Project 5

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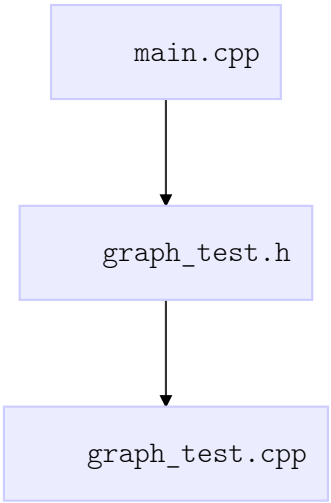
File list



Memory leakage check

```
==4179== HEAP SUMMARY:
==4179==     in use at exit: 195,584 bytes in 7 blocks
==4179==   total heap usage: 77 allocs, 70 frees, 198,848 bytes allocated
==4179==
==4179== LEAK SUMMARY:
==4179==    definitely lost: 0 bytes in 0 blocks
==4179==    indirectly lost: 0 bytes in 0 blocks
==4179==      possibly lost: 0 bytes in 0 blocks
==4179==    still reachable: 195,584 bytes in 7 blocks
==4179==         suppressed: 0 bytes in 0 blocks
```

JOJ passed

✓ Accepted

```
prepare (1/3):
finished

make (2/3):
g++ -std=c++14 -O3 -Wall -g -c main.cpp
g++ -std=c++14 -O3 -Wall -g -c graph_test.cpp
g++ -std=c++14 -O3 -Wall -g -o main main.o graph_test.o
finished

clean (3/3):
finished

all task finished, build successfully
```

#	状态 ⓘ	耗时	内存占用
#1	✓ Accepted	2ms	376.0 KiB
#2	✓ Accepted	2ms	376.0 KiB
#3	✓ Accepted	2ms	312.0 KiB
#4	✓ Accepted	2ms	436.0 KiB
#5	✓ Accepted	2ms	544.0 KiB

Appendix

1. Main.cpp

```cpp
#include <iostream>
#include "graph_test.h"

using namespace std;

int main() {
    ios::sync_with_stdio(false);
    cin.tie(0);
```

```
    int node_num;
    cin >> node_num;
    Graph graph = Graph();
    for (int i = 0; i < node_num; i++) {
        graph.node_vec.push_back(new Node);
    }
    while (!cin.eof()) {
        int node_start_code, node_end_code;
        Edge edge_temp;
        cin >> node_start_code;
        if (cin.eof()) break;
        cin >> node_end_code >> edge_temp.weight;
        set_graph(graph, edge_temp, node_start_code, node_end_code);
    }
    tell_DAG(graph);
    calculate_MST(graph);
    // to avoid memory leak, we need to delete nodes.
    for (int i = 0; i < node_num; i++) {
        delete graph.node_vec.back();
        graph.node_vec.pop_back();
    }
    return 0;
}
```

2. graph_test.h

```
#ifndef GRAPH_TEST_H
#define GRAPH_TEST_H
#define INFINITY INT_MAX

#include <iostream>
#include <sstream>
#include <algorithm>
#include <climits>
#include <list>
#include <set>
#include <map>
#include <deque>
#include <vector>

using namespace std;
struct Node;
struct Edge;

struct Node {
    int degree = 0;
    int order_num = 0;
    int smallest_weight = 0;
    list<Edge> adjacent;
```

```
    list<Edge> undirected;
};

struct Edge {
    int weight = 0;
    Node *distinction;
};

struct Edge_comp {
    bool operator()(const Node *a, const Node *b) const {
        return b->order_num > a->order_num;
    }
};

struct Graph {
    vector<Node *> node_vec;
    multimap<Node *, Edge, Edge_comp> edge_map;
    multimap<Node *, Edge, Edge_comp> undirected_edge_map;
};

struct smallest_weight_comp {
    bool operator()(const Node *a, const Node *b) const {
        return b->smallest_weight > a->smallest_weight;
    }
};

bool degree_comp(const Node *a, const Node *b);

bool order_comp(const Node *a, const Node *b);

void set_graph(Graph &graph, Edge &edge_temp, int node_start_code, int
node_end_code);

void tell_DAG(Graph graph);

void calculate_MST(Graph graph);

#endif
```

3. graph_test.cpp

```
#include <iostream>

#include "graph_test.h"

using namespace std;

bool degree_comp(const Node *a, const Node *b) {
    return a->degree < b->degree;
```

```
}

bool order_comp(const Node *a, const Node *b) {
    return a->order_num < b->order_num;
}

static void printDAG(bool isDAG) {
    if (!isDAG) {
        cout << "The graph is not a DAG" << endl;
    } else {
        cout << "The graph is a DAG" << endl;
    }
}

static void printMST(bool MST_exist, int weight_all){
    if (!MST_exist) {
        cout << "The total weight of MST is " << weight_all << endl;
    } else {
        cout << "No MST exists!" << endl;
    }
}

void set_graph(Graph &graph, Edge &edge_temp, int node_start_code, int
node_end_code){
    Edge edge_undirected_I;
    Edge edge_undirected_II;
    edge_undirected_I.weight = edge_undirected_II.weight = edge_temp.weight;
    graph.node_vec[node_start_code]->order_num = node_start_code;
    graph.node_vec[node_end_code]->order_num = node_end_code;
    graph.node_vec[node_end_code]->degree++;
    graph.node_vec[node_end_code]->smallest_weight = 0;
    graph.node_vec[node_start_code]->smallest_weight =
graph.node_vec[node_end_code]->smallest_weight;
    edge_temp.distinction = graph.node_vec[node_end_code];
    edge_undirected_I.distinction = graph.node_vec[node_end_code];
    edge_undirected_II.distinction = graph.node_vec[node_start_code];
    graph.node_vec[node_start_code]->adjacent.push_back(edge_temp);
    graph.node_vec[node_start_code]->undirected.push_back(edge_undirected_I);
    graph.node_vec[node_end_code]->undirected.push_back(edge_undirected_II);
    graph.edge_map.insert(make_pair(graph.node_vec[node_start_code],
edge_temp));
    graph.undirected_edge_map.insert(make_pair(graph.node_vec[node_start_code],
edge_undirected_I));
    graph.undirected_edge_map.insert(make_pair(graph.node_vec[node_end_code],
edge_undirected_II));
}

void tell_DAG(Graph graph) {
    std::sort(graph.node_vec.begin(), graph.node_vec.end(), degree_comp);
```

```
53      vector<Node *> S;
54      for (auto &it : graph.node_vec) {
55          if (it->degree == 0) {
56              S.push_back(it);
57          } else {
58              break;
59          }
60      }
61      std::sort(graph.node_vec.begin(), graph.node_vec.end(), order_comp);
62      while (!S.empty()) {
63          auto n = *S.begin();
64          S.erase(S.begin());
65          for (auto it = n->adjacent.begin(); it != n->adjacent.end(); ++it) {
66              auto m = it->distinction;
67              for (auto tt = graph.edge_map.begin(); tt != graph.edge_map.end();
    ++tt) {
68                  if (tt->first == n && tt->second.distinction == m) {
69                      graph.edge_map.erase(tt);
70                      break;
71                  }
72              }
73              m->degree--;
74              if (!m->degree) {
75                  S.push_back(m);
76              }
77          }
78      }
79      printDAG(graph.edge_map.empty());
80  }
81
82  void calculate_MST(Graph graph) {
83      multiset<Node *, smallest_weight_comp> connected_nodes;
84      multiset<Node *, smallest_weight_comp> disperse_nodes;
85      std::sort(graph.node_vec.begin(),
86                graph.node_vec.end(),
87                order_comp);
88      auto size = graph.node_vec.size();
89      for (unsigned int i = 0; i < size; ++i) {
90          graph.node_vec[i]->smallest_weight = INT_MAX;
91      }
92      graph.node_vec[0]->smallest_weight = 0;
93      connected_nodes.clear();
94      for (unsigned int i = 0; i < size; ++i) {
95          disperse_nodes.insert(graph.node_vec[i]);
96      }
97      int weight_all = 0;
98      bool MST_exist = false;
99      while (!disperse_nodes.empty()) {
100         auto v = *disperse_nodes.begin();
```

```
        if (v->smallest_weight == INT_MAX) {
            MST_exist = true;
            break;
        }
        weight_all += v->smallest_weight;
        connected_nodes.insert(v);
        disperse_nodes.erase(disperse_nodes.begin());
        for (auto undirected_list_it = v->undirected.begin(); undirected_list_it
!= v->undirected.end();
             ++undirected_list_it) {
            auto u = undirected_list_it->distinction;
            for (auto disperse_nodes_it = disperse_nodes.begin();
disperse_nodes_it != disperse_nodes.end();
                 ++disperse_nodes_it) {
                if ((*disperse_nodes_it) == u) {
                    auto it_u = disperse_nodes_it;
                    int current_weight = 0;
                    for (auto it = graph.undirected_edge_map.begin(); it !=
graph.undirected_edge_map.end();) {
                        if (it->second.distinction == u && it->first == v) {
                            current_weight = it->second.weight;
                            it = graph.undirected_edge_map.erase(it);
                            break;
                        } else {
                            it++;
                        }
                    }
                    if (u->smallest_weight > current_weight) {
                        u->smallest_weight = current_weight;
                    }
                    for (auto it = graph.undirected_edge_map.begin(); it !=
graph.undirected_edge_map.end();) {
                        if (it->first == u && it->second.distinction == v) {
                            it = graph.undirected_edge_map.erase(it);
                            break;
                        } else {
                            it++;
                        }
                    }
                    for (auto it = u->undirected.begin(); it != u-
>undirected.end();) {
                        if (it->distinction == v) {
                            it = u->undirected.erase(it);
                            break;
                        } else {
                            it++;
                        }
                    }
                    disperse_nodes.erase(it_u);
```

```
                    disperse_nodes.insert(u);
                    break;
                }
            }
        }
    }
    printMST(MST_exist, weight_all);
}
```