Implementation in Competitive Programming

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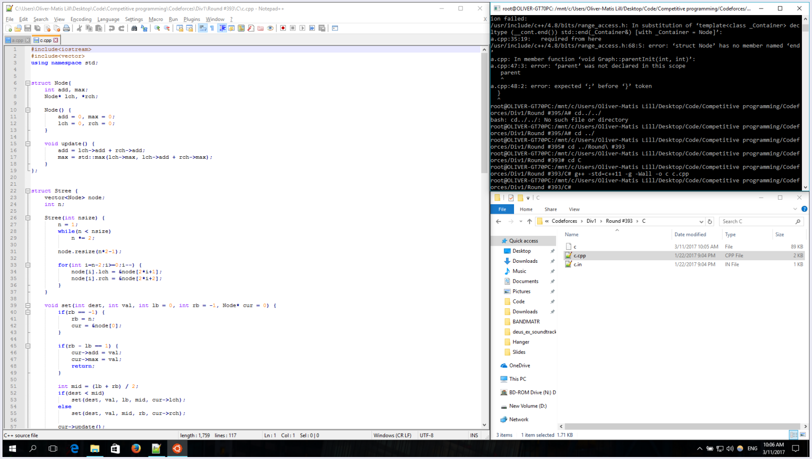
Lecture Structure

- At the beginning I will hold a lecture
- Rest of the lecture will be spent on problem solving

Subjects

- Work environment
- Standard library
- Implementation tips

My Programming Environment


C:\Users\Oliver-Matis Lill\Desktop\Code\Competitive programming\Codeforces\Div1\Round #393\C\c.cpp - Notepad++
File Edit Search View Encoding Language Settings Macro Run Plugins Window ?
a.cpp
c.cpp

```cpp
#include<iostream>
#include<vector>
using namespace std;


struct Node{
    int add, max;
    Node* lch, *rch;

    Node() {
        add = 0, max = 0;
        lch = 0, rch = 0;
    }

    void update() {
        add = lch->add + rch->add;
        max = std::max(lch->max, lch->add + rch->max);
    }
};


struct Stree {
    vector<Node> node;
    int n;

    Stree(int nsize) {
        n = 1;
        while(n < nsize)
            n *= 2;

        node.resize(n*2-1);

        for(int i=n-2;i>=0;i--) {
            node[i].lch = &node[2*i+1];
            node[i].rch = &node[2*i+2];
        }
    }

    void set(int dest, int val, int lb = 0, int rb = -1, Node* cur = 0) {
        if(rb == -1) {
            rb = n;
            cur = &node[0];
        }

        if(rb - lb == 1) {
            cur->add = val;
            cur->max = val;
            return;
        }

        int mid = (lb + rb) / 2;
        if(dest < mid)
            set(dest, val, lb, mid, cur->lch);
        else
            set(dest, val, mid, rb, cur->rch);

        cur->update();
```

C++ source file
length : 1,759 lines : 117
Ln : 1 Col : 1 Sel : 0 | 0
Windows (CR LF)
UTF-8
INS
root@OLIVER-GT70PC: /mnt/c/Users/Oliver-Matis Lill/Desktop/Code/Competitive programming/Codeforces/...

```
ion failed:
/usr/include/c++/4.8/bits/range_access.h: In substitution of ‘template<class _Container> dec
ltype (__cont.end()) std::end(_Container&) [with _Container = Node]’:
a.cpp:35:19:   required from here
/usr/include/c++/4.8/bits/range_access.h:68:5: error: ‘struct Node’ has no member named ‘end
’

a.cpp: In member function ‘void Graph::parentInit(int, int)’:
a.cpp:47:3: error: ‘parent’ was not declared in this scope
   parent
   ^

a.cpp:48:2: error: expected ‘;’ before ‘}’ token
  }
  ^
root@OLIVER-GT70PC:/mnt/c/Users/Oliver-Matis Lill/Desktop/Code/Competitive programming/Codef
orces/Div1/Round #395/A# cd../../
bash: cd../../: No such file or directory
root@OLIVER-GT70PC:/mnt/c/Users/Oliver-Matis Lill/Desktop/Code/Competitive programming/Codef
orces/Div1/Round #395/A# cd ../
root@OLIVER-GT70PC:/mnt/c/Users/Oliver-Matis Lill/Desktop/Code/Competitive programming/Codef
orces/Div1/Round #395# cd ../Round\ #393
root@OLIVER-GT70PC:/mnt/c/Users/Oliver-Matis Lill/Desktop/Code/Competitive programming/Codef
orces/Div1/Round #393# cd C
root@OLIVER-GT70PC:/mnt/c/Users/Oliver-Matis Lill/Desktop/Code/Competitive programming/Codef
orces/Div1/Round #393/C# g++ -std=c++11 -g -Wall -o c c.cpp
root@OLIVER-GT70PC:/mnt/c/Users/Oliver-Matis Lill/Desktop/Code/Competitive programming/Codef
orces/Div1/Round #393/C#
```

Name	Date modified	Type	Size
c	3/11/2017 10:05 AM	File	89 KB
c.cpp	1/22/2017 9:04 PM	CPP File	2 KB
c.in	1/22/2017 9:04 PM	IN File	1 KB

My Tools

- Bash on Ubuntu on Windows - Linux command line on windows, more convenient than a virtual machine
- Notepad++ - Good text editor for windows
- Windows Explorer - You can run stuff from the address bar
- g++ - Compiles C++ files
- gdb - Debugging tool

Standard Library

- Most languages have their own standard library
- Contains a lot of functions, objects and other stuff that give you a lot of power
- Accessible in almost any environment (including in programming contests)
- Very useful in contests

Elements from the Standard Library

Some useful C++ standard library functions/classes:

1. vector - resizeable array of objects
2. sort - sorting function. Can use your own predicate. $O(N \log N)$ complexity
3. lower_bound\upper_bound - binary search on sorted array. $O(\log N)$ complexity
4. priority_queue - heap. $O(\log N)$ insertion, deletion, maximum finding
5. set\map - very powerful self-balancing binary tree. $O(\log N)$ insertion, deletion, lookup. In practice, these operations are slower than binary search and heap operations

Problems 1, 2, 3 test your skill with the Standard Library

Standard Library Summary

- Learn to use some standard library reference. My favorite for C++ is: `http://www.cplusplus.com/reference/`
- Experiment with the standard library as much as possible (especially in competitive programming)
- Useful everywhere

Implementation

- Implementation is creative work
- There are many ways to implement the same thing, some better than others
- Focus on the readability and elegance of your code. Those attributes are useful for example:
  1. For avoiding and fixing bugs
  2. For implementing very complicated stuff
  3. For focusing when writing code
  4. When sharing code with others
- The following tips should be helpful in achieving that

Locality

- Declare your variables in as small scope as possible
- Makes it clearer where and how the variables are used
- Allows you to better reuse variable names
- Helps you avoid mixing up variables

Example

```
//... includes, etc ...
int ind, a, b;
long long dp[20][20];

int main() {
    //... some code ...
    if(something) {
        //... use the variables ...
    }
}
```

$\rightarrow$

```
//... includes, etc ...

int main() {
    //... some code ...
    if(something) {
        int ind, a, b;
        long long dp[20][20];
        //... use the variables ...
    }
}
```

Scope

- Scope can be created without keywords (like if/while)
- Useful for creating locality

Example

```
//... includes, etc ...
int main() {
    //... some code ...

    int x, y, dx, dy;
    //... use those variables ...

    //... some unrelated code ...

    double xd, yd, dxd, dyd;
    //... use those variables ...
}
```

$\rightarrow$

```
//... includes, etc ...
int main() {
    //... some code ...
    {
        int x, y, dx, dy;
        //... use those variables ...
    }
    //... some unrelated code ...
    {
        double x, y, dx, dy;
        //... use those variables ...
    }
}
```

Keyword static

- Enables you to declare global variables in local scope, giving them the benefits of locality

Example

```
//... includes, etc ...
int dp1[1001][1001];
double dp2[101][50001];

int function1() {
    //... calculation on dp1 ...
    return dp1[1000][1000]
}
double function2() {
    //... calculation on dp2 ...
    return dp2[100][50000];
}
// ... rest of the code ...
```

$\rightarrow$

```
//... includes, etc ...

int function1() {
    static int dp[1001][1001];
    //... calculation on dp ...
    return dp[1000][1000]
}
double function2() {
    static double dp[101][50001];
    //... calculation on dp ...
    return dp[100][50000];
}
// ... rest of the code ...
```

Object Oriented Programming

- OOP (Object Oriented Programming) is a very powerful tool. Learn to use it!
- Allows you to logically connect variables, functions and etc.
- Gives you more options to create locality
- Allows you to declare functions locally

Object Oriented Programming

Example

```
//... includes, etc ...
vector<int> arc[2][100000];
int weight[2][100000];

void construct(int i, int seed) {
    //uses arc[i] and weight[i]
}
int calculate(int i) {
    //uses arc[i] and weight[i]
}
int main() {
    construct(0, 15);
    construct(1, 2017);
    cout<<calculate(0)<<'␣';
    cout<<calculate(1)<<'\n';
}
```

$\rightarrow$

```
//... includes, etc ...
struct Graph {
    vector<int> arc[100000];
    int weight[100000];
    //constructor
    Graph(int seed) {
        //uses arc and weight
    }
    int calculate() {
        //uses arc and weight
    }
};
int main() {
    static Graph g1(15), g2(2107);
    cout<<g1.calculate()<<'␣';
    cout<<g2.calculate()<<'\n';
}
```

Initializer List

- Gives you a very elegant way to initialize objects
- Can be used to initialize standard library objects

Example

```
//... includes, etc ...
struct Object {
    int cnt, val, size;
};
int main() {
    Object cur;
    cur.cnt = 1, cur.val = 10;
    cur.size = 2;
    vector<int> arr(3);
    arr[0] = 2, arr[1] = 15;
    arr[2] = 52;
}
```

→

```
//... includes, etc ...
struct Object {
    int cnt, val, size;
};
int main() {
    Object cur = {1, 10, 2};
    vector<int> arr = {2, 15, 52};
}
```

Lambda Functions

- Allows you to create one-time, nameless local functions
- Makes sorting with a function simpler and more readable

Example

```
//... includes, etc ...
bool pred(Object l, Object r) {
    return l.cnt*l.val <
          r.cnt*r.val;
}
int main() {
    //... some code ...
    vector<Object> objects;
    //... construct objects ...
    sort(objects.begin(),
        objects.end(),
        pred);
}
```

$\rightarrow$

```
//... includes, etc ...
int main() {
    //... some code ...
    vector<Object> objects;
    //... construct objects ...
    sort(objects.begin(),
        objects.end(),
        [](Object l, Object r)
       {return l.cnt*l.val <
             r.cnt*r.val;});
}
```

Pointers

- More convenient way to refer to objects than indices, cur->next[1]->next[3] is better than next[next[cur][1]][3]
- Useful for finding multiple orderings of an array of objects

Example

```
vector<Object*> byVal(n);
for(int i=0;i<n;i++) byVal[i] = &object[i];
sort(byVal.begin(), byVal.end(),
        [](Object* l, Object* r) {return l->val < r->val;});

vector<Object*> odd(n/2);
for(int i=1;i<n;i+=2) odd[i/2] = byVal[i];
sort(odd.begin(), odd.end(),
        [](Object* l, Object* r) {return l->size < r->size;});

for(int i=0;i<n/2;i++) odd[i]->result += i;
```

Summary

- Competitive programming can help direct you to write a lot of code
- Use it to develop your implementation skill and to learn to write more elegant and readable code
- The aforementioned tips are only tools, use them intelligently. Don't try to forcibly use something if it's not helpful
- Implementation is creative work and can be quite interesting