[CENG 315 All Sections] Algorithms

THE 7

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Requested files: the7.cpp (Download)
Type of work: Individual work

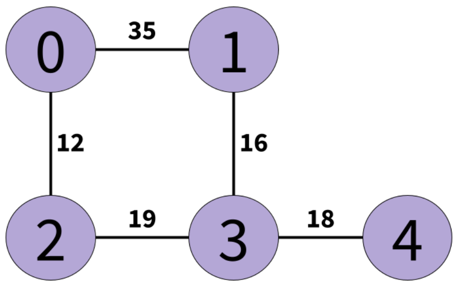
Can Cat Catch the Final?

It's finals week(s) at METU, and Cat is trying to get to her final on time. When Cat is on her way to the building, you call her to remind her that the exam is open book & notes. Turns out she forgot to print her notes and wants to get to the printer to print the slides. Also, Cat realizes that she left her ID in her dorm room, so she also wants to go to her dorm before the exam starts.

You know that Cat needs to follow the shortest route from her location to the exam building, but she also wants to stop by the printer and her dorm. You know how long it takes her to walk between buildings, and how much time she has left until the exam. So you offer your help to Cat to see if she can make it in time by writing a little program. Your program should decide the best thing for Cat to do to be on time for the exam. If she cannot be on time even without stopping by the dorm or the printer, your program should report that it is impossible.

There are **N** buildings in METU. Each building is numbered from **0** to **N-1**. Each building is connected to another building by a road and there are **M** roads on the campus. Each road can be walked in both directions. Moreover, walking each road takes Cat **T** minutes. Cat is currently in building **S**, the exam is in building **D**, the printer is in building **X**, and Cat lives in dorm building **Y**. There are **L** minutes left until the exam starts. So, you need to find the quickest route from **S** that ends in **D** which also visits **X** and **Y.** Additionally, Cat can visit a building (including S, D, X, and Y) *multiple times.*

Example graph of the campus:



L=65 (minutes left for the exam to start)
N=5 (number of buildings)
S=0, **D**=4 (Cat is in building 0, exam is in building 4)
X=1, **Y**=2 (printer is in building 1, dorm is building 2)
M=5 (number of roads)
Roads=[{0, 1, 35}, {0, 2, 12}, {1, 3, 16}, {2, 3, 19}, {3, 4, 18}]
                    ^
                    T (time it takes Cat to walk that road)
PrintPath=0 (0: do not print the path / 1: print the path)

You need to write a function called *CanCatch*, which takes the number of buildings (***N***), information about the ***M*** Roads, the building that you are in (***S***), exam building (***D***), the building the printer is located (***X***), your dorm building (***Y***), and time left until the exam starts (***L***). The function should print whether or not you can catch the exam before it starts, and if you can catch the exam, the function should report the path you need to follow to catch it (you need to print the full path depending on the **PrintPath** parameter). This path may or may not include X and/or Y according to the time Cat has left for the exam:

- **If it is possible to visit both X and Y before the exam starts, you need to choose the shortest path.** The path should start from S, should go through both X and Y, and end in D. If order of visits to X and Y does not change the time cost, *she would rather stop by the printer (X) first, then stop by her dorm (Y).*
- **If it is impossible to visit both X and Y before the exam starts, you need to find the shortest path that goes through only one of them.** The path should start from S, should go through only one of X or Y, and end in D. You need to choose the path with the shortest time. *If Cat can stop by her dorm or the printer at the same time cost, she would rather stop by the printer (X).*
- **If passing through even one of X or Y is not possible timewise, you need to find the shortest path from S to D without visiting X or Y.**

- **If Cat cannot even make it to the exam without stopping by X or Y, you should report that it is impossible to catch the exam.**

Road information is given to you as a vector of **Road** structs. A **Road** struct contains two *buildings* on each end of the road and the *time* it takes to travel that road.

```
struct Road {
  std::pair<int, int> buildings;
  int time;
  Road(std::pair<int, int> bs, int t) : buildings(bs), time(t) {}
};
```

CanCatch's function declaration is:

```
void CanCatch(int n, std::vector<Road> roads, int s, int d, int x, int y, int l, int printPath);
```

Inputs:
----

n = number of buildings **(N)**
roads = information about roads supplied with Road structs.
s = the building Cat is in **(S)**
d = the building of the exam **(D)**
x = the building the printer is located **(X)**
y = Cat's dorm building **(Y)**
l = time left until the exam starts **(L)**
printPath = whether to print the full path (1) or not (0)

Outputs:

You need to print whether Cat can make it in time to the exam or not, and if she can, whether she can visit X and Y, the time it will take her to catch the exam as fast as possible, and the path she should take (if printPath == 1).

Possible output formats are:

```
YES BOTH <time of path>MINUTES
<path>

YES PRINTER <time of path>MINUTES
<path>

YES DORM <time of path>MINUTES
<path>

YES DIRECTLY <time of path>MINUTES
<path>

IMPOSSIBLE
```

The path should be printed in order by separating the building numbers in the path with '->'. An example path that goes through nodes 1, 2, 3, and 4 should be printed as follows:

```
1->2->3->4
```

Note that the last element in the path does not have '->' or a space after it and the output ends with a newline char ('\n').

*Hint: You can use the supplied **PrintRange** function to easily print elements of containers with iterators.*

Example IO:

Input: l=85, n=5, s=0, d=4, x=1, y=2, m=5, printPath=1
roads=[{0, 1, 35}, {0, 2, 12}, {1, 3, 16}, {2, 3, 19}, {3, 4, 18}]

Output:
```
YES BOTH 81MINUTES
0->2->3->1->3->4
```

Input: l=15, n=5, s=0, d=4, x=1, y=2, m=5, printPath = 1
roads=[{0, 1, 35}, {0, 2, 12}, {1, 3, 16}, {2, 3, 19}, {3, 4, 18}]

Output:
```
IMPOSSIBLE
```

Input: l=49, n=5, s=0, d=4, x=1, y=2, m=5, printPath = 0
roads=[{0, 1, 35}, {0, 2, 12}, {1, 3, 16}, {2, 3, 19}, {3, 4, 18}]

Output:

```
YES DORM 49MINUTES
```

Note: Road struct is represented as '{buildings.first, buildings.second, time}'

Constraints:

- 1 ≤ ***L*** ≤ 120
- 4 ≤ ***N*** ≤ 500
- 1 ≤ ***T*** ≤ 250
- All of ***N, S, D, X,*** and ***Y*** are integers.
- ***PrintPath*** either 0 or 1

Specifications:

- Cat can always reach *X, Y,* and *D* from *S*.
- Your output must *exactly* be in the specified format.
- Consider infinity as **INT_MAX** (defined in <climits>)
- The total time for a path won't exceed **INT_MAX**.
- There is **1 task** to be solved in **12 hours** in this take home exam.
- You will implement your solutions in "**the7.cpp**" file.
- You are free to add other functions, classes, structs etc. to "**the7.cpp**"
- **Do not** change the first line of the "**the7.cpp**"
- **Do not** change the arguments of ***CanCatch*** function. ***CanCatch*** function does not have the input *M* as an argument, the input parsing phase is handled for you in the "**main.cpp**" file.
- Some headers, structs, and utility functions are defined in "**the7.h**". You can define your own functions and structs in "**the7.cpp**" file. Using *std::pair* and *std::priority_queue* is allowed.
- The full contents of "**the7.h**" are below:

```
#pragma once

#include <climits>
#include <iostream>
#include <queue>
#include <stack>
#include <unordered_map>
#include <vector>

template <class ForwardIt>
void PrintRange(ForwardIt first, ForwardIt last, std::string delim = "->") {
    if (first == last) {
        return;
    }
    --last;
    for (; first != last; ++first) {
        std::cout << *first << delim;
    }
    std::cout << *first;
}

struct Road {
    std::pair<int, int> buildings;
    int time;
    Road(std::pair<int, int> bs, int t) : buildings(bs), time(t) {}
};

void CanCatch(int n, std::vector<Road> roads, int s, int d, int x, int y, int l, int printPath);
```

- A collection of files have been uploaded to *ODTUClass course page* with the name ***THE7Files*** that you can use if you want to work locally. Note that included test cases are the same ones in the VPL.
- Your code will be compiled with **-Wall** and **-std=c++11** flags.
- You can test your the7.cpp on the virtual lab environment. If you click run, your function will be compiled and executed with sample test cases. If you click evaluate, your work will be temporarily graded for a limited number of inputs.
- The grade you see in the lab is not your final grade, your code will be reevaluated with completely different inputs after the exam.

Evaluation:

- After your exam, black box evaluation will be carried out. You will get full points if you print the time and the path *exactly* as described to stdout.

The system has the following limits:

- a maximum execution time of 10 seconds (your functions should return in less than 2-3 seconds for the largest inputs)
- a 192 MB maximum memory limit
- an execution file size of 2MB.
- Solutions with longer running times **will not be graded**.
- If you are sure that your solution works in the expected complexity constraints but your evaluation fails due to limits in the lab environment, the constant factors may be the problem.

Appendix:

The main in the "**main.cpp**" in supplied files has a function that reads input files and calls the CanCatch function. The path to an input file is given as a command line argument to the executable. You can compile and execute the given code with:

```
g++ -Wall -std=c++11 -o the7 main.cpp the7.cpp
./the7 path/to/test/input
```

The format of the given sample input files is as follows.

```
<L>
<N>
<S> <D>
<X> <Y>
<M>
<building#1> <building#2> <time>  <- Represents a road.
...
<PrintPath>
```

Requested files

the7.cpp

```
#include "the7.h"

// Implement your solution after this line

void CanCatch(int n, std::vector<Road> roads, int s, int d, int x, int y, int l, int printPath) {
    // You can change these variables. These are here for demo only.
    std::vector<int> path;
    int cost = INT_MAX;





    // You can use the PrintRange function to print the path.
    // It helps you print elements of containers with iterators (e.g., std::vector).
    // Usage: PrintRange(path.begin(), path.end());

}
```

VPL