



# ACM/ICPC Template

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# Chapter 1

## java TODO

1.1 读写

1.2 高精

## Chapter 2

# dp 优化

### 2.1 决策单调性优化

- 形式： $f[i] = f[j] + w[j, i]$  形式决策单调。
- 一般打表找规律看决策是否单调。
- 四边形不等式： $w[i, j] + w[i + 1, j + 1] \leq w[i + 1, j] + w[i, j + 1]$ , 则满足决策单调性。
- 有时候不满足决策单调性，但是去掉完全不合法状态之后可以满足。

```
1 #include <bits/stdc++.h>
2 #define MAXN 51234
3
4 using namespace std;
5 typedef long long arrayN[MAXN];
6
7 deque < pair< pair<int, int> , int> > deq;
8 arrayN f, sum, c;
9 long long L;
10
11 long long sqr(long long x)
12 {
13     return x * x;
14 }
15
16 long long trans(int l, int r)
17 {
18     return sqr(1LL * r - (l + 1) - L + sum[r] - sum[l]) + f[l];
19 }
```

```
20 int myLowBound(pair <int, int> pr, int ori, int now)
21 {
22     int l = pr.first, r = pr.second;
23     for (; l < r; )
24     {
25         int mid = l + r >> 1;
26         if (trans(ori, mid) <= trans(now, mid)) l = mid + 1;
27         else r = mid;
28     }
29     return l;
30 }
31
32 int main()
33 {
34     int n;
35     freopen("toys.in", "r", stdin);
36     cin >> n >> L;
37     for (int i = 1; i <= n; ++i)
38     {
39         cin >> c[i];
40         sum[i] = sum[i - 1] + c[i];
41     }
42     deq.push_back(make_pair(make_pair(1, n), 0));
43     for (int i = 1; i <= n; ++i)
44     {
45         for (; deq.front().first.second < i; deq.pop_front());
46         f[i] = trans(deq.front().second, i);
47         if (i == n) break;
48         deq.front().first.first = i + 1;
49         if (deq.front().first.second < i + 1) deq.pop_front();
50         for (; !deq.empty() && trans(deq.back().second, deq.back().
51 first.first) >= trans(i, deq.back().first.first); deq.pop_back
52 ());
53         if (deq.empty()) deq.push_back(make_pair(make_pair(i + 1, n
54 ), i));
55
56         else
57         {
58             int x = myLowBound(deq.back().first, deq.back().second,
59 i);
60             if (trans(i, x) >= (trans(deq.back().second, x))) x++;
61             deq.back().first.second = x - 1;
62             if (x <= n) deq.push_back(make_pair(make_pair(x, n), i)
63 );
64         }
65     }
66 }
```

```

61     cout << f[n] << endl;
62     return 0;
63 }

```

Listing 2.1: hnoi2008toys.cpp

## 2.2 单调队列优化以及写仙人掌图

- 题目背景：仙人掌图上最长链
- 形式： $f[i] = \max(g[j]) + w[i]$ ， $w[i]$  单调，可见，如果  $j < k$ ， $g[j] < g[k]$ ，则  $j$  可以直接不考虑，所以此时维护  $g$  单调减的队列即可。
- 仙人掌图找环：首先形成 bfs 树，发现有环，记  $pt$ ,  $ph$ ，然后选  $pt$  沿着  $pre$  走到跟，一路打时间戳；再从  $ph$  沿着  $pre$  走，就可以找到  $lca$ 。  $pt$ ,  $ph$  到  $lca$  的路径，加上  $pt \rightarrow ph$  就是基环了。

```

1 #include <bits/stdc++.h>
2 #define MAXN 1123456
3 #define MAXM 2123456
4
5 typedef int arrayN[MAXN], arrayM[MAXM];
6
7 using namespace std;
8
9 arrayN fir, cost, t, pre, vis;
10 arrayM e, nxt, c;
11 long long ans, dst[MAXN];
12 int num, now, visNow;
13
14 void link(int u, int v, int w)
15 {
16     e[++num] = v, nxt[num] = fir[u];
17     fir[u] = num, c[num] = w;
18 }
19
20 vector<int> bfsFindCycle(int x)
21 {
22     ++now;
23     vector<int> cyc;
24     deque<int> deq;
25     int pt = 0, ph = 0, last;
26     deq.push_back(x);
27     t[x] = now;
28     for (; !deq.empty() && !pt;)

```

```

29 {
30     int u = deq.front();
31     deq.pop_front();
32     for (int p = fir[u]; p && !pt; p = nxt[p])
33         if (e[p] != pre[u])
34             if (t[e[p]] == now)
35             {
36                 pt = u, ph = e[p];
37                 last = c[p];
38             }
39             else
40             {
41                 t[e[p]] = now;
42                 pre[e[p]] = u;
43                 cost[e[p]] = c[p];
44                 deq.push_back(e[p]);
45             }
46     }
47     vector<int> cycTmp;
48     if (pt)
49     {
50         ++now;
51         int tmp = pt;
52         for (; tmp != x; tmp = pre[tmp])
53             t[tmp] = now;
54         t[x] = now;
55         int lca = ph;
56         for (; t[lca] != now; lca = pre[lca]);
57         for (tmp = pt; tmp != lca; tmp = pre[tmp])
58         {
59             swap(last, cost[tmp]);
60             cyc.push_back(tmp);
61         }
62         cyc.push_back(lca);
63         cost[lca] = last;
64
65         for (tmp = ph; tmp != lca; tmp = pre[tmp])
66             cycTmp.push_back(tmp);
67         for (; !cycTmp.empty(); cycTmp.pop_back())
68             cyc.push_back(cycTmp.back());
69     } else cyc.push_back(x);
70
71     ++now;
72     for (int i = 0; i < cyc.size(); ++i)
73         t[cyc[i]] = now;
74     return cyc;

```

```

75 }
76
77 struct node
78 {
79     long long w;
80     long long lst, f;}g[MAXN * 2];
81
82 long long bfsLongest(int rt, int &nrt)
83 {
84     long long lst = 0;
85     deque <int> deq;
86     deq.push_back(rt);
87     nrt = rt;
88     vis[rt] = ++visNow;
89     dst[rt] = 0;
90     for (; !deq.empty(); )
91     {
92         int u = deq.front();
93         deq.pop_front();
94         for (int p = fir[u]; p; p = nxt[p])
95             if (vis[e[p]] != visNow && t[e[p]] != now)
96             {
97                 vis[e[p]] = visNow;
98                 dst[e[p]] = dst[u] + c[p];
99                 if (dst[e[p]] > lst)
100                 {
101                     lst = dst[e[p]];
102                     nrt = e[p];
103                 }
104                 deq.push_back(e[p]);
105             }
106     }
107     return lst;
108 }
109
110 long long solve(int x)
111 {
112     long long ans = 0;
113     vector <int> cyc = bfsFindCycle(x);
114     int n = cyc.size();
115     for (int i = 0; i < n; ++i)
116     {
117         int pt, pp;
118         t[cyc[i]] = 0;
119         g[i].lst = bfsLongest(cyc[i], pt);
120         ans = max(ans, bfsLongest(pt, pp));

```

```

121         t[cyc[i]] = now;
122         if (n == 1) return g[i].lst;
123         g[i].w = cost[cyc[i]];
124         g[i].f = 0;
125         g[i + n] = g[i];
126     }
127     g[0].w = 0;
128     for (int i = 1; i < 2 * n; ++i)
129         g[i].w += g[i - 1].w;
130     g[0].f = g[0].lst;
131     deque <int> deq;
132     deq.push_back(0);
133     for (int i = 1; i < 2 * n; ++i)
134     {
135         for (; deq.front() + n <= i; deq.pop_front());
136         g[i].f = g[i].lst + g[i].w + g[deq.front()].lst - g[deq.
front()].w;
137         for (; !deq.empty() && g[deq.back()].lst - g[deq.back()].w
<= g[i].lst - g[i].w; deq.pop_back());
138         deq.push_back(i);
139     }
140     for (int i = 0; i < 2 * n; ++i)
141         ans = max(ans, g[i].f);
142     return ans;
143 }
144
145 int main()
146 {
147     freopen("island.in", "r", stdin);
148     int n;
149     num = 1;
150     scanf("%d", &n);
151     for (int i = 1; i <= n; ++i)
152     {
153         int v, len;
154         scanf("%d%d", &v, &len);
155         link(i, v, len);
156         link(v, i, len);
157     }
158     long long ans = 0;
159     for (int i = 1; i <= n; ++i)
160         if (!vis[i])
161             ans += solve(i);
162     printf("%lld\n", ans);
163     return 0;

```

## 2.3 斜率优化

- $f[i] = \min(a[i] * x[j] + b[i] * y[j])$
- 更好的理解：设  $P=f[i]$ , 则  $y = (-a/b)x + P/b$ . 求满足要求的最小截距。或者通过各种转化，最优决策就是从无穷远朝原点移动，第一个碰上的点为最优决策点。
- 很好的性质：所有最优决策一定在当前所有点构成的凸包上。（例如，在最优决策点划一条相应斜率的线，其余点均在该线上方，）

### 2.3.1 斜率以及 x 维都单调

想像斜率越来越大的直线往 y 正方向移动，第 i 次移动首次碰上 k。对于以后的决策，因为斜率更大，那么在 k 之前，第 i 次移动没有碰上的点必然再也用不上了，所以可以维护一个单调队列。下面例题是：把一个序列切开，每个部分权值是平方加常数，求权值和最小值

```

1 #include <deque>
2 #include <cstdio>
3 #include <cstring>
4 #include <iostream>
5 #include <cstdlib>
6
7 #define MAXN 512345
8
9 using namespace std;
10 typedef long long arrayN[MAXN];
11
12 struct node
13 {
14     long long x, y, f;
15     node (long long tx = 0, long long ty = 0, long long tf = 0)
16     {
17         x = tx, y = ty, f = tf;
18     }
19     //y = f + sum^2, x = sum
20 }g[MAXN];
21
22 long long sqr(long long x)
23 {

```

```

24     return x * x;
25 }
26
27 long long cross(long long x1, long long y1, long long x2, long long
    y2)
28 {
29     return x1 * y2 - x2 * y1;
30 }
31
32 deque < int > deq;
33
34 int main()
35 {
36     freopen("hdu3507.in", "r", stdin);
37     int N, M;
38     for (; scanf("%d%d", &N, &M) != EOF; )
39     {
40
41         deq.clear();
42         g[0] = node(0, 0, 0);
43         deq.push_back(0);
44         for (int i = 1; i <= N; ++i)
45         {
46             int x;
47             scanf("%d", &x);
48             g[i].x = g[i - 1].x + x;
49             long long lim = g[i].x << 1;
50             for (; deq.size() > 1; deq.pop_front())
51             {
52                 node u = g[deq[0]];
53                 node v = g[deq[1]];
54                 if ((v.y - u.y) > lim * (v.x - u.x))
55                     break;
56             }
57             node pt = g[deq.front()];
58             g[i].f = pt.f + sqr(g[i].x - pt.x) + M;
59             g[i].y = sqr(g[i].x) + g[i].f;
60             for (; deq.size() >= 2; deq.pop_back())
61             {
62                 node A = g[deq[deq.size() - 2]];
63                 node B = g[deq[deq.size() - 1]];
64                 node C = g[i];
65                 if (cross(B.x - A.x, B.y - A.y, C.x - B.x, C.y - B.
y) > 0) break;
66             }
67             deq.push_back(i);

```



```

68     }
69     cout << g[N].f << endl;
70 }
71 return 0;
72 }

```

Listing 2.3: hdu3507.cpp

### 2.3.2 随便什么情况：cdq 分治优化

- 排序的顺序，凸壳的方向写之前一定要画清楚。
- 这里归并排一维的序可以节省一个  $\log$  的复杂度
- cdq 分治的顺序至关重要，千万不能乱。
- $f[i]$  表示第  $i$  天手上的券全换成现金最多多少，其中  $x[j], y[j]$  分别表示用  $f[j]$  的钱换成 A, B 券分别能有多少。
- $f[i] = \max(\max(A[i] * x[j] + B[i] * x[j], f[j]))$
- 就是经典的斜率优化问题咯。不用平衡树的话可以离线用 cdq 分治。先按照  $A[i]/B[i]$  排序（具体大小顺序画一画就知道了）。solve(l, r) 时需要按照下标 lab 大小分为两部分。然后 solve(l, mid)，同时主义归并把递散维  $x$  排好序。l ~ mid 至 mid + 1 r 转移。最后 solve(mid + 1, r)，接着归并排好  $x$  就行了。

```

1 #include <bits/stdc++.h>
2 #define MST(a, b) memset((a), (b), sizeof(a))
3 #define MAXN 112345
4 #define esp 1e-8
5
6 using namespace std;
7
8 struct node
9 {
10     double A, B, rate; //A/B
11     double x, y;
12     double f;
13 }g[MAXN];
14
15 int lab[MAXN], a[MAXN];
16
17 int cmp(double x)
18 {
19     if (x < -esp) return -1;
20     if (x > esp) return 1;

```

```

21     return 0;
22 }
23
24 int smaller(int u, int v)
25 {
26     int tx = cmp(g[u].x - g[v].x);
27     int ty = cmp(g[u].y - g[v].y);
28     return tx < 0 || (tx == 0 && ty < 0);
29 }
30
31 void mergeSortX(int al, int ar, int bl, int br)
32 {
33     int Na = 0;
34     for (int i = al; i <= ar; ++i)
35     {
36         while (bl <= br && smaller(lab[bl], lab[i]))
37             a[++Na] = lab[bl++];
38         a[++Na] = lab[i];
39     }
40     for (; bl <= br; ++bl)
41         a[++Na] = lab[bl];
42     for (int i = 1; i <= Na; ++i)
43         lab[al + i - 1] = a[i];
44 }
45
46 double cross(int A, int B, int C)
47 {
48     return (g[B].x - g[A].x) * (g[C].y - g[B].y) - (g[B].y - g[A].y)
49         * (g[C].x - g[B].x);
50 }
51
52 double comRate(int A, int B, int C)
53 {
54     return (g[B].y - g[A].y) * g[C].B + g[C].A * (g[B].x - g[A].x);
55 }
56
57 void getRightPartF(int al, int ar, int bl, int br)
58 {
59     int Na = 0;
60     double lim = 0;
61     for (int i = al; i <= ar; ++i)
62     {
63         lim = max(lim, g[lab[i]].f);
64         while (Na >= 2 && cmp(cross(a[Na - 1], a[Na], lab[i])) >=
0)

```

```

65     —Na;
66     a[++Na] = lab[i];
67 }
68 int La = 1;
69 for (int i = bl; i <= br; ++i)
70 {
71     int p = lab[i];      g[p].f = max(g[p].f, lim);
72     for (; La + 1 <= Na && cmp(comRate(a[La], a[La + 1], p)) >= 16
73         0; ++La);
74     g[p].f = max(g[p].f, g[a[La]].x * g[p].A + g[a[La]].y * g[p].B);
75 }
76
77 void solve(int l, int r)
78 {
79     if (l == r)
80     {
81         int p = lab[l];
82         //g[p].f = max(g[p].f, g[p - 1].f);
83         g[p].x *= g[p].f;
84         g[p].y *= g[p].f;
85         return ;
86     }
87     int Na = r - l + 1;
88     int upLim = 0, downLim = MAXN;
89     for (int i = l; i <= r; ++i)
90     {
91         upLim = max(upLim, lab[i]);
92         downLim = min(downLim, lab[i]);
93     }
94     int midLim = (upLim + downLim) >> 1;
95     int pLow = 0;
96     for (int i = l; i <= r; ++i)
97         if (lab[i] <= midLim)
98             a[++pLow] = lab[i];
99     int pHigh = pLow;
100    for (int i = l; i <= r; ++i)
101        if (lab[i] > midLim)
102            a[++pHigh] = lab[i];
103    for (int i = 1; i <= Na; ++i)
104        lab[i + l - 1] = a[i];
105    pLow += l - 1;
106    solve(l, pLow);
107    getRightPartF(l, pLow, pLow + 1, r);
108    solve(pLow + 1, r);
109
110    mergeSortX(l, pLow, pLow + 1, r);
111 }
112 int com(int u, int v)
113 {
114     node tu = g[u];
115     node tv = g[v];
116     return tu.A * tv.B < tv.A * tu.B;
117 }
118
119 int main()
120 {
121     // freopen("cash4.in", "r", stdin);
122     int N, S;
123     scanf("%d%d", &N, &S);
124     for (int i = 1; i <= N; ++i)
125     {
126         scanf("%lf%lf%lf", &g[i].A, &g[i].B, &g[i].rate);
127         g[i].y = 1.0 / (g[i].B + g[i].A * g[i].rate);
128         g[i].x = g[i].y * g[i].rate;
129         g[i].f = S;
130         lab[i] = i;
131     }
132     g[1].f = S;
133     sort(lab + 1, lab + N + 1, com);
134     solve(1, N);
135     double ans = 0;
136     for (int i = 1; i <= N; ++i)
137         ans = max(ans, g[i].f);
138     printf("%.3f\n", ans);
139     return 0;
140 }

```

Listing 2.4: cash.cpp

## Chapter 3

# 图论

### 3.1 tarjan TODO

#### 3.1.1 2-sat TODO

如果没有产生矛盾, 把处在同一个强联通分量中的点和边缩成一个点, 得到新的有向图  $G'$ . 然后, 把  $G'$  中的所有弧反向, 得到图  $G''$ . 现在观察  $G''$ , 由于已经进行了缩点操作, 所以是拓扑图.

把  $G''$  所以点标记未着色. 按照拓扑顺序重复下面操作: 1. 选择未着色的顶点  $x$ . 把  $x$  染成红色. 2. 把所有与  $x$  矛盾的顶点  $y$  及其子孙全部染成蓝色. 3. 重复操作 1 和 2, 知道不存在未着色的点位置. 此时  $G''$  中被染成红色的点在图  $G$  中对应的定点集合, 就是 2-SAT 的一组解

```
1 //指定小写字母元音/辅音
2 //给出第i个位置是元音/辅音蕴涵j位置元音/辅音
3 //给定字符串st, 求字典序不小于它的最小的合法2-sat方案
4 #include <bits/stdc++.h>
5 #define MAXN 500
6 #define MAXM 512345
7
8 using namespace std;
9 typedef int arrayN[MAXN], arrayM[MAXM];
10
11 char g[30], st[MAXN];
12 arrayN fir0, low, dfn, inVec, cnt, belong;
13 arrayN deg, con0, con1, fir1, topOrder, col;
14 arrayM e0, nxt0, e1, nxt1;
15 int num, now, tot, nextAlp[30][2], firAlp[2];
16 vector<int> vec;
17
18 int getKind(char ch) {
```

```
19     if (ch == 'V') return 0;
20     else return 1;
21 }
22
23 void link0(int u, int v) {
24     e0[++num] = v, nxt0[num] = fir0[u];
25     fir0[u] = num;
26 }
27
28 void link1(int u, int v) {
29     e1[++num] = v, nxt1[num] = fir1[u];
30     fir1[u] = num;
31 }
32
33 void tarjan(int x) {
34     low[x] = dfn[x] = ++now;
35     vec.push_back(x);
36     for (int p = fir0[x], q; p; p = nxt0[p])
37         if (!inVec[q = e0[p]])
38             if (!dfn[e0[p]]) {
39                 tarjan(e0[p]);
40                 low[x] = min(low[x], low[e0[p]]);
41             } else low[x] = min(low[x], dfn[e0[p]]);
42     if (low[x] == dfn[x]) {
43         cnt[belong[x] = ++tot] = 1;
44         inVec[x] = 1;
45         for (; vec.back() != x; vec.pop_back()) {
46             int q = vec.back();
47             inVec[q] = 1;
48             cnt[belong[q] = tot]++;
49         }
50         vec.pop_back();
51     }
52 }
53
54 void topSort() {
55     int l = 1, r = 0;
56     for (int i = 1; i <= tot; ++i)
57         if (deg[i] == 0) topOrder[++r] = i;
58     for (; l <= r; ++l) {
59         int u = topOrder[l];
60         for (int p = fir1[u]; p; p = nxt1[p]) {
61             --deg[e1[p]];
62             if (deg[e1[p]] == 0) topOrder[++r] = e1[p];
63         }
64     }
```

```

65 }
66 int getDAG(int n) {
67     for (int i = 1; i <= n * 2; ++i)
68         dfn[i] = low[i] = belong[i] = inVec[i] = deg[i] = 0;
69     now = tot = num = 0;    for (int i = 1; i <= n * 2; ++i)
70         if (!dfn[i]) tarjan(i);
71     for (int i = 1; i <= n; ++i)
72         if (belong[i] == belong[con0[i]]) return 0;
73     for (int i = 1; i <= 2 * n; ++i) {
74         for (int p = fir0[i]; p; p = nxt0[p]) {
75             int q = e0[p];
76             if (belong[i] == belong[q]) continue;
77             link1(belong[q], belong[i]);
78             deg[belong[i]]++;
79         }
80         con1[belong[i]] = belong[con0[i]];
81         con1[belong[con0[i]]] = belong[i];
82     }
83     topSort();
84     return 1;
85 }
86
87 int dye(int x, int co) {
88     if (col[x]) {
89         return (co == col[x]);
90     }
91     col[x] = co;
92     for (int p = fir1[x]; p; p = nxt1[p])
93         if (!dye(e1[p], co)) return 0;
94     return 1;
95 }
96
97 int originDye(int p, int n) {
98     int all = -1;
99     if (firAlp[0] > 'z') all = 0;
100    if (firAlp[1] > 'z') all = 1;
101    if (all >= 0)
102        for (int i = 1; i <= n; ++i) {
103            int pos1 = i + all * n;
104            int pos0 = con1[pos1];
105            if (col[pos0] == 2) return 0;
106            col[pos0] = 1;
107            if (!dye(pos1, 2)) return 0;
108        }
109    for (int i = 1; i <= p + 1; ++i) {
110        int pos = belong[i];

```

```

111        if (getKind(g[st[i - 1] - 'a'])) pos = con1[pos];
112        if (col[pos] == 2) return 0;
113        col[pos] = 1;
114        if (!dye(con1[pos], 2)) return 0;
115    }
116    return 1;
117 }
118 int DAGDye(int n) {
119     for (int i = 1; i <= n; ++i) {
120         int x = topOrder[i];
121         if (!col[x]) {
122             col[x] = 1;
123             if (!dye(con1[x], 2)) return 0;
124         }
125     }
126     return 1;
127 }
128
129 int finalCheck(int n, int p) {
130     for (int i = 1; i <= n; ++i) {
131         if (col[belong[i]] != 1 && col[belong[con0[i]]] != 1)
132             return 0;
133     }
134     return 1;
135 }
136
137 int solve(int n, int p) {
138     memset(col, 0, sizeof(col));
139     if (!originDye(p, n)) return 0;
140     if (!DAGDye(tot)) return 0;
141     return finalCheck(n, p);
142 }
143
144 void getNextAlp() {
145     int len = strlen(g);
146     firAlp[1] = firAlp[0] = 'z' + 1;
147     for (int i = 0; i < len; ++i) {
148         nextAlp[i][0] = nextAlp[i][1] = 'z' + 1;
149         int k = getKind(g[i]);
150         firAlp[k] = min(firAlp[k], i + 'a');
151         for (int j = i + 1; j < len; ++j) {
152             int k = getKind(g[j]);
153             nextAlp[i][k] = min(nextAlp[i][k], 'a' + j);
154         }
155         if (nextAlp[i][0] > nextAlp[i][1])
156             swap(nextAlp[i][0], nextAlp[i][1]);

```

```

156     }
157 }
158 int main() {
159 #ifndef ONLINE_JUDGE
160     freopen("in.txt", "r", stdin);#endif
161     scanf("%s", g);
162     int n, m;
163     scanf("%d%d", &n, &m);
164     for (int i = 1; i <= n; ++i) {
165         con0[i] = i + n;
166         con0[i + n] = i;
167     }
168     num = 0;
169     for (int i = 1; i <= m; ++i) {
170         char t1, t2;
171         int pos1, pos2;
172         scanf("%d %c %d %c\n", &pos1, &t1, &pos2, &t2);
173         // if (i == 50 && n == 50 && m == 50) printf("%d %c %d %c\n", pos1, t1, pos2, t2);
174         int k1 = getKind(t1);
175         int k2 = getKind(t2);
176         pos1 += k1 * n;
177         pos2 += k2 * n;
178         link0(pos1, pos2);
179         link0(con0[pos2], con0[pos1]);
180     }
181     scanf("%s", st);
182     // if (n == 50 && m == 50) printf("%s\n", st);
183     getNextAlp();
184     if (getDAG(n) == 0) {
185         printf("-1\n");
186         return 0;
187     }
188     int flag = solve(n, n - 1);
189     for (int i = n - 1; i >= 0 && !flag; --i) {
190         int tmp = st[i] - 'a';
191         for (int j = 0; j <= 1 && !flag; ++j)
192             if (nextAlp[st[i] - 'a'][j] <= 'z') {
193                 st[i] = nextAlp[tmp][j];
194                 flag = solve(n, i);
195                 if (flag) {
196                     for (int k = i + 1; k <= n - 1; ++k) {
197                         int u = firAlp[0];
198                         int v = firAlp[1];
199                         if (u > v) swap(u, v);
200                         st[k] = u;

```

```

201         if (solve(n, k)) continue;
202         st[k] = v;
203     }
204 }
205 }
206 }
207 if (!flag) printf("-1\n");
208 else printf("%s\n", st);
209 return 0;
210 }

```

Listing 3.1: cf568C.cpp

### 3.1.2 割顶，点双联通分量 TODO

### 3.1.3 桥，边双联通分量 TODO

## 3.2 平面图 TODO

farmland 那道题，平面图判定 hnoi

## 3.3 最佳追捕算法

## 3.4 网络流 TODO

### 3.4.1 dinic

uva11248 流量大于等于 C 的流是否存在。如果不存在，修改哪些边的流量可以使得存在。

```

1 #include <bits/stdc++.h>
2 #define REP(i, n) for(int i = 0; i < (int) (n); ++i)
3 #define REPP(i, a, b) for (int i = (int) (a); i <= (int) (b); ++i)
4 #define MST(a, b) memset((a), (b), sizeof(a))
5 #define MAXN 205
6 #define MAXM 21234
7
8 using namespace std;
9
10 typedef int arrayN[MAXN], arrayM[MAXM];
11 int N, E, C, num;
12 const int INF = ~0U >> 1;
13 arrayN fir, d;
14 arrayM nxt, e;
15 long long c[MAXM], c0[MAXM];

```

```

16 struct edge
17 {
18     int u, v, lab;
19     edge(int u = 0, int v = 0, int lab = 0): u(u), v(v), lab(lab) {};
20     } g[MAXM], cand[MAXM];
21
22 void link(int u, int v, int w)
23 {
24     e[++num] = v, nxt[num] = fir[u];
25     fir[u] = num, c[num] = 1LL * w;
26 }
27
28 void copy(long long cs[], long long cd[])
29 {
30     REPP(i, 1, num) cd[i] = cs[i];
31 }
32
33 bool bfs(int s)
34 {
35     MST(d, 0x3f);
36     d[s] = 0;
37     queue<int> que;
38     que.push(s);
39     for (; !que.empty(); )
40     {
41         int u = que.front();
42         que.pop();
43         for (int p = fir[u]; p; p = nxt[p])
44             if (c[p] && d[e[p]] > d[u] + 1)
45             {
46                 d[e[p]] = d[u] + 1;
47                 que.push(e[p]);
48             }
49     }
50     return d[N] < d[0];
51 }
52
53 long long dfs(int x, long long low)
54 {
55     long long flow = 0;
56     if (x == N) return low;
57     for (int p = fir[x]; p; p = nxt[p])
58         if (c[p] && d[e[p]] == d[x] + 1)
59         {
60             long long tmp = dfs(e[p], min(low, c[p]));

```

```

61             if (!tmp) d[e[p]] = d[0];
62             c[p] -= tmp, c[p ^ 1] += tmp;
63             flow += tmp, low -= tmp;
64             if (!low) break;
65         }
66     return flow;
67 }
68
69 int com(edge A, edge B)
70 {
71     return A.u < B.u || (A.u == B.u && A.v < B.v);
72 }
73
74 void findCutEdge(long long base)
75 {
76     int tot = 0;
77     REPP(i, 1, N)
78         if (d[i] < d[0])
79             for (int p = fir[i]; p; p = nxt[p])
80                 if (d[e[p]] >= d[0] && !(p & 1))
81                     cand[++tot] = edge(i, e[p], p);
82     copy(c, c0);
83
84     int ansTot = 0;
85     REPP(i, 1, tot)
86     {
87         copy(c0, c);
88         c[cand[i].lab] = C;
89         long long ans = base;
90         for (; ans < C && bfs(1); ans += dfs(1, C));
91         if (ans >= C) g[++ansTot] = cand[i];
92     }
93     if (ansTot == 0)
94     {
95         printf("not possible\n");
96         return ;
97     }
98     sort(g + 1, g + ansTot + 1, com);
99     printf("possible option:(%d,%d)", g[1].u, g[1].v);
100     REPP(i, 2, ansTot)
101         printf(" (%d,%d)", g[i].u, g[i].v);
102     printf("\n");
103 }
104
105 int main()
106 {
107     freopen("uva11248.in", "r", stdin);

```

```

107 int task = 0;
108 for (;;)
109 {
110     scanf("%d%d%d", &N, &E, &C);
111     if (N + E + C == 0) break;    num = 1;
112     MST(fir, 0);
113     REP(i, E)
114     {
115         int u, v, w;
116         scanf("%d%d%d", &u, &v, &w);
117         link(u, v, w);
118         link(v, u, 0);
119     }
120     long long ans = 0;
121     for (; ans < C && bfs(1); ans += dfs(1, C));
122     ++task;
123     printf("Case %d: ", task);
124     if (ans >= C)
125     {
126         printf("possible\n");
127         continue;
128     }
129     findCutEdge(ans);
130 }
131 return 0;
132 }

```

Listing 3.2: uva11248.cpp

### 3.4.2 费用流 TODO

### 3.4.3 常见模型 TODO

## 3.5 弦图

### 3.5.1 做法与常见问题

做法如下：

- 最大势算法求待验证完美消除序列
  1. 未被选的点中选被标记次数最多的点  $i$
  2. 把  $i$  相邻的点标记次数 + 1
- 判断是否为完美消除序列（下述扫描必需全部完成）
  1. 上述序列依次扫描，扫到  $i$
  2. 标号小于  $seq[i]$  的与  $i$  相邻点为  $j_1, j_2, \dots, j_k$

3. 判断  $j_k$  与  $j_1, j_2, \dots, j_{k-1}$  相邻即可

常见问题如下：

- 色数：贪心按照完美消除序列产生顺序依次染最小的能染的颜色
- 最大独立集：贪心按照完美消除序列产生顺序倒着依次选，能选就选
- 最小团覆盖（用最少的团覆盖所有点）：最大独立集带上下面的  $N$  集合
- 极大团：
  - $N(v) = w \mid w \text{ 与 } v \text{ 相邻, 且先加入}$
  - 团一定是  $v \text{ union } N(v)$  的形式
  - 现在需要判断每个  $v \text{ union } N(v)$  是否为极大团
  - $next[v]$  是与  $v$  相邻的, 最靠近  $v$  的已经加入完美序列的点
  - $next[w] = v$  且  $|N(v)| + 1 \leq |N(w)|$ , 则  $v$  不是极大团
- 最大团 = 最小染色, 最大点独立集 = 最小团覆盖（对于弦图任何诱导子图成立, 即完美图）
- 区间图的完美消除序列就是右端点排序。从大到小依次加入完美消除序列。选最多区间不重叠：（最大独立集），从小到大排序依次加

### 3.5.2 万不得已用线性作法

这个是判断是否为弦图

```

1 #include <bits/stdc++.h>
2 #define MAXN 1123
3 #define MAXM 2123456
4
5 using namespace std;
6 typedef int arrayN[MAXN], arrayM[MAXM];
7
8 arrayN fir, firMcs, nxtMcs, mcsSeq, l;
9 arrayN vis, r, cnt, preMcs, lab;
10 arrayM nxt, e;
11 int num, flag[MAXN][MAXN];
12 int mx; // max
13
14 void link(int u, int v)
15 {
16     e[++num] = v, nxt[num] = fir[u];
17     fir[u] = num;
18 }
19
20 void delMcs(int pos, int pt)

```

```

21 {
22     if (nxtMcs[pt] == pt)
23     {
24         r[l[pos]] = r[pos];
25         l[r[pos]] = l[pos];           if (pos == mx) mx = l[mx];
26         firMcs[pos] = 0;
27         return ;
28     }
29     preMcs[nxtMcs[pt]] = preMcs[pt];
30     nxtMcs[preMcs[pt]] = nxtMcs[pt];
31     if (firMcs[pos] == pt)
32         firMcs[pos] = nxtMcs[pt];
33 }
34
35 void insMcs(int pos, int pt)
36 {
37     if (firMcs[pos])
38     {
39         int tmp = firMcs[pos];
40         nxtMcs[pt] = tmp;
41         preMcs[pt] = preMcs[tmp];
42         nxtMcs[preMcs[pt]] = pt;
43         preMcs[nxtMcs[pt]] = pt;
44         return;
45     }
46     preMcs[pt] = nxtMcs[pt] = firMcs[pos] = pt;
47     if (firMcs[pos - 1]) //easy wrong
48     {
49         l[pos] = pos - 1;
50         r[pos] = r[pos - 1];
51     } else
52     {
53         if (l[pos - 1] == pos - 1)
54             l[pos] = r[pos] = pos;
55         else
56         {
57             l[pos] = l[pos - 1];
58             r[pos] = r[pos - 1];
59         }
60     }
61     r[l[pos]] = l[r[pos]] = pos;
62     if (pos > mx) mx = pos;
63 }
64
65 void getMcsSeq(int n, int m)
66 {

```

```

67     mx = 0;
68     l[0] = 0, r[0] = 0;
69     memset(firMcs, 0, sizeof(firMcs));
70     memset(cnt, 0, sizeof(cnt));
71     for (int i = 1; i <= n; ++i)
72     {
73         nxtMcs[i] = i + 1;
74         preMcs[i] = i - 1;
75     }
76     nxtMcs[n] = 1, preMcs[1] = n;
77     firMcs[0] = 1;
78     memset(vis, 0, sizeof(vis));
79     for (int i = 1; i <= n; ++i)
80     {
81         int tmp = (mcsSeq[i] = firMcs[mx]);
82         delMcs(cnt[tmp], tmp);
83         vis[tmp] = 1;
84         for (int p = fir[tmp]; p; p = nxt[p])
85             if (!vis[e[p]])
86             {
87                 delMcs(cnt[e[p]], e[p]);
88                 ++cnt[e[p]];
89                 insMcs(cnt[e[p]], e[p]);
90             }
91     }
92 }
93
94 int checkMcs(int n)
95 {
96     for (int i = 1; i <= n; ++i)
97         lab[mcsSeq[i]] = i;
98     memset(vis, 0, sizeof(vis));
99     int now = 0;
100     for (int i = 1; i <= n; ++i)
101     {
102         ++now;
103         int pt = mcsSeq[i], cnt = 0, bgst = 0;
104         for (int p = fir[pt]; p; p = nxt[p])
105             if (lab[e[p]] < i)
106             {
107                 vis[e[p]] = now;
108                 ++cnt;
109                 if (lab[e[p]] > bgst)
110                     bgst = e[p];
111             }
112         if (bgst == 0) continue;

```



```

113     for (int p = fir[bgst]; p; p = nxt[p])
114     {
115         if (lab[e[p]] < i && vis[e[p]] == now)
116             —cnt;
117     }     if (cnt > 1) return 0;
118 }
119 return 1;
120 }
121
122 int main()
123 {
124     // freopen("in.txt", "r", stdin);
125     //freopen("out.txt", "w", stdout);
126     for (;;)
127     {
128         int n, m;
129         scanf("%d%d", &n, &m);
130         if (n + m == 0) break;
131         num = 0;
132         memset(fir, 0, sizeof(fir));
133         memset(flag, 0, sizeof(flag));
134         for (int i = 1; i <= m; ++i)
135         {
136             int u, v;
137             scanf("%d%d", &u, &v);
138             if (flag[u][v] || u == v) continue;
139             link(u, v);
140             link(v, u);
141             flag[u][v] = flag[v][u] = 1;
142         }
143         getMcsSeq(n, m);
144         if (checkMcs(n)) printf("Perfect\n\n");
145         else printf("Imperfect\n\n");
146     }
147     return 0;
148 }

```

Listing 3.3: zoj1015.cpp

### 3.5.3 nlogn 好写得更多

这个是求色数

```

1 #include <bits/stdc++.h>
2 #define MAXN 11234
3 #define MAXM 2123456
4

```

```

5 using namespace std;
6
7 typedef int arrayN[MAXN], arrayM[MAXM];
8
9 arrayN fir, mcsOrder, label, col;
10 arrayM e, nxt;
11 int num, n, base, seg[MAXN * 4];
12 set <int> s;
13
14 void link(int u, int v) {
15     e[++num] = v, nxt[num] = fir[u];
16     fir[u] = num;
17 }
18
19 int maxLab(int u, int v) {
20     return label[u] > label[v] ? u : v;
21 }
22
23 void change(int x, int val) {
24     label[x] = val;
25     x += base;
26     for (x >= 1; x; x >= 1) {
27         seg[x] = maxLab(seg[x << 1], seg[x << 1 ^ 1]);
28     }
29 }
30
31 void getMCS() {
32     for (base = 1; base <= n + 1; base <= 1);
33     for (int i = 1; i <= n; ++i) seg[i + base] = i;
34     label[0] = -1;
35     for (int i = base - 1; i >= 1; —i)
36         seg[i] = maxLab(seg[i << 1], seg[i << 1 ^ 1]);
37     int tot = 0;
38     for (int i = 1; i <= n; ++i) {
39         int x = mcsOrder[++tot] = seg[1];
40         change(x, -1);
41         for (int p = fir[x]; p; p = nxt[p]) {
42             if (label[e[p]] >= 0) change(e[p], label[e[p]] + 1);
43         }
44     }
45 }
46
47 int main()
48 {
49     #ifndef ONLINE_JUDGE
50     freopen("in.txt", "r", stdin);
51     #endif

```

```

51 int m;
52 scanf("%d", &n, &m);
53 for (int i = 1; i <= m; ++i) {
54     int u, v; scanf("%d", &u, &v);
55     link(u, v);
56     link(v, u);
57 }
58 getMCS();
59 int ans = 0;
60 for (int i = 1; i <= n; ++i)
61     s.insert(i);
62 for (int j = 1; j <= n; ++j) {
63     int i = mcsOrder[j];
64     for (int p = fir[i]; p; p = nxt[p]) {
65         set<int>::iterator it = s.find(col[e[p]]);
66         if (it != s.end())
67             s.erase(it);
68     }
69     col[i] = *s.begin();
70     ans = max(ans, col[i]);
71     for (int p = fir[i]; p; p = nxt[p]) {
72         set<int>::iterator it = s.find(col[e[p]]);
73         if (col[e[p]] && it == s.end())
74             s.insert(col[e[p]]);
75     }
76 }
77 printf("%d\n", ans);
78 return 0;
79 }

```

Listing 3.4: hnoi2008.cpp

## 3.6 最小树形图

- 特别注意判断 root 的地方.
- 下面这题是二分, 选择大于等于 bLowLim 的边才有效
- 这是指定了 root 为 0
- 不固定根的时候, 只需要新加根节点. 到每个点连边, 边权大于所有边之和即可.

```

1 #include <bits/stdc++.h>
2 #define REP(i, n) for (int i = 0; i < (int) (n); ++i)
3 #define REPP(i, a, b) for(int i = (int) (a); i <= (int) (b); ++i)
4 #define MST(a, b) memset((a), (b), sizeof(a))
5 #define MAXN 66
6 #define MAXM 11234
7
8 using namespace std;
9 const int oo = ~0U>>1;
10 typedef int arrayN[MAXN], arrayM[MAXM];
11
12 int N, M, C;
13 arrayN vis, minW, belong, pre;
14
15 struct edge
16 {
17     int u, v, b, c;
18     edge(int u1 = 0, int v1 = 0, int b1 = 0, int c1 = 0)
19     {
20         u = u1, v = v1, b = b1, c = c1;
21     }
22 }edOri[MAXM], ed[MAXM];
23
24 int zhuLiu(int bLowLim)
25 {
26     int root = 0, tot = N, ntot;
27     int ans = 0;
28     REP(i, M) ed[i] = edOri[i];
29     for (;;)
30     {
31         REP(i, tot) minW[i] = oo, vis[i] = -1, belong[i] = -1;
32         REP(i, M)
33         {
34             if (ed[i].u == ed[i].v || ed[i].b < bLowLim) continue;
35             if (ed[i].c < minW[ed[i].v])
36             {
37                 minW[ed[i].v] = ed[i].c;
38                 pre[ed[i].v] = ed[i].u;
39             }
40         }
41
42         pre[root] = -1;
43         minW[root] = 0;
44         REP(i, tot)
45             if (minW[i] >= oo) return oo;
46         else ans += minW[i];

```

```

47  ntot = 0;
48  REP(i, tot)
49      if (vis[i] == -1)
50      {
51
52          int h1 = i;
53          for (; vis[h1] == -1; h1 = pre[h1]) {
54              vis[h1] = i;
55              if (h1 == root) break;
56          }
57          if (h1 == root || vis[h1] != i) continue;
58          int h2 = h1;
59          for (h2 = pre[h1]; h2 != h1; h2 = pre[h2])
60              belong[h2] = ntot;
61          belong[h1] = ntot++;
62      }
63  REP(i, tot) if (belong[i] == -1) belong[i] = ntot++;
64  REP(i, M)
65  {
66      ed[i].c -= minW[ed[i].v];
67      ed[i].u = belong[ed[i].u];
68      ed[i].v = belong[ed[i].v];
69  }
70  if (tot == ntot) return ans;
71  tot = ntot;
72  root = belong[root];
73  }
74  }
75
76  int main()
77  {
78      freopen("in.txt", "r", stdin);
79      int task;
80      for (scanf("%d", &task); task; --task)
81      {
82          int L = 1, R = 1;
83          scanf("%d%d%d", &N, &M, &C);
84          REP(i, M)
85          {
86              int u, v, b, c;
87              scanf("%d%d%d%d", &u, &v, &b, &c);
88              edOri[i] = edge(u, v, b, c);
89              R = max(R, b);
90          }
91          L = 0;
92          for (; L < R; )

```

```

93      {
94          int mid = (L + R + 1) >> 1;
95          if (zhuLiu(mid) > C)
96              R = mid - 1;
97          else L = mid;
98      }
99      if (L == 0) printf("streaming not possible.\n");
100     else printf("%d kbps\n", L);
101 }
102 return 0;
103 }

```

Listing 3.5: uva11865.cpp

## 3.7 二分图

### 3.7.1 普通 KM

```

1  #include <bits/stdc++.h>
2  #define REP(i, n) for (int i = 0; i < (n); ++i)
3  #define REPP(i, a, b) for(int i = (a); i <= (b); ++i)
4  #define MST(a, b) memset((a), (b), sizeof(a))
5  #define MAXN 512
6  #define INF 0x3f3f3f3f
7
8  using namespace std;
9
10 typedef int arrayN[MAXN];
11
12 int n;
13 arrayN S, T, match, w[MAXN], lx, ly;
14
15 int dfs(int x)
16 {
17     S[x] = 1;
18     REPP(i, 1, n)
19         if (lx[x] + ly[i] == w[x][i] && !T[i])
20         {
21             T[i] = 1; //容易忽略
22             if (!match[i] || dfs(match[i])) //dfs中别漏了match
23             {
24                 match[i] = x;
25                 return 1;
26             }
27         }

```

```

28     return 0;
29 }
30
31 void update()
32 { int minL = INF; //找最小
33   REPP(i, 1, n)
34     if (S[i])
35       REPP(j, 1, n)
36         if (!T[j])
37           minL = min(minL, lx[i] + ly[j] - w[i][j]);
38   REPP(i, 1, n)
39   {
40     if (S[i]) lx[i] -= minL;
41     if (T[i]) ly[i] += minL;
42   }
43 }
44 void KM()
45 {
46   REPP(i, 1, n)
47   {
48     lx[i] = 0;
49     ly[i] = 0;
50     match[i] = 0;
51     REPP(j, 1, n)
52       lx[i] = max(lx[i], w[i][j]);
53   }
54   REPP(i, 1, n)
55   {
56     for (;;)
57     {
58       MST(S, 0);
59       MST(T, 0);
60       if (dfs(i)) break;
61       else update();
62     }
63   }
64 }
65 int main()
66 {
67   freopen("in.txt", "r", stdin);
68   for (; scanf("%d", &n) != EOF; )
69   {
70     REPP(i, 1, n)
71       REPP(j, 1, n)
72         scanf("%d", &w[i][j]);
73     KM();

```

```

74     REPP(i, 1, n)
75       printf("%d%c", lx[i], " \n"[i == n]);
76     REPP(i, 1, n)
77       printf("%d%c", ly[i], " \n"[i == n]);
78     int ans = 0;
79     REPP(i, 1, n)
80       ans += w[match[i]][i];
81     printf("%d\n", ans);
82   }
83   return 0;
84 }

```

Listing 3.6: uva11383.cpp

### 3.7.2 牛逼 KM TODO

### 3.7.3 常见问题汇总

- 最大独立集: 等于顶点数减去最大匹配。最大匹配中点全部去掉, 剩余的点为独立集。此时共  $|V|-2|M|$  个点。接着从匹配边取一边加入独立集 (这两个点不可能同时与非匹配点相邻, 否则可以增广)。
- 最大团: 补图的最大独立集
- 最小点覆盖: 即最大匹配。输出方案见代码
- 最小路径覆盖所有点
- DAG 最小不相交路径覆盖:  
把原图中的每个点  $V$  拆成  $V_x$  和  $V_y$ , 如果有一条有向边  $A \rightarrow B$ , 那么就加边  $A_x - B_y$ 。这样就得到了一个二分图, 最小路径覆盖 = 原图的节点数 - 新图最大匹配。证明: 一开始每个点都独立的为一条路径, 总共有  $n$  条不相交路径。我们每次在二分图里加一条边就相当于把两条路径合成了一条路径, 因为路径之间不能有公共点, 所以加的边之间也不能有公共点, 这就是匹配的定义。所以有: 最小路径覆盖 = 原图的节点数 - 新图最大匹配。
- 有向无环图最小可相交路径覆盖: 先用 floyd 求出原图的传递闭包, 即如果  $a$  到  $b$  有路, 那么就加边  $a \rightarrow b$ 。然后就转化成了最小不相交路径覆盖问题。
- 稳定婚姻问题很有趣, 见白书 P353。

### 3.7.4 最小点覆盖输出方案

```

1 #include <bits/stdc++.h>
2 #define REP(i, n) for (int i = 0; i < (n); ++i)
3 #define REPP(i, a, b) for(int i = (a); i <= (b); ++i)
4 #define MAXN 1123
5 #define MST(a, b) memset((a), (b), sizeof(a))
6
7 using namespace std;
8
9 int n, m, tot, w[MAXN][MAXN], vis[MAXN], cok[MAXN], rok[MAXN],
    match[MAXN];
10
11 int dfs(int x)
12 {
13     REPP(i, 1, n)
14         if (w[x][i] && !vis[i])
15         {
16             vis[i] = 1; //容易忽略
17             if (!match[i] || dfs(match[i]))
18             {
19                 match[i] = x;
20                 return 1;
21             }
22         }
23     return 0;
24 }
25
26 void dfs2(int x)
27 {
28     rok[x] = 1;
29     REPP(i, 1, n)
30         if (w[x][i] && !cok[i])
31         {
32             cok[i] = 1;
33             dfs2(match[i]);
34         }
35 }
36
37 int main()
38 {
39     freopen("in.txt", "r", stdin);
40     for (;;)
41     {
42         scanf("%d%d%d", &n, &m, &tot);
43         if (n + m + tot == 0) break;
44         MST(w, 0);
45         REPP(i, 1, tot)

```

```

46     {
47         int u, v;
48         scanf("%d%d", &u, &v);
49         w[u][v] = 1;
50     }
51     MST(match, 0);
52     int ans = 0;
53     REPP(i, 1, n)
54     {
55         MST(vis, 0);
56         if (dfs(i)) ++ans;
57     }
58     printf("%d", ans);
59     MST(vis, 0);
60     MST(rok, 0);
61     MST(cok, 0);
62     REPP(i, 1, n)
63         vis[match[i]] = 1;
64     REPP(i, 1, n)
65         if (!vis[i])
66             dfs2(i);
67     REPP(i, 1, n)
68         if (!rok[i])
69             printf(" r%d", i);
70     REPP(i, 1, n)
71         if (cok[i])
72             printf(" c%d", i);
73     printf("\n");
74 }
75 return 0;
76 }

```

Listing 3.7: uva11419.cpp

## 3.8 带花树 TODO

## 3.9 最大团 TODO

## 3.10 欧拉理论 TODO

## Chapter 4

# 数据结构

### 4.1 左偏树 TODO

### 4.2 splay TODO

### 4.3 lct TODO

### 4.4 可持久化线段树以及 LCA 不能再写错了 !!!

本题要求路径上 k 大

```
1 #include <bits/stdc++.h>
2 #define MAXN 112345
3 #define MAXNODE 5012345
4
5 using namespace std;
6 typedef int arrayN[MAXN * 2];
7
8 arrayN e, nxt, fir;
9 int num, tot;
10
11 struct segmentNode
12 {
13     segmentNode *l, *r;
14     int low, up, num;
15 }tree[MAXNODE];
16
17 struct node
18 {
19     int val, dep;
```

```
20     int f[25];
21     segmentNode *rt;
22 } a[MAXN];
23
24
25 void link(int u, int v)
26 {
27     e[++num] = v, nxt[num] = fir[u];
28     fir[u] = num;
29 }
30
31 segmentNode *build(int l, int r)
32 {
33     segmentNode *tp = &tree[tot++];
34     int mid = l + r >> 1;
35     tp->low = l, tp->up = r;
36     tp->num = 0;
37     tp->l = tp->r = NULL;
38     if (l == r) return tp;
39     tp->l = build(l, mid);
40     tp->r = build(mid + 1, r);
41     return tp;
42 }
43
44 segmentNode *change(segmentNode *u, int x)
45 {
46     segmentNode *tp = &tree[tot++];
47     tp->l = u->l, tp->r = u->r;
48     tp->num = u->num + 1;
49     tp->low = u->low, tp->up = u->up;
50     int mid = tp->up + tp->low >> 1;
51     if (tp->low == tp->up) return tp;
52     if (x <= mid) tp->l = change(u->l, x);
53     else tp->r = change(u->r, x);
54     return tp;
55 }
56
57 void dfs(int x, int fa, int depth)
58 {
59     a[x].dep = depth;
60     a[x].f[0] = fa;
61     a[x].rt = change(a[fa].rt, a[x].val);
62     for (int p = fir[x]; p; p = nxt[p])
63         if (e[p] != fa)
64             dfs(e[p], x, depth + 1);
65 }
```

```

66 void initLCA(int n)
67 {
68     for (int i = 1; i <= 20; ++i)    for (int j = 1; j <= n; ++j)
69         a[j].f[i] = a[a[j].f[i - 1]].f[i - 1];
70 }
71
72 int getLCA(int u, int v)
73 {
74     if (a[u].dep < a[v].dep) swap(u, v);
75     int dt = a[u].dep - a[v].dep;
76     for (int i = 20; i >= 0 && dt; i--)
77         if (a[u].f[i] && ((1<<i) <= dt))
78         {
79             u = a[u].f[i];
80             dt -= (1 << i);
81         }
82     if (u == v) return u;
83     for (int i = 20; i >= 0; --i)
84         if (a[u].f[i] != a[v].f[i])
85             u = a[u].f[i], v = a[v].f[i];
86     return a[u].f[0];
87 }
88
89 int ask(int u, int v, int lca, int k)
90 {
91     int fa = a[lca].f[0];
92     segmentNode *lk1l = a[u].rt, *lk1r = a[lca].rt;
93     segmentNode *lk2l = a[v].rt, *lk2r = a[fa].rt;
94     for (; ;)
95     {
96         if (lk1l->low == lk1l->up) return lk1l->low;
97         int tmp = lk1l->l->num - lk1r->l->num + lk2l->l->num - lk2r->l->num;
98         if (tmp >= k)
99         {
100             lk1l = lk1l->l, lk1r = lk1r->l;
101             lk2l = lk2l->l, lk2r = lk2r->l;
102         } else
103         {
104             k -= tmp;
105             lk1l = lk1l->r, lk1r = lk1r->r;
106             lk2l = lk2l->r, lk2r = lk2r->r;
107         }
108     }
109 }
110 }

```

```

111 vector<int> vec;
112
113 int main()
114 {
115     freopen("in.txt", "r", stdin);
116     int n, m;
117     scanf("%d%d", &n, &m);
118     for (int i = 1; i <= n; ++i)
119     {
120         scanf("%d", &a[i].val);
121         vec.push_back(a[i].val);
122     }
123     sort(vec.begin(), vec.end());
124     vec.resize(unique(vec.begin(), vec.end()) - vec.begin());
125     for (int i = 1; i <= n; ++i)
126         a[i].val = lower_bound(vec.begin(), vec.end(), a[i].val) - vec.begin();
127     for (int i = 1; i < n; ++i)
128     {
129         int u, v;
130         scanf("%d%d", &u, &v);
131         link(u, v);
132         link(v, u);
133     }
134     a[0].rt = build(0, n);
135     dfs(1, 0, 1);
136     initLCA(n);
137     for (int i = 1; i <= m; ++i)
138     {
139         int u, v, k;
140         scanf("%d%d%d", &u, &v, &k);
141         int lca = getLCA(u, v);
142         printf("%d\n", vec[ask(u, v, lca, k)]);
143     }
144     return 0;
145 }
146 }

```

Listing 4.1: COT.cpp

## 4.5 点分治

```

1 #include <cstdlib>
2 #include <cstdio>
3 #include <iostream>

```

```

4 #include <vector>
5 #include <cstring>
6 #include <algorithm>
7 #define REP(i, n) for(int i = 0; i < (int) (n); ++i)
8 #define REPP(i, a, b) for(int i = (int) (a); i <= (int) (b); ++i)
9 #define MST(a, b) memset(a, (b), sizeof(a))
10 #define MAXN 11111
11 //小于等于k的点对
12 using namespace std;
13 typedef int arrayN[MAXN * 2];
14
15 arrayN fir, nxt, e, c, sizeN, vis;
16 int n, k, ans, num;
17 vector<int> stRoot, stEp;
18
19
20 void link(int u, int v, int w)
21 {
22     e[++num] = v, nxt[num] = fir[u], fir[u] = num;
23     c[num] = w;
24 }
25
26 int dfsSize(int x, int fa)
27 {
28     sizeN[x] = 1;
29     for (int p = fir[x]; p; p = nxt[p])
30         if (e[p] != fa && !vis[e[p]])
31             sizeN[x] += dfsSize(e[p], x);
32     return sizeN[x];
33 }
34
35 int getRoot(int x, int fa, int totN)
36 {
37     int maxSize = totN - sizeN[x];
38     for (int p = fir[x]; p; p = nxt[p])
39         if (e[p] != fa && !vis[e[p]])
40             {
41                 maxSize = max(maxSize, sizeN[e[p]]);
42                 int tmp = getRoot(e[p], x, totN);
43                 if (tmp) return tmp;
44             }
45     if (maxSize <= totN / 2) return x;
46     return 0;
47 }
48
49 void dfsSt(int x, int fa, int len)
50 {
51     stEp.push_back(len);
52     for (int p = fir[x]; p; p = nxt[p])
53         if (!vis[e[p]] && e[p] != fa)
54             dfsSt(e[p], x, len + c[p]);
55 }
56
57 int calc(vector<int> &st)
58 {
59     int tmp = 0;
60     sort(st.begin(), st.end());
61     int L = 0, R = st.size() - 1;
62     for (; L < R;)
63     {
64         if (st[L] + st[R] <= k) tmp += R - L, L++;
65         else --R;
66     }
67     return tmp;
68 }
69
70 void solve(int x)
71 {
72     int root = getRoot(x, x, dfsSize(x, x));
73     vis[root] = 1;
74     stRoot.clear();
75     stRoot.push_back(0);
76     for (int p = fir[root]; p; p = nxt[p])
77         if (!vis[e[p]])
78             {
79                 stEp.clear();
80                 dfsSt(e[p], root, c[p]);
81                 ans += calc(stEp);
82                 REP(i, stEp.size())
83                     stRoot.push_back(stEp[i]);
84             }
85     ans += calc(stRoot);
86     for (int p = fir[root]; p; p = nxt[p])
87         if (!vis[e[p]]) solve(e[p]);
88     vis[root] = 0;
89 }
90
91 int main()
92 {
93     freopen("in.txt", "r", stdin);
94     for (;;)
95     {

```



```

96     scanf("%d%d", &n, &k);
97     if (n + k == 0) break;
98     ans = 0;
99     num = 0;
100    MST(fir, 0);      REPP(i, 1, n - 1)
101    {
102        int u, v, w;
103        scanf("%d%d%d", &u, &v, &w);
104        link(u, v, w);
105        link(v, u, w);
106    }
107    MST(vis, 0);
108    ans = 0;
109    solve(1);
110    printf("%d\n", ans);
111 }
112 return 0;
113 }

```

Listing 4.2: poj1741.cpp

树上 A 权值不超过  $\lim$  的 B 权值和最大的路径

```

1 #include <cstdlib>
2 #include <cstdio>
3 #include <iostream>
4 #include <vector>
5 #include <cstring>
6 #include <algorithm>
7 #define REP(i, n) for(int i = 0; i < (int) (n); ++i)
8 #define REPP(i, a, b) for(int i = (int) (a); i <= (int) (b); ++i)
9 #define MST(a, b) memset(a, (b), sizeof(a))
10 #define MAXN 11111
11 //小于等于k的点
12 using namespace std;
13 typedef int arrayN[MAXN * 2];
14
15 arrayN fir, nxt, e, c, sizeN, vis;
16 int n, k, ans, num;
17 vector<int> stRoot, stEp;
18
19 void link(int u, int v, int w)
20 {
21     e[++num] = v, nxt[num] = fir[u], fir[u] = num;
22     c[num] = w;
23 }

```

```

24 }
25
26 int dfsSize(int x, int fa)
27 {
28     sizeN[x] = 1;
29     for (int p = fir[x]; p; p = nxt[p])
30         if (e[p] != fa && !vis[e[p]])
31             sizeN[x] += dfsSize(e[p], x);
32     return sizeN[x];
33 }
34
35 int getRoot(int x, int fa, int totN)
36 {
37     int maxSize = totN - sizeN[x];
38     for (int p = fir[x]; p; p = nxt[p])
39         if (e[p] != fa && !vis[e[p]])
40         {
41             maxSize = max(maxSize, sizeN[e[p]]);
42             int tmp = getRoot(e[p], x, totN);
43             if (tmp) return tmp;
44         }
45     if (maxSize <= totN / 2) return x;
46     return 0;
47 }
48
49 void dfsSt(int x, int fa, int len)
50 {
51     stEp.push_back(len);
52     for (int p = fir[x]; p; p = nxt[p])
53         if (!vis[e[p]] && e[p] != fa)
54             dfsSt(e[p], x, len + c[p]);
55 }
56
57 int calc(vector<int> &st)
58 {
59     int tmp = 0;
60     sort(st.begin(), st.end());
61     int L = 0, R = st.size() - 1;
62     for (; L < R;)
63     {
64         if (st[L] + st[R] <= k) tmp += R - L, L++;
65         else --R;
66     }
67     return tmp;
68 }
69

```

```

70 void solve(int x)
71 {
72     int root = getRoot(x, x, dfsSize(x, x));
73     vis[root] = 1;
74     stRoot.clear();    stRoot.push_back(0);
75     for (int p = fir[root]; p; p = nxt[p])
76         if (!vis[e[p]])
77             {
78                 stEp.clear();
79                 dfsSt(e[p], root, c[p]);
80                 ans -= calc(stEp);
81                 REP(i, stEp.size())
82                     stRoot.push_back(stEp[i]);
83             }
84     ans += calc(stRoot);
85     for (int p = fir[root]; p; p = nxt[p])
86         if (!vis[e[p]]) solve(e[p]);
87     vis[root] = 0;
88 }
89
90 int main()
91 {
92     freopen("in.txt", "r", stdin);
93     for (;;)
94     {
95         scanf("%d%d", &n, &k);
96         if (n + k == 0) break;
97         ans = 0;
98         num = 0;
99         MST(fir, 0);
100        REPP(i, 1, n - 1)
101        {
102            int u, v, w;
103            scanf("%d%d%d", &u, &v, &w);
104            link(u, v, w);
105            link(v, u, w);
106        }
107        MST(vis, 0);
108        ans = 0;
109        solve(1);
110        printf("%d\n", ans);
111    }
112    return 0;
113 }

```

Listing 4.3: poj1741.cpp

## 4.6 树链剖分 TODO

## 4.7 qtree TODO

## Chapter 5

# 其他算法

### 5.1 pq 树 TODO

### 5.2 DLX TODO

### 5.3 对抗搜索 TODO

### 5.4 cdq 分治与读入优化

- 不要排结构体，因为排结构体到时候还要排回来。
- 线段树打时间戳不要 `memset()`;
- 在严格小的限制下，第二维排序的时候一定要双关键字排序
- 这题是三维空间中，三个坐标都不减的最长链

```
1 #include <iostream>
2 #include <cstring>
3 #include <cstdlib>
4 #include <cstdio>
5 #include <algorithm>
6 #define REP(i, n) for(int i = 0; i < (int) (n); ++i)
7 #define REPP(i, a, b) for(int i = (int) (a); i <= (int) (b); ++i)
8 #define REDD(i, a, b) for(int i = (int) (a); i >= (int) (b); --i)
9 #define MST(a, b) memset((a), (b), sizeof(a))
10 #define MAXN 111111
11 #include <vector>
12
```

```
13 using namespace std;
14 int zLim;
15
16 long long gTot[MAXN * 4];
17 int t, g[MAXN * 4], n, ti[MAXN * 4], now;
18 struct node
19 {
20     int x, y, z, f;
21     long long tot;
22 } a[MAXN];
23
24 int comx(node A, node B)
25 {
26     return (A.x < B.x) || ((A.x == B.x) && (A.y < B.y)) || ((A.x ==
27         B.x) && (A.y == B.y) && A.z < B.z);
28 }
29
30 int comy(node A, node B)
31 {
32     return A.y < B.y;
33 }
34
35 void change(int pos, int x, long long cnt)
36 {
37     pos += t;
38     if (ti[pos] != now) g[pos] = gTot[pos] = 0;
39     if (x < g[pos]) return ;
40     if (x == g[pos]) gTot[pos] += cnt;
41     else gTot[pos] = cnt, g[pos] = x;
42     ti[pos] = now;
43
44     for(pos >>= 1; pos; pos >>= 1)
45     {
46         if (ti[pos << 1] != now) g[pos << 1] = gTot[pos << 1] = 0;
47         if (ti[pos << 1 ^ 1] != now) g[pos << 1 ^ 1] = gTot[pos << 1
48             ^ 1] = 0;
49         ti[pos] = now;
50         g[pos] = max(g[pos << 1], g[pos << 1 ^ 1]);
51         gTot[pos] = 0;
52         if (g[pos] == g[pos << 1]) gTot[pos] += gTot[pos << 1];
53         if (g[pos] == g[pos << 1 ^ 1]) gTot[pos] += gTot[pos << 1 ^ 1];
54     }
55 }
56
57 int ask(int l, int r, long long &cnt)
58 {
59
```

```

57     if (l > r) return 0;
58     int tmp = 0;
59     cnt = 0;
60     l += t - 1, r += t + 1;
61     for (; (l ^ r) != 1; l >>= 1, r >>= 1)
62     {
63         if (!(l & 1))
64         {
65             if (ti[l + 1] == now)
66             {
67                 if (tmp == g[l + 1]) cnt += gTot[l + 1];
68                 else if (tmp < g[l + 1])
69                 {
70                     tmp = g[l + 1];
71                     cnt = gTot[l + 1];
72                 }
73             }
74             if (r & 1)
75             {
76                 if (ti[r - 1] == now)
77                 {
78                     if (tmp == g[r - 1]) cnt += gTot[r - 1];
79                     else if (tmp < g[r - 1])
80                     {
81                         tmp = g[r - 1];
82                         cnt = gTot[r - 1];
83                     }
84                 }
85             }
86         }
87     }
88     return tmp;
89 }
90
91 void solve(int l, int r)
92 {
93     if (l == r) return ;
94     int mid = (l + r) >> 1;
95     solve(mid + 1, r);
96
97     sort(a + mid + 1, a + r + 1, comy);
98     sort(a + l, a + mid + 1, comy);
99
100     // MST(g, 0);
101     //MST(gTot, 0);
102     ++now;

```

```

103     int pos = r + 1;
104     REDD(i, mid, l)
105     {
106         for (; pos > mid + 1 && a[pos - 1].y >= a[i].y; --pos)
107         {
108             change(a[pos - 1].z, a[pos - 1].f, a[pos - 1].tot);
109         }
110
111         long long tmpTot;
112         int tmp = ask(a[i].z, zLim, tmpTot) + 1;
113         if (a[i].f == tmp) a[i].tot += tmpTot;
114         else if (a[i].f < tmp)
115         {
116             a[i].f = tmp;
117             a[i].tot = tmpTot;
118         }
119     }
120
121     sort(a + l, a + r + 1, comx);
122     solve(l, mid);
123 }
124
125 int INT()
126 {
127     int res;
128     char ch;
129     while (ch = getchar(), !isdigit(ch));
130     for (res = ch - '0'; ch = getchar(), isdigit(ch);)
131         res = res * 10 + ch - '0';
132     return res;
133 }
134
135 int main()
136 {
137     int task;
138     freopen("in.txt", "r", stdin);
139     now = 0;
140     for (task = INT(); task; --task)
141     {
142         n = INT();
143         vector<int> dataZ;
144         REPP(i, 1, n)
145         {
146             a[i].x = INT();
147             a[i].y = INT();
148             a[i].z = INT();

```

149	a[i].f = 1;	161	solve(1, n);
150	a[i].tot = 1;	162	int ans = 0;
151	dataZ.push_back(a[i].z);	163	long long cnt = 0;
152	}	164	REPP(i, 1, n)
153	sort(dataZ.begin(), dataZ.end());	165	{
	unique(dataZ.begin(), dataZ.end()) - dataZ.begin());	166	if (ans == a[i].f) cnt += a[i].tot;
154	REPP(i, 1, n)	167	else if (ans < a[i].f) cnt = a[i].tot, ans = a[i].f;
155	{	168	}
156	a[i].z = (lower_bound(dataZ.begin(), dataZ.end(), a[i].	169	printf("%d %lld\n", ans, cnt);
	z) - dataZ.begin()) + 1;	170	}
157	}	171	return 0;
158	zLim = dataZ.size();	172 }	
159	for (t = 1; t <= zLim + 1; t <= 1);		
160	sort(a + 1, a + n + 1, comx);		

Listing 5.1: hdu4742.cpp