Project documentation

Data structure course design

——Course scheduling software

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1. Analysis

1.1 Project background analysis

Courses are arranged for each major at the university. Assume that any major has a fixed period of study. Each academic year contains two semesters. The courses offered by each major are determined, and the schedule of the courses must meet the prerequisite relationship. The prerequisites for each course are determined. Each course takes exactly one semester, assuming that there are five lessons each morning and afternoon. It is on this premise to design a teaching plan preparation process.

1.2 Project function requirements

1. The input data includes: the number of courses offered per semester (the sum of the number of courses offered per semester must be equal to the total number of courses), the course number, the course name, the number of weekly hours, the designated start semester, the prerequisites If the designated start semester is 0, it means that there is a computer to designate the start semester.
2. If the input data is not reasonable, such as the number of courses offered each semester and the total number of courses are not equal, appropriate prompt information should be displayed.
3. Store the input data in a text file and load it into the computer.
4. Use text files to store the lesson schedules for each semester.

Schedule requirements and course information:

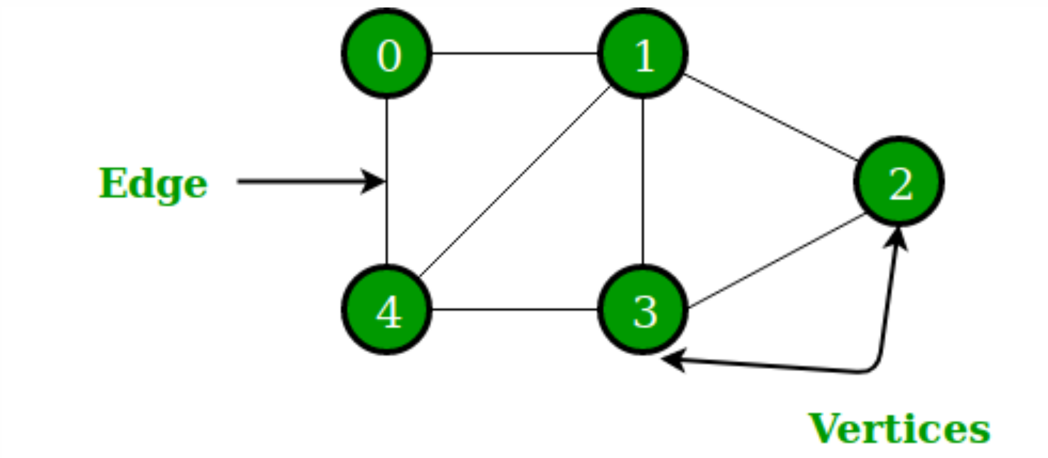
Assume that there are classes from Monday to Friday. There are 10 lessons per day. The first major session is 1-2. The second major session is 3-5. The third major session is 6-7. The 4 major sections are 8-10 lessons. When arranging lessons, if there are 3 lessons in a course, 3 consecutive lessons will be given priority; if 3 consecutive lessons cannot be arranged, then 2 lessons will be given consecutively. Reschedule a single lesson; if a course needs to be scheduled for two days, for better teaching results, it is best not to arrange for two consecutive days, such as giving priority to two lessons apart, and set weekday to indicate that the current schedule Working day, the working day of the next scheduled class is:

$weekday = (weekday + 2 - 5)?(Weekday + 2 - 5) : (weekday + 2);$

2. Design

2.1 Data structure design

The schedual is a typical graph data structure,whiche consists of a finite set of vertices(or nodes) and set of Edges which connect a pair of nodes.The above sentence is the definition of the graph,A Graph is a non-linear data structure consisting of nodes and edges. The nodes are sometimes also referred to as vertices and the edges are lines or arcs that connect any two nodes in the graph.



In the above Graph, the set of vertices $V = 0, 1, 2, 3, 4$ and the set of edges$E = 01, 12, 23, 34, 04, 14, 13$.

Graphs are used to solve many real-life problems. Graphs are used to represent networks. The networks may include paths in a city or telephone network or circuit network. Graphs are also used in social networks like linkedIn, Facebook. For example, in Facebook, each person is represented with a vertex(or node). Each node is a structure and contains information like person id, name, gender, locale etc.

The "create grid vertex" function of this question corresponds to the point of creating a graph structure and determining the size of the graph. The corresponding operation of "adding the edge of the grid" is to construct the edges of the graph. For the convenience of coding this question and the subsequent implementation of the minimum spanning tree, this question uses a storage structure called adjacency matrix to store graph structure.

Graph is a data structure that consists of following two components: **1.** A finite set of vertices also called as nodes. **2.** A finite set of ordered pair of the form (u, v) called as edge. The pair is ordered because (u, v) is not same as (v, u) in case of a directed graph(di-graph). The pair of the form (u, v) indicates that there is an edge from vertex u to vertex v. The edges may contain weight/value/cost.

Now let's analyze the five-vertex graph in the previous figure :

Following two are the most commonly used representations of a graph.

1. Adjacency Matrix
2. Adjacency List

There are other representations also like, Incidence Matrix and Incidence List. The choice of the graph representation is situation specific. It totally depends on the type of operations to be performed and ease of use.

Adjacency Matrix: Adjacency Matrix is a 2D array of size $V \times V$ where V is the number of vertices in a graph. Let the 2D array be $adj[][]$, a slot $adj[i][j] = 1$ indicates that there is an edge from vertex i to vertex j. Adjacency matrix for undirected graph is always symmetric. Adjacency Matrix is also used to represent weighted graphs. If $adj[i][j] = w$, then there is an edge from vertex i to vertex j with weight w.

The adjacency matrix for the above example graph is:

$$
\begin{array}{c|ccccc}
 & 0 & 1 & 2 & 3 & 4 \\
\hline
0 & 0 & 1 & 0 & 0 & 1 \\
1 & 1 & 0 & 1 & 1 & 1 \\
2 & 0 & 1 & 0 & 1 & 0 \\
3 & 0 & 1 & 1 & 0 & 1 \\
4 & 1 & 1 & 0 & 1 & 0
\end{array}
$$

> *Pros:* Representation is easier to implement and follow. Removing an edge takes $O(1)$ time. Queries like whether there is an edge from vertex 'u' to vertex 'v' are efficient and can be done $O(1)$.
>
> *Cons:* Consumes more space $O(V^2)$. Even if the graph is sparse(contains less number of edges), it consumes the same space. Adding a vertex is $O(V^2)$ time.

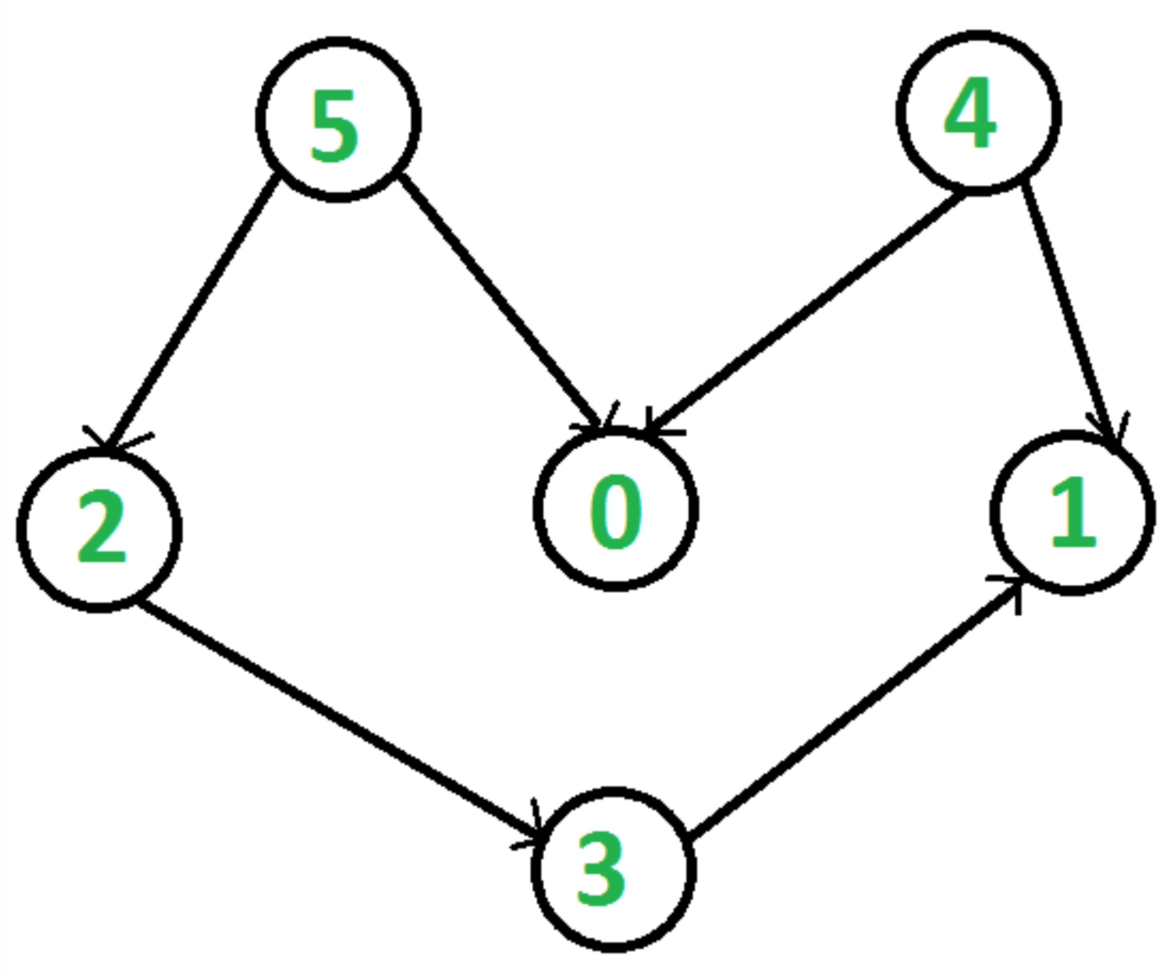
Adjacency List: An array of lists is used. Size of the array is equal to the number of vertices. Let the array be $array[]$. An entry $array[i]$ represents the list of vertices adjacent to the ith vertex. This representation can also be used to represent a weighted graph. The weights of edges can be represented as lists of pairs. Following is adjacency list representation of the above graph.

2.2 Algorithm design

The main algorithm involved in this problem is the **Topological sort** used to construct the minimum spanning tree.

Topological sorting for Directed Acyclic Graph (DAG) is a linear ordering of vertices such that for every directed edge uv, vertex u comes before v in the ordering. Topological Sorting for a graph is not possible if the graph is not a DAG.

For example, a topological sorting of the following graph is “5 4 2 3 1 0”. There can be more than one topological sorting for a graph. For example, another topological sorting of the following graph is “4 5 2 3 1 0”. The first vertex in topological sorting is always a vertex with in-degree as 0 (a vertex with no incoming edges).



Topological Sorting vs Depth First Traversal (DFS): In DFS, we print a vertex and then recursively call DFS for its adjacent vertices. In topological sorting, we need to print a vertex before its adjacent vertices. For example, in the given graph, the vertex ‘5’ should be printed before vertex ‘0’, but unlike DFS, the vertex ‘4’ should also be printed before vertex ‘0’. So Topological sorting is different from DFS. For example, a DFS of the shown graph is “5 2 3 1 0 4”, but it is not a topological sorting.

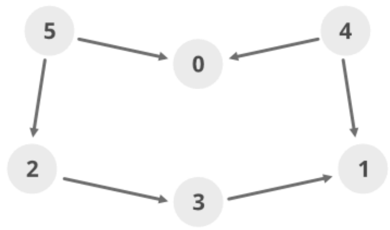
Algorithm to find Topological Sorting:

We recommend to first see implementation of DFS here. We can modify DFS to find Topological Sorting of a graph. In DFS , we start from a vertex, we first print it and then recursively call DFS for its adjacent vertices. In topological sorting, we use a temporary stack. We don’t print the vertex immediately, we first recursively call topological sorting for all its adjacent vertices, then push it to a stack. Finally, print contents of stack. Note that a vertex is pushed to stack only when all of its adjacent vertices (and their adjacent vertices and so on) are already in stack.

Simply put, the method of topological sorting can be summarized as:

1. Find points with a degree of 0 and put them into a sorted sequence
2. Delete all edges emitted by this point
3. Continue to find the next point with a degree of 0, put it into the sequence, and repeat the above steps
4. Until all nodes are put into the sequence.

Below image is an illustration of the above approach:



Adja cent list (G)
0 →
1 →
2 → 3
3 → 1
4 → 0, 1
5 → 2, 0

visited

0	1	2	3	4	5
false	false	false	false	false	false

Stack(empty)

Step 1: Topological Sort(0), visited[0] = true

List is empty. No more recursion call.

Stack | 0 |

Step 2: Topological Sort(1), visited[1] = true

List is empty. No more recursion call.

Stack | 0 | 1 |

Step 3: Topological Sort(2), visited[2] = true

Topological Sort(3), visited[3] = true

'1' is already visited. No more recurrsion call

Stack | 0 | 1 | 3 | 2 |

Step 4: Topological Sort(4), visited[4] = true

'0' , '1' are already visited. No more recurrsion call

Stack | 0 | 1 | 3 | 2 | 4 |

Step 5: Topological Sort(5), visited[5] = true

'2' , '0' are already visited. No more recurrsion call

Stack | 0 | 1 | 3 | 2 | 4 | 5 |

Step 6: Print all elements of stack from top to bottom

2.3 Member and operational design

1. Course

Private:

```
std::string _number;//课程编号
    std::string _name;//课程名字
    int _time;//学时数
    int _semester;//开课学期
    bool _havePre;
    int _degree;//入度
    std::vector<std::string> _pre;
```

Public operation:

```
Course() {
        _number = "0";
        _name = "0";
        _havePre = false;
        _degree = 0;

    }

    Course(std::string &nu, std::string &na, int ti, int se, bool ha) {
        _number = nu;
        _name = na;
        _time = ti;
        _semester = se;
        _havePre = ha;
    }
```

2. Graph

Data & functions:

```
public:
    std::vector<Course> _name;         //储存顶点名称的数组
    std::vector<Course> _classname;   //在矩阵中有用的顶点们
    int _matrix[29][29];        //邻接矩阵表示
    int _size;            //course name数
    int _vertexes;   //真实的顶点数
    std::vector<Course> _classlist;//拓扑排序后的课程顺序
    Graph() = default;

    Graph(std::vector<Course> course) {
        _name = course;
        _size = course.size();
        _vertexes = 0;
    }

    void initMatrix();
```

```
    bool findInDegree(Course co);//查找入度为0的顶点
    std::vector<Course> topologicalSort();
```

Core function:

Initialize adjacency matrix :

```
void Graph::initMatrix() {
    for (auto &i : _name) {
        if (!i._semester) {
            _classname.push_back(i);
        }
    }
    _vertexes = _classname.size();
    int mat[_vertexes][_vertexes];
    for (int i = 0; i < _vertexes; ++i) {
        for (int j = 0; j < _vertexes; ++j) {
            mat[i][j] = 0;
            if (_classname[j]._havePre) {
                //j的前驱是i, 也就是i的后继是j matrix[i][j]置1
                for (auto it = _classname[j]._pre.begin(); it !=
_classname[j]._pre.end(); ++it) {
                    if (*it == _classname[i]._number) {
                        mat[i][j] = 1;
                    }
                }
            }
        }
    }

    for (int i = 0; i < _vertexes; ++i) {
        for (int j = 0; j < _vertexes; ++j) {
            _matrix[i][j] = mat[i][j];
        }
    }
}
```

Find if the vertex's is a zero degree:

```
bool Graph::findInDegree(Course co) {
    for (int i = 0; i < _classname.size(); ++i) {
        if (_classname[i]._number == co._number) {
            if (_classname[i]._degree == 0) {
                return true;
            } else {
                return false;
            }
        }
    }
}
```

Topological Sorting

```
void Graph::topologicalSort()
{
    stack<int> Stack;

    // Mark all the vertices as not visited
    bool *visited = new bool[V];
    for (int i = 0; i < V; i++)
        visited[i] = false;

    // Call the recursive helper function to store Topological
    // Sort starting from all vertices one by one
    for (int i = 0; i < V; i++)
      if (visited[i] == false)
        topologicalSortUtil(i, visited, Stack);

    // Print contents of stack
    while (Stack.empty() == false)
    {
        cout << Stack.top() << " ";
        Stack.pop();
    }
}
```

3. Realization

3.1 Implementation of Reading files and processing data

1. Reading file core code

```
ector<Course> readFile() {
    ifstream ifs;//输入
    ofstream ofstream1;//输出
    ifs.open("../in.txt");
    if (ifs.fail()) {
        cerr << "Error opeing a file" << endl;
        ifs.close();
        exit(1);
    }
    auto line = new string[10000];
    int num = 0;
    while (ifs >> line[num]) {
        num++;
    }

    vector<Course> courses;
    int j = 0;
    for (int i = 5; i < num; ++i) {
        if (line[i][0] == 'c' && line[i + 1][0] != 'c') {
            //判断是否为课号
            Course co;
            j++;//新增一个课程
            co._number = line[i];
            co._name = line[i + 1];
            int ti = stoi(line[i + 2]);
            int se = stoi(line[i + 3]);
            co._time = ti;
            co._semester = se;
            co._degree = 0;
            int k = i + 4;
            int m = 0;
            while (line[k][0] == 'c' && line[k + 1][0] == 'c') {
                co._havePre = true;
                co._pre.push_back(line[k]);
                co._degree++;
                m++;
                k++;
            }
            courses.push_back(co);
        }
    }
```

```
    ifs.close();
    return courses;//size
}
```

2. Reading file diagram

input file:

in.txt

课程编号	课程名称	学时数	指定开课学期	先修课程
c01	程序设计基础	5	0	
c02	离散数学	6	0	c01
c03	数据结构算法	4	0	c01 c02
c04	汇编语言	5	0	c01
c05	算法设计	4	0	c03 c04
c06	计算机组成原理	6	0	
c07	微机原理	4	0	c03
c08	单片机应用	3	0	c03
c09	编译原理	5	0	c03
c10	操作系统原理	4	0	c03
c11	数据库原理	5	0	c03
c12	高等数学	6	0	
c13	线性代数	6	0	
c14	数值分析	6	0	c12
c15	普通物理	4	0	c12
c16	计算机文化	3	0	
c17	计算机系统结构	6	0	c06
c18	计算机网络	5	0	c03
c19	数据通信	6	0	
c20	面向对象程序设计	3	0	c01 c03
c21	Java	3	0	c01 c03
c22	C#.net	5	0	c01 c03
c23	PowerBuilder	5	0	c01 c03
c24	VC++	3	0	c01 c03
c25	ASP程序设计	5	0	c01 c03
c26	JSP程序设计	5	0	c01 c03
c27	VB.net	5	0	c01 c03
c28	Delphi	5	0	c01 c03
c29	C++Builder	5	0	c01 c03
c30	英语	5	1	
c31	英语	5	2	
c32	英语	5	3	
c33	英语	5	4	
c34	英语	5	5	
c35	英语	5	6	
c36	英语	5	7	
c37	英语	5	8	
c38	大学语文	3	1	

out put:

```
/Users/xuedixuedi/lxdThings/Code/github/Data-Structure-design/009/cmake-build-debug/009
c01 程序设计基础
c02 离散数学
c03 数据结构算法
c04 汇编语言
c05 算法设计
c06 计算机组成原理
c07 微机原理
c08 单片机应用
c09 编译原理
c10 操作系统原理
c11 数据库原理
c12 高等数学
c13 线性代数
c14 数值分析
c15 普通物理
c16 计算机文化
c17 计算机系统结构
c18 计算机网络
c19 数据通信
c20 面向对象程序设计
c21 Java
c22 C#.net
c23 PowerBuilder
c24 VC++
c25 ASP程序设计
c26 JSP程序设计
c27 VB.net
c28 Delphi
c29 C++Builder
c30 英语
c31 英语
c32 英语
c33 英语
c34 英语
c35 英语
c36 英语
c37 英语
c38 大学语文
```

3.2 Directed graph adjacency matrix construction

1. Adjacency matrix construction core code

```
void Graph::initMatrix() {
    for (auto &i : _name) {
        if (!i._semester) {
            _classname.push_back(i);
        }
    }
    _vertexes = _classname.size();
```

```
    int mat[_vertexes][_vertexes];
    for (int i = 0; i < _vertexes; ++i) {
        for (int j = 0; j < _vertexes; ++j) {
            mat[i][j] = 0;
            if (_classname[j]._havePre) {
                //j的前驱是i，也就是i的后继是j matrix[i][j]置1
                for (auto it = _classname[j]._pre.begin(); it !=
_classname[j]._pre.end(); ++it) {
                    if (*it == _classname[i]._number) {
                        mat[i][j] = 1;
                    }
                }
            }
        }
    }

    for (int i = 0; i < _vertexes; ++i) {
        for (int j = 0; j < _vertexes; ++j) {
            _matrix[i][j] = mat[i][j];
        }
    }
}
```

2. Adjacency matrix construction diagram

input file:

in.txt

课程编号	课程名称	学时数	指定开课学期	先修课程
c01	程序设计基础	5	0	
c02	离散数学	6	0	c01
c03	数据结构算法	4	0	c01 c02
c04	汇编语言	5	0	c01
c05	算法设计	4	0	c03 c04
c06	计算机组成原理	6	0	
c07	微机原理	4	0	c03
c08	单片机应用	3	0	c03
c09	编译原理	5	0	c03
c10	操作系统原理	4	0	c03
c11	数据库原理	5	0	c03
c12	高等数学	6	0	
c13	线性代数	6	0	
c14	数值分析	6	0	c12
c15	普通物理	4	0	c12
c16	计算机文化	3	0	
c17	计算机系统结构	6	0	c06
c18	计算机网络	5	0	c03
c19	数据通信	6	0	
c20	面向对象程序设计	3	0	c01 c03
c21	Java	3	0	c01 c03
c22	C#.net	5	0	c01 c03
c23	PowerBuilder	5	0	c01 c03
c24	VC++	3	0	c01 c03
c25	ASP程序设计	5	0	c01 c03
c26	JSP程序设计	5	0	c01 c03
c27	VB.net	5	0	c01 c03
c28	Delphi	5	0	c01 c03
c29	C++Builder	5	0	c01 c03
c30	英语	5	1	
c31	英语	5	2	
c32	英语	5	3	
c33	英语	5	4	
c34	英语	5	5	
c35	英语	5	6	
c36	英语	5	7	
c37	英语	5	8	
c38	大学语文	3	1	

out put:

```
009
/Users/xuedixuedi/lxdThings/Code/github/Data-Structure-design/009/cmake-build-debug/009
0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1
0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 0 1 1 1 1 1 0 0 0 0 0 0 1 0 1 1 1 1 1 1 1 1 1 1
0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

3.3 Implement of finding Topological Sorting Sequences

1. Finding Topological Sorting Sequences core function

```cpp
std::vector<Course> Graph::topologicalSort() {
    std::vector<Course> ans;
    for (int i = 0; i < _classname.size(); ++i) {
        if (findInDegree(_classname[i])) {
            //把入度为0的节点放入
            ans.push_back(_classname[i]);
            //把这个点的后继节点入度-1
            for (int j = 0; j < _classname.size(); ++j) {
                if (_matrix[i][j] == 1) {
                    _classname[j]._degree--;
                }
            }
        }
    }
    _classlist = ans;
```

```
        return ans;
    }
```

2. Diagram

input file:

in.txt

课程编号	课程名称	学时数	指定开课学期	先修课程
c01	程序设计基础	5	0	
c02	离散数学	6	0	c01
c03	数据结构算法	4	0	c01 c02
c04	汇编语言	5	0	c01
c05	算法设计	4	0	c03 c04
c06	计算机组成原理	6	0	
c07	微机原理	4	0	c03
c08	单片机应用	3	0	c03
c09	编译原理	5	0	c03
c10	操作系统原理	4	0	c03
c11	数据库原理	5	0	c03
c12	高等数学	6	0	
c13	线性代数	6	0	
c14	数值分析	6	0	c12
c15	普通物理	4	0	c12
c16	计算机文化	3	0	
c17	计算机系统结构	6	0	c06
c18	计算机网络	5	0	c03
c19	数据通信	6	0	
c20	面向对象程序设计	3	0	c01 c03
c21	Java	3	0	c01 c03
c22	C#.net	5	0	c01 c03
c23	PowerBuilder	5	0	c01 c03
c24	VC++	3	0	c01 c03
c25	ASP程序设计	5	0	c01 c03
c26	JSP程序设计	5	0	c01 c03
c27	VB.net	5	0	c01 c03
c28	Delphi	5	0	c01 c03
c29	C++Builder	5	0	c01 c03
c30	英语	5	1	
c31	英语	5	2	
c32	英语	5	3	
c33	英语	5	4	
c34	英语	5	5	
c35	英语	5	6	
c36	英语	5	7	
c37	英语	5	8	
c38	大学语文	3	1	

out put:

```
/Users/xuedixuedi/lxdThings/Code/github/Data-Structure-design/009/cmake-build-debug/009
程序设计基础 离散数学 数据结构算法 汇编语言 算法设计 计算机组成原理 微机原理 单片机应用 编译原理
  操作系统原理 数据库原理 高等数学 线性代数 数值分析 普通物理 计算机文化 计算机系统结构 计算机网络
   数据通信 面向对象程序设计 Java C#.net PowerBuilder VC++ ASP程序设计 JSP程序设计 VB.net
  Delphi C++Builder
```

3.4 Schedules Excluded Each Semester

1. Output file core code:

```
void arrangeClass(int sem, Graph *gr) {
    int ttime = 0;//这些课程的总时间
    vector<Course> list;
    for (int i = 0; i < gr->_name.size(); ++i) {
        if (gr->_name[i]._semester == sem) {
            list.push_back(gr->_name[i]);
            ttime += gr->_name[i]._time;
```

```
        }
    }

    if (!gr->_classlist.empty()) {
        for (auto it = gr->_classlist.begin(); it != gr->_classlist.end(); ++it) {
            if (it->_semester == 0) {
                ttime += it->_time;
                list.push_back(*it);
                it->_semester = sem;
            }
            if (ttime > 20) {
                break;
            }
        }
    }

    outPut(sem, list);

}
```

```
//输出文件:
void outPut(int sem, vector<Course> ls) {
    string xx = "../out0.txt";
    xx[6] = static_cast<char> (sem);
    auto str = xx.c_str();
    ofstream out;
    out.open(str);
    out << "The " << sem << " semester's curriculum:" << endl;

    //我想先把ls按照课时数排一排
    sort(ls.begin(), ls.end(), cmp);
    for (int i = 0; i < ls.size(); ++i) {
//          cout << ls[i]._time << ' ';
    }

    int classtime[ls.size()];//对应课程的课时
    vector<Course> schedual;
    for (int i = 0; i < ls.size(); ++i) {
        classtime[i] = ls[i]._time;
    }

    for (int k = 0; k < 3; ++k) {
        for (int i = 0; i < ls.size(); ++i) {
            if (classtime[i]) {
                if (classtime[i] % 2) {
                    //奇数情况
                    schedual.push_back(ls[i]);
                    schedual.push_back(ls[i]);
                    schedual.push_back(ls[i]);
                    classtime[i] -= 3;
                } else {
```

```
                    //偶数情况
                    schedual.push_back(ls[i]);
                    schedual.push_back(ls[i]);
                    classtime[i] -= 2;
                }
            }
        }
    }

    int hd = 4;
    int num = 0;
    string temp1;

    for (int i = 0; i < schedual.size(); ++i) {
        num++;
        out << schedual[i]._name << '|';
        if (schedual[i]._number != schedual[i + 1]._number && schedual[i]._number == schedual[i - 2]._number) {
            num++;
            out << "     |";
        }
        if (num == 4) {
            num = 0;
            out << endl;
        }
    }

    out.close();

}
```

2. Output timetable

Semester 1:

Mon	Tues	Wed	Thri	Fri
离散数学	程序设计基础		离散数学	程序设计基础
离散数学	程序设计基础		离散数学	程序设计基础
数据结构	程序设计基础		数据结构	英语
数据结构			数据结构	英语
英语	大学语文			
英语	大学语文			
英语	大学语文			

Semester 2:

Mon	Tues	Wed	Thri	Fri
计算机组成原理	英语	计算机组成原理	算法设计	计算机组成原理
计算机组成原理	英语	计算机组成原理	算法设计	计算机组成原理
汇编语言	英语		汇编语言	英语
汇编语言			汇编语言	英语
算法设计	微机原理			
算法设计	微机原理			

Semester 3:

Mon	Tues	Wed	Thri	Fri
编译原理	程序设计基础	英语	编译原理	操作系统原理
编译原理	程序设计基础	英语	编译原理	操作系统原理
编译原理	程序设计基础	英语		英语
				英语
数据库原理	操作系统原理		数据库原理	单片机应用
数据库原理	操作系统原理		数据库原理	单片机应用
数据库原理			数据库原理	单片机应用

Semester 4:

Mon	Tues	Wed	Thri	Fri
高等数学		高等数学	线性代数	高等数学

高等数学		高等数学	线性代数	高等数学
线性代数		数值分析		数值分析
线性代数		数值分析		数值分析
数值分析	英语			英语
数值分析	英语			英语
	英语			

Semester5:

Mon	**Tues**	**Wed**	**Thri**	**Fri**
计算机系统结构		计算机系统结构	普通物理	计算机系统结构
计算机系统结构		计算机系统结构	普通物理	计算机系统结构
普通物理			英语	计算机网络
普通物理			英语	计算机网络
英语	计算机网络		计算机文化	
英语	计算机网络		计算机文化	
英语	计算机网络		计算机文化	

Semester6:

Mon	**Tues**	**Wed**	**Thri**	**Fri**
C#.net		面向对象程序设计	C#.net	程序设计基础
C#.net		面向对象程序设计	C#.net	程序设计基础
C#.net		面向对象程序设计		数据通信
				数据通信
数据通信		数据通信	英语	Java
数据通信		数据通信	英语	Java

英语			英语	Java
英语				

Semester7:

Mon	**Tues**	**Wed**	**Thri**	**Fri**
PowerBuilder	ASP程序设计		PowerBuilder	ASP程序设计
PowerBuilder	ASP程序设计		PowerBuilder	ASP程序设计
PowerBuilder	ASP程序设计		数据结构	JSP程序设计
数据结构			英语	JSP程序设计
英语	JSP程序设计		VC++	
英语	JSP程序设计		VC++	
英语	JSP程序设计		VC++	

Semester8:

Mon	**Tues**	**Wed**	**Thri**	**Fri**
VB.net	Delphi		VB.net	Delphi
VB.net	Delphi		VB.net	Delphi
VB.net	Delphi		英语	
			英语	
英语	C++Builder			C++Builder
英语	C++Builder			C++Builder
英语				C++Builder

4. Test

4.1 Error test

Fail to open the file

input:

A txt file with wrong name

Expected outcome:

Error opening file

Experimental result: