found  
  
...Program finished with exit code 0  
Press ENTER to exit console.
```

## 3.2 Execution #2

Sample 2)



```
main.cpp  greedy_color_grap... :
1 <graph>
2   <nodes>
3       <node name="A" />
4       <node name="B" />
5       <node name="C" />
6   </nodes>
7   <edges>
8       <edge src="A" dst="B" />
9       <edge src="A" dst="C" />
10      <edge src="B" dst="C" />
11  </edges>
12 </graph>

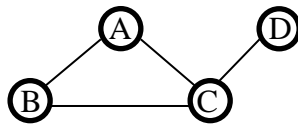
Vertex A is 0
Vertex B is 1
Vertex C is 2
Edge A--B
Edge A--C
Edge B--C
Total Number of Vertices: 3
Total Number of Edges: 3
Vertex A or 0 is connected with Vertex B or 1
Vertex A or 0 is connected with Vertex C or 2
Vertex B or 1 is connected with Vertex A or 0
Vertex B or 1 is connected with Vertex C or 2
Vertex C or 2 is connected with Vertex A or 0
Vertex C or 2 is connected with Vertex B or 1
Vertex A is coloured 1
Vertex B is coloured 2
Vertex C is coloured 3
sh: 1: PAUSE: not found

...Program finished with exit code 0
Press ENTER to exit console.
```



### 3.3 Execution #3

Sample 3)



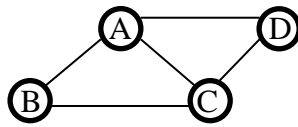
```
main.cpp  greedy_color_grap...  :
1  <graph>
2  <nodes>
3      <node name="A"/>
4      <node name="B"/>
5      <node name="C"/>
6      <node name="D"/>
7  </nodes>
8  <edges>
9      <edge src="A" dst="B" />
10     <edge src="A" dst="C" />
11     <edge src="B" dst="C" />
12     <edge src="C" dst="D" />
13 </edges>
14 </graph>

Vertex A is 0
Vertex B is 1
Vertex C is 2
Vertex D is 3
Edge A--B
Edge A--C
Edge B--C
Edge C--D
Total Number of Vertices: 4
Total Number of Edges: 4
Vertex A or 0 is connected with Vertex B or 1
Vertex A or 0 is connected with Vertex C or 2
Vertex B or 1 is connected with Vertex A or 0
Vertex B or 1 is connected with Vertex C or 2
Vertex C or 2 is connected with Vertex A or 0
Vertex C or 2 is connected with Vertex B or 1
Vertex C or 2 is connected with Vertex D or 3
Vertex D or 3 is connected with Vertex C or 2
Vertex A is coloured 1
Vertex B is coloured 2
Vertex C is coloured 3
Vertex D is coloured 1
sh: 1: PAUSE: not found

...Program finished with exit code 0
Press ENTER to exit console.
```

### 3.4 Execution #4

Sample 4)



```
main.cpp  greedy_color_gra...  
1 <graph>  
2   <nodes>  
3       <node name="A"/>  
4       <node name="B"/>  
5       <node name="C"/>  
6       <node name="D"/>  
7   </nodes>  
8   <edges>  
9       <edge src="A" dst="B" />  
10      <edge src="A" dst="C" />  
11      <edge src="B" dst="C" />  
12      <edge src="C" dst="D" />  
13      <edge src="D" dst="A" />  
14   </edges>  
15 </graph>  
  
Vertex A is 0  
Vertex B is 1  
Vertex C is 2  
Vertex D is 3  
Edge A--B  
Edge A--C  
Edge B--C  
Edge C--D  
Edge D--A  
Total Number of Vertices: 4  
Total Number of Edges: 5  
Vertex A or 0 is connected with Vertex B or 1  
Vertex A or 0 is connected with Vertex C or 2  
Vertex A or 0 is connected with Vertex D or 3  
Vertex B or 1 is connected with Vertex A or 0  
Vertex B or 1 is connected with Vertex C or 2  
Vertex C or 2 is connected with Vertex A or 0  
Vertex C or 2 is connected with Vertex B or 1  
Vertex C or 2 is connected with Vertex D or 3  
Vertex D or 3 is connected with Vertex C or 2  
Vertex D or 3 is connected with Vertex A or 0  
Vertex A is coloured 1  
Vertex B is coloured 2  
Vertex C is coloured 3  
Vertex D is coloured 2  
sh: 1: PAUSE: not found  
  
...Program finished with exit code 0  
Press ENTER to exit console.
```

## References

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