ACM Template

UESTC_Jungle

Last build at October 23, 2018

Contents

1 Datastructure

1.1 Fenwick

```
/* Fenwick Tree (Binary Indexed Tree), by Abreto <m@abreto.net>. */
#include <cstring>

using namespace std;

template <class T = int, int MAXN = 100001>
struct fenwick {
  static inline int lowbit(int x) {
    return (x&(-x));
  }
  int N;
  T f[MAXN]; /* 1=based. */
  fenwick(void):N(MAXN) {
    init();
  }
  fenwick(int n):N(n) {
    init();
  }
  void init(void) {
    memset(f,0,sizeof(f));
  }
  void upd(int i, T dx) {
    while(i <= N) {
      f[i] += dx;
      i += lowbit(i);
    }
  }
  T sum(int i) {
    T ret = 0;
    while(i) {
      ret += f[i];
      i -= lowbit(i);
    }
    return ret;
  }
};
```

```
/* Fenwick Tree (Binary Indexed Tree), by Abreto <m@abreto.net>. */

#define MAXN 100001
#define LOWBIT(x)   ((x)&(-(x)))

int N;
int fen[MAXN];

void update(int i, int dx) {
  while(i <= N) {
    fen[i] += dx;
    i += LOWBIT(i);
  }
}

int sum(int i) {
  int s = 0;
  while(i > 0) {
    s += fen[i];
    i -= LOWBIT(i);
  }
  return s;
}
```

1.2 BST in pb_ds

```
/* Red-Black tree via pb_ds. */
#include<bits/stdc++.h>
#include<ext/pb_ds/assoc_container.hpp>
#include<ext/pb_ds/tree_policy.hpp>
using namespace __gnu_pbds;
using namespace std;
template <typename T>
using ordered_set = tree<T, null_type, less<T>, rb_tree_tag,
    tree_order_statistics_node_update>;

int main() {
  ordered_set<int>  s;
  s.insert(1);
  s.insert(3);
  cout << s.order_of_key(2) << endl; // the number of elements in the s less than 2
  cout << *s.find_by_order(0) << endl; // print the 0-th smallest number in s(0-based
      )
}
```

1.3 Segment Tree

```
/* Segment tree (Interval tree, range tree), by Abreto <m@abreto.net>. */

template <int STMAX = 1000000>
struct segment_tree {
  struct node_t {
    static inline node_t merge(node_t n1, node_t n2) {
      node_t ans;
      ans.l = n1.l;
      ans.r = n2.r;
      /* merge n1 and n2 to ans. */
      return ans;
    }

    /* Data field */
    int l,r;
  } nodes[(STMAX+1)<<2];

  struct lazy_t {
    int marked; /* Optional */
    /* lazy mark. */

    lazy_t(void) {
      clear();
    }
    void clear(void) {
      marked=0;
    }
  } marks[(STMAX+1)<<2];

  inline void maintain_leaf(int o, int idx) {
    nodes[o].l = nodes[o].r = idx;
    /* Operations to single elements ... */
  }
  inline void maintain(int o) {
    nodes[o] = node_t::merge(nodes[o<<1], nodes[o<<1|1]);
  }

  /* Usage: build(1,1,n); */
  void build(int o, int l, int r) { /* [l,r] */
```

```
    if( r <= l ) {
      maintain_leaf(o, l);
    } else {
      int mid = l+r>>1;
      build(o<<1, l, mid);
      build(o<<1|1, mid+1, r);
      maintain(o);
    }
  }

  /* Modify all elements in [l,r] */
  void mark(lazy_t act, int o) {
    /* do something .. */
    marks[o].marked = 1;
  }

  /* Pass cached updates. */
  void pushdown(int o) {
    if( marks[o].marked ) {
      mark(marks[o], o<<1);
      mark(marks[o], o<<1|1);
      marks[o].clear();
    }
  }

  /* Do act on all elements in [L,R] */
  void upd(int L, int R, lazy_t act, int o, int l, int r) {
    if( L <= l && r <= R ) {
      mark(act, o);
    } else if (L <= R) {
      int mid = (l+r)>>1;
      pushdown(o);
      if( L <= mid ) upd(L, R, act, o<<1, l, mid);
      if( R > mid ) upd(L, R, act, o<<1|1, mid+1, r);
      maintain(o);
    }
  }

  node_t qry(int L, int R, int o, int l, int r) {
    if(L <= l && r <= R)
      return nodes[o];
    else if (L <= R) {
      int mid = (l+r)>>1;
      pushdown(o);
      if(R <= mid) return qry(L,R,o<<1,l,mid);
      if(L > mid) return qry(L,R,o<<1|1,mid+1,r);
      return node_t::merge(qry(L,R,o<<1,l,mid),qry(L,R,o<<1|1,mid+1,r));
    }
  }

  int N;

  segment_tree(void):N(STMAX) {}
  segment_tree(int n):N(n) {}
  void build(int n) {
    N = n;
    build(1,1,N);
  }
  void update(int L, int R, lazy_t act) {
    upd(L,R,act,1,1,N);
  }
  node_t query(int L, int R) {
    return qry(L,R,1,1,N);
  }
```

```
};
```

```
/* Segment tree (Interval tree, range tree), by Abreto <m@abreto.net>. */

#define MAXN    1000001

typedef struct {
  int l,r;
  /* Data field */
} node_t;

node_t merge(node_t n1, node_t n2) {
  node_t ans;
  ans.l = n1.l;
  ans.r = n2.r;
  /* merge n1 and n2 to ans. */
  return ans;
}

typedef struct {
  int marked; /* Optional */
  /* lazy mark. */
} lazy_t;

int A[MAXN];
node_t nodes[MAXN<<2];
lazy_t marks[MAXN<<2];

void maintain_leaf(int o, int idx) {
  nodes[o].l = nodes[o].r = idx;
  /* Operations to single elements ... */
}
void maintain(int o) {
  nodes[o] = merge(nodes[o<<1], nodes[o<<1|1]);
}

/* Usage: build(1,1,n); */
void build(int o, int l, int r) { /* [l,r] */
  if( r <= l ) {
    maintain_leaf(o, l);
  } else {
    int mid = l+r>>1;
    build(o<<1, l, mid);
    build(o<<1|1, mid+1, r);
    maintain(o);
  }
  marks[o].marked = 0;
}

/* Modify all elements in [l,r] */
void mark(lazy_t act, int o) {
  /* do something .. */
  marks[o].marked = 1;
}

/* Pass cached updates. */
void pushdown(int o) {
  if( marks[o].marked ) {
    mark(marks[o], o<<1);
    mark(marks[o], o<<1|1);
    marks[o].marked = 0;
  }
}

```

```
/* **DISCARDED** */
/* Set A[p]=v. Usage: modify(p, v, 1, 1, n);
void modify(int p, int v, int o, int l, int r)
{
    if( r - l < 2 )
    {
        maintain_leaf(o, v);
    } else {
        int mid = (l+r)/2;
        pushdown(o);
        if( p <= mid ) modify(p, v, o*2, l, mid);
        else modify(p, v, o*2+1, mid, r);
        maintain(o);
    }
}*/

/* Do act on all elements in [L,R] */
void update(int L, int R, lazy_t act, int o, int l, int r) {
  if( L <= l && r <= R ) {
    mark(act, o);
  } else if (L <= R) {
    int mid = (l+r)>>1;
    pushdown(o);
    if( L <= mid ) update(L, R, act, o<<1, l, mid);
    if( R > mid ) update(L, R, act, o<<1|1, mid+1, r);
    maintain(o);
  }
}
```

1.4 Sparse Table

```
/* RMQ with Sparse Table, by Abreto <m@abreto.net>. */

int min(int a, int b) {
  return (a<b)?a:b;
}

#define MAXN    100001
#define MAXLOG  32

int N;
int A[MAXN];    /* indexed from 0. */
int st[MAXN][MAXLOG];

void st_init() {
  int i = 0, j = 0, t = 0;
  for(i = 0; i < N; ++i) st[i][0] = A[i];
  for(j = 1; (t=(1<<j)) <= N; ++j)
    for(i = 0; (i+t-1) < N; ++i)
      st[i][j] = min(st[i][j-1], st[i+(t>>1)][j-1]);
  /* st(i,j) = min(st(i,j-1), st(i+2^(j-1),j-1)). */
}

int st_query(int l, int r) {
  int k = 0;
  while((1<<(k+1)) <= (r-l+1)) k++;
  return min(st[l][k], st[r-(1<<k)+1][k]);
}
```

1.5 Treap

```
#include <bits/stdc++.h>

using namespace std;

#define MAXN  (2560000)

int __treap_mem[MAXN];
void init_treap_mem(void) {
  for( int i = 1 ; i < MAXN ; i++ )
    __treap_mem[i-1] = i;
}
int alloc_address(void) {
  int ret = __treap_mem[0];
  __treap_mem[0] = __treap_mem[ret];
  return ret;
}
void free_address(int p) {
  __treap_mem[p] = __treap_mem[0];
  __treap_mem[0] = p;
}

typedef int key_t;
typedef int val_t;
struct treap {
  key_t x;
  val_t v;
  int r;    /* random priority */
  int eq, s;  /* number of equal ones, size of subtree (include root itself) */
  treap *fa;  /* point to its father */
  treap *ch[2]; /* 0 for left child, 1 for right child. */

  treap(void);
  inline void maintain(void); /* update s */
  inline void set_child(int d, treap *child);
  inline int which(void); /* determine which child this is of its father */
  inline int cmp(key_t ox); /* determine which child to insert ox */
  treap *rotate(void);  /* rotate this to its father, return this */
} treap_nodes[MAXN];

treap *new_treap(key_t x, val_t v, treap *f) {
  treap *ret = treap_nodes + alloc_address();
  ret->x = x;
  ret->v = v;
  ret->eq = ret->s = 1;
  ret->fa = f;
  ret->ch[0] = ret->ch[1] = NULL;
}
void free_treap(treap *p) {
  free_address( p - treap_nodes );
}
void treap_clear(void) {
  init_treap_mem();
}

treap::treap(void) {
  r = rand();
  eq = s = 0;
  fa = ch[0] = ch[1] = NULL;
}
inline void treap::maintain(void) {
  s = eq;
  for( int i = 0 ; i < 2 ; i++ )
    if( ch[i] )
      s += ch[i]->s;
```

```
}
inline void treap::set_child(int d, treap *child) {
  ch[d] = child;
  maintain();
  if( child ) child->fa = this;
}
inline int treap::which(void) {
  if( NULL == fa ) return -1; /* this is not a child */
  else return ( fa->ch[1] == this );
}
inline int treap::cmp(key_t ox) {
  if( ox == x ) return -1;  /* equal */
  else return ( ox > x );   /* left less, right more */
}
treap *treap::rotate(void) {
  if ( NULL == fa ) return this;  /* no father, already global root. */
  int d = which();
  fa->set_child(d, ch[d^1]);
  set_child(d^1, fa);
  return this;
}

// --- deprecated |
typedef int T;

struct node {
  T v;  /* value of this node */
  int r;  /* random priority */
  int eq; /* the number of equal things */
  int s;  /* the size of subtree rooted at this */
  node *ch[2];  /* 0 for left child, 1 for right child. */
  node(void) {
    r = rand();
    ch[0] = ch[1] = NULL;
  }
  /* return where to insert x */
  int cmp(T x) {
    if(v == x) return -1;
    else return (x < v) ? 0 : 1;
  }
  /* return 1 if this node is prior to other */
  int pri(node *o) {
    return (r > (o->r));
  }
  /* maintain the s field */
  void maintain(void) {
    s = eq;
    if(NULL != ch[0]) s += ch[0]->s;
    if(NULL != ch[1]) s += ch[1]->s;
  }
};

/* move o to ch[d] of o->ch[d^1] */
void rotate(node *&o, int d) {
  node *k = o->ch[d^1];
  o->ch[d^1] = k->ch[d];
  o->maintain();
  k->ch[d] = o;
  k->maintain();
  o = k;
}
```

1.6 Splay

```
/* splay, by Abreto<m@abreto.net>. */

#ifndef NULL
#define NULL 0
#endif

struct node {
  node *f, *ch[2];
  int sz;
  node(node *fa = NULL, node *lc = NULL, node *rc = NULL) {
    f = fa;
    ch[0] = lc;
    ch[1] = rc;
    maintain();
  }
  inline int szof(const int d) const {
    return ch[d] ? ch[d]->sz : 0;
  }
  inline void maintain(void) {
    sz = szof(0) + szof(1) + 1;
  }
  inline int which(void) {
    if (NULL == f) return 0;
    return (f->ch[1] == this);  /* f[which()] == this */
  }
  inline node *setf(node *fa, int d = 0) {
    f = fa;
    if (f) {
      f->ch[d] = this;
      f->maintain();
    }
    return f;
  }
  inline node *setc(node *son, int d = 0) {
    ch[d] = son;
    if (son) son->f = this;
    maintain();
    return this;
  }
  /* rotate this to its fater, return this. */
  inline node *rotate(void) {
    if (f != NULL) {
      node *ff = f->f;
      int d = which(), fd = f->which();
      setc(f->setc(ch[d ^ 1], d), d ^ 1);
      setf(ff, fd);
    }
    return this;
  }
  /* splay this to child of target */
  inline node *splay(node * const target = NULL) {
    while (f != target) {
      if (target != f->f) {
        ( (which() == f->which()) ? f : this )->rotate();
      }
      rotate();
    }
    return this;
  }
  /* 0-based rank */
  inline node *get_k_th(unsigned k) {
    node *p = this;
```

```
    int rank;
    while (k != (rank = (p->szof(0)))) {
      if (k < rank) {
        p = p->ch[0];
      } else {
        k -= (rank + 1);
        p = p->ch[1];
      }
    }
    return p->splay(f);
  }
};
```

```
/* HDU 3487 - Play with Chain, by Abreto<m@abreto.net>. */
#include <bits/stdc++.h>

using namespace std;

#define MAXN    300300

int n, m;

#define LC(p)   ch[p][0]
#define RC(p)   ch[p][1]
#define TARGET(p) LC(RC(p))

int nodes;
int val[MAXN], ch[MAXN][2], fa[MAXN], sz[MAXN];
int rev[MAXN];

inline int new_node(int v, int f) {
  int p = (++nodes);
  val[p] = v;
  fa[p] = f;
  ch[p][0] = ch[p][1] = rev[p] = 0;
  sz[p] = 1;
  return p;
}
inline void maintain(int p) {
  if (p) {
    sz[p] = sz[LC(p)] + sz[RC(p)] + 1;
  }
}
inline void make_child(int f, int d, int p) { /* make p the d-th ch of f */
  ch[f][d] = p;
  if(p) fa[p] = f;
}
inline void myrev(int p) {
  if (p) {
    rev[p] ^= 1;
    swap(LC(p), RC(p));
  }
}
inline void pushdown(int p) {
  if(p && rev[p]) {
    if(LC(p)) myrev(LC(p));
    if(RC(p)) myrev(RC(p));
    rev[p] = 0;
  }
}
int build(int f = 0, int l = 0, int r = n+1) {
  if(r < l) return 0;
  if(l == r) return new_node(l, f);
  int mid = l+r>>1;
```

```
52    int p = new_node(mid, f);
53    LC(p) = build(p, l, mid-1);
54    RC(p) = build(p, mid+1, r);
55    maintain(p);
56    return p;
57  }
58  inline int which(int p) {  /* return 1 if p is a right child or 0 if p is a left
        child. */
59    return (RC(fa[p]) == p);
60  }
61  inline int rotate(int p) { /* rotate p to its father. [!] make sure p is not global
        root. */
62    int f = fa[p], ff = fa[f];
63    if(0 == f) return p;  /* p is global root */
64    pushdown(f);
65    pushdown(p);
66    int d = which(p), df = which(f);
67    make_child(f, d, ch[p][d^1]);
68    make_child(p, d^1, f);
69    maintain(f);
70    maintain(p);
71    fa[p] = ff;
72    if(ff) ch[ff][df] = p;
73    return p;
74  }
75  inline int splay(int p, int fr) { /* splay p to the son of fr, return p. */
76    pushdown(p);
77    while(fa[p] != fr) {
78      int f = fa[p], dp = which(p);
79      if(fa[f] == fr) {
80        return rotate(p);
81      } else {
82        int df = which(f);
83        if(dp == df) {
84          rotate(f);
85        } else {
86          rotate(p);
87        }
88        rotate(p);
89      }
90    }
91    return p;
92  }
93  inline int get_k_th(int root, int k) {
94    int p = root;
95    int rank;
96    while(k != (rank = (sz[LC(p)] + 1))) {
97      pushdown(p);
98      if(k < rank) p = LC(p);
99      else {
100       k -= rank;
101       p = RC(p);
102     }
103   }
104   return splay(p, fa[root]);
105 }
106 inline int merge(int left, int right) {
107   pushdown(left);
108   if(RC(left)) left = get_k_th(left, sz[left]);
109   RC(left) = right;
110   maintain(left);
111   fa[right] = left;
112   return left;
113 }
```

```
114 inline int split(int root, int d) { /* split ch[root][d], return the root of splited
        out. */
115   pushdown(root);
116   int child = ch[root][d];
117   ch[root][d] = 0;
118   maintain(root);
119   fa[child] = 0;
120   return child;
121 }
122 inline int concat(int root, int d, int p) { /* make p be ch[root][d], return root */
123   pushdown(root);
124   ch[root][d] = p;
125   fa[p] = root;
126   maintain(root);
127   return root;
128 }
129
130 void myclear(void) {
131   nodes = 0;
132 }
133
134 int ans[MAXN];
135 void inorder(int p, int &pos) {
136   if(0 == p) return;
137   pushdown(p);
138   inorder(LC(p), pos);
139   if( (0 < val[p]) && (val[p] < n+1) ) ans[pos++] = val[p];
140   inorder(RC(p), pos);
141 }
142
143 void handle() {
144   int i;
145   int root;
146   myclear();
147   root = build(0);
148   while(m--) {
149     char command[8];
150     int a, b, c;
151     int tar;
152     scanf("%s%d%d", command, &a, &b);
153     if('C' == command[0]) {
154       scanf("%d", &c);
155       root = get_k_th(root, a);
156       RC(root) = get_k_th(RC(root), b-a+2);
157       tar = split(RC(root), 0);
158       maintain(root);
159       root = get_k_th(root, c+1);
160       RC(root) = get_k_th(RC(root), 1);
161       RC(root) = concat(RC(root), 0, tar);
162       maintain(root);
163     } else {
164       root = get_k_th(root, a);
165       RC(root) = get_k_th(RC(root), b-a+2);
166       myrev(TARGET(root));
167     }
168   }
169   int pos = 0;
170   inorder(root, pos);
171   for(i = 0; i < n; i++) printf("%s%d", i ? " ":"", ans[i]);
172   puts("");
173 }
174
175 int main(void) {
176   while( scanf("%d%d", &n, &m) && (n > 0) && (m > 0) )
```

```
177     handle();
178   return 0;
179 }
```

2 Dynamic Programming

2.1 LIS $O(n \log n)$

```
1
2  int top = 0;
3  for( int i=1; i<=n; i++ ) {
4    if( ap[i] > dp[top] ) { // 如果大于 ”模拟栈” 的栈顶元素直接 入栈 长度加 1
5      top++;
6      dp[top] = ap[i];
7      continue;
8    }
9    int m = ap[i];
10   // lower_bound 前闭后开 返回不小于 m 的最小值的位置
11   pos = lower_bound(dp,dp+top,m)-dp; // 注意减去dp
12   if( dp[pos] > ap[i])
13     dp[pos] = ap[i];
14 }
```

2.2 LCS $O(n \log n)$

总的来说，就是把 LCS 转化成 LIS，然后用 LIS 的 $\mathcal{O}(N \log N)$ 算法来求解。
实现如下：（引用）
假设有两个序列 $s_1[1 \ldots 6] = abcadc$, $s_2[1 \ldots 7] = cabedab$.
记录 s_1 中每个元素在 s_2 中出现的位置, 再将位置按降序排列, 则上面的例子可表示为：
$loc(a) = \{6, 2\}$, $loc(b) = \{7, 3\}$, $loc(c) = \{1\}$, $loc(d) = \{5\}$. (倒着扫一遍 s_2 即可把位置扔进 vector).
将 s_1 中每个元素的位置按 s_1 中元素的顺序排列成一个序列 $s_3 = \{6, 2, 7, 3, 1, 6, 2, 5, 1\}$.
在对 s_3 求 LIS 得到的值即为求 LCS 的答案。

2.3 Improved by quadrilateral inequality

```
1  /*
2   * 四边形不等式
3   *
4   * 如果 dp(i,j) 满足 dp(i,j)<=dp(i,j+1)<=dp(i+1,j+1)
5   * 那么决策 s(i,j) 满足 s(i,j)<=s(i,j+1)<=s(i+1,j+1)
6   * 可以变形为:
7   *       s(i-1,j) <= s(i,j) <= s(i,j+1)  // dp方向：i增j减
8   *  或
9   *       s(i,j-1) <= s(i,j) <= s(i+1,j)  // dp方向：区间长度L增
10  */
11 #include <bits/stdc++.h>
12
13 using namespace std;
14
15 #define MAXN    1024
16 #define inf     (0x3fffffff)
17
18 int n, m;
19 int v[MAXN];
20 int s[MAXN];
21 int w[MAXN][MAXN];
22 int dp[MAXN][MAXN];
23 int c[MAXN][MAXN];
24
25 int wa(void) {
26   int i, j, k;
27   for(i = 1; i <= n; ++i) {
28     scanf("%d", v+i);
29     s[i] = v[i] + s[i-1];
```

```
  }
  for(i = 1; i <= n; ++i) {
    w[i][i] = 0;
    for(j = i+1; j <= n; ++j)
      w[i][j] = w[i][j-1] + v[j] * (s[j-1] - s[i-1]);
  }
  /* doing dp */
  for(i = 1; i <= n; ++i) {
    dp[i][0] = w[1][i];
    c[i][0] = 1;
    c[i][i] = i-1;
    for(j = i-1; j > 0; j--) {
      dp[i][j] = inf;
      for(k = c[i-1][j]; k <= c[i][j+1]; ++k)
        if(dp[k][j-1]+w[k+1][i] <= dp[i][j]) {
          dp[i][j] = dp[k][j-1] + w[k+1][i];
          c[i][j] = k;
        }
    }
  }
  /* dp done */
  return dp[n][m];
}

int main(void) {
  while(EOF != scanf("%d%d", &n, &m) && n && m) {
    printf("%d\n", wa());
  }
  return 0;
}
```

2.4 Improved by Slope

```
/* type 1: */
/* bzoj 1010 */
#include <bits/stdc++.h>

using namespace std;
typedef long double ll;
#define MAXN    50050
#define eps     (1e-8)

int N;
ll L;
ll S[MAXN];
ll f[MAXN];
ll dp[MAXN];

inline ll k(int j) {
  return (-2.0) * (f[j] + L);
}
inline ll b(int j) {
  return dp[j] + f[j]*f[j] + 2ll*f[j]*L;
}
inline ll g(int j, int i) {
  return k(j) * f[i] + b(j);
}

/* check if l1 & l3 <= l2 */
inline int check(int l1, int l2, int l3) {
  /*ll left = b(l3)*k(l1)+b(l1)*k(l2)+b(l2)*k(l3);
  ll right = b(l1)*k(l3)+b(l3)*k(l2)+b(l2)*k(l1);*/
  ll left = b(l3)*k(l1)-b(l1)*k(l3);
```

```
31    ll right = k(l2)*(b(l3)-b(l1))+b(l2)*(k(l1)-k(l3));
32    return (left <= right);
33  }
34
35  int Q[MAXN], ql, qr;
36
37  int main(void) {
38    int i;
39    scanf("%d%Lf", &N, &L);
40    L += 1.0;
41    for(i = 1; i <= N; ++i) {
42      scanf("%Lf", S+i);
43      S[i] += S[i-1];
44      f[i] = S[i] + (double)i;
45    }
46    Q[qr++] = 0;
47    for(i = 1; i <= N; ++i) {
48      /* <!-- STARED */
49      for(; ql+1 < qr && g(Q[ql],i) >= g(Q[ql+1],i); ql++);
50      dp[i] = g(Q[ql], i) + f[i]*f[i] + L*L; //printf("%d: %lld,%lld\n", i, dp[i], dp[i
            ]-f[i]*f[i]);
51      for(; ql+1 < qr && check(Q[qr-2], Q[qr-1], i); qr--);
52      Q[qr++] = i;
53      /* --> */
54    }
55    printf("%lld\n", (long long int)round(dp[N]));
56    return 0;
57  }
```