

IN2010

Oblig 2

25. september 2020

Upload your assignment at [Devilry](#) by October 9, 2020 at 23:59. You may deliver in groups consisting of up to three participants.

1 General description: project planner

In this assignment, you are going to develop a project planning tool. A *project* consists of *tasks*, each taking an estimated *time* and certain *manpower* to complete.

Figure 1 shows an example project, where a project with eight tasks is depicted as a directed graph. Each task is represented as a node with a unique identity, time estimate (T), and manpower requirements (M). The dependency between two tasks is represented as a directed edge.

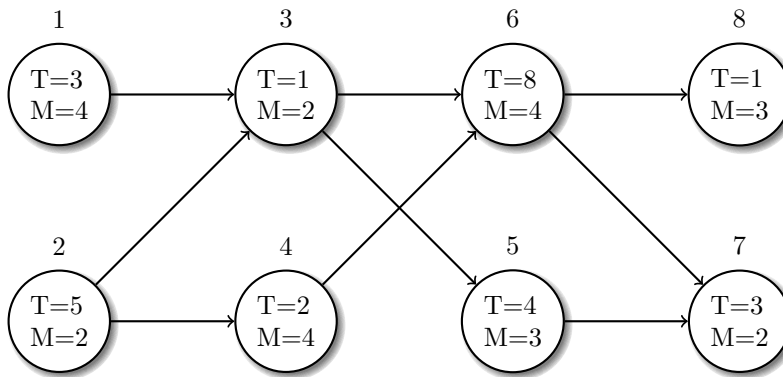


Figure 1: A sample directed graph of a project

2 Problems

Your implementation of the project planner should solve the following problems:

Realizability

Is the project realizable considering only the task dependencies (ignoring manpower and time information). A project is unrealizable if the dependency graph includes one or more cycles, or two nodes depending on each other (it is not possible to realize the project if task 1 has to be completed before task 2 can be started and task 1 cannot be started until task 2 is completed).

If the project is not realizable your program should find a cycle (or two co-depending nodes) and print them before it finally terminates.

NOTE: Your program does not have to find all cycles if there are more than one, just one of them.

Optimal time schedule

If the project is realizable the program should plan an ideal time schedule, so that the project is finished as early as possible. The plan should be given by describing the earliest start and finishing time of each task.

In this assignment we will assume to have infinite manpower. This means that a task can be started as soon as all of its dependencies are finished. For example, in Figure 1, task 6 cannot be started until task 3 and 4 have been completed. This also means that multiple tasks might have to be executed simultaneously in an ideal plan.

NOTE: This is not parallel programming. This assignment does not include threads. You should use one or more graph algorithms to calculate these times.

Latest start, slack and critical tasks

Because a task may depend on multiple tasks, some tasks can be *delayed* without delaying the overall project completion time.

In Figure 1 task 1 can be delayed at least 2 time units as task 3 also must wait for task 2 which takes longer time than task 1. But task 3 might also be delayed because task 5 can be delayed as task 6 takes very long time increasing the maximum time task 1 can be delayed. When a task may be delayed, we say that it has positive (non-zero) *slack* (e.g. task 1 has 3 slack).

Task 2, 4, 6 and 7 may not be delayed though as they represent the longest path (in time steps) through the graph. Tasks that may not be delayed are *critical* and have 0 slack.

Your program should calculate the latest possible finishing time for a task without delaying the overall project completion time as well as slack and whether a task is critical.

3 What should be printed?

The program should print a simulation of the execution of the project. That is, the time schedule, including the starting times, finishing times, and the manpower used at all times. See Figure 3, for a suggested output.

```
Time: 0      Starting: 1
             Starting: 2
             Current staff: 6

Time: 3      Finished: 1
             Current staff: 2

Time: 5      Finished: 2
             Starting: 3
             Starting: 4
             Current staff: 6

Time: 6      Finished: 3
             Starting: 5
             Current staff: 7

Time: 7      Finished: 4
             Starting: 6
             Current staff: 7

Time: 10     Finished: 5
             Current staff: 4

Time: 15     Finished: 6
             Starting: 7
             Starting: 8
             Current staff: 5

Time: 16     Finished: 8
             Current staff: 2

Time: 18     Finished: 7

**** Shortest possible project execution is 18 ****
```

Figure 2: Suggestes output

It should also print a list of all tasks with the following information:

- Identity number

- Name
- Time needed to finish the task
- Manpower required to complete the task
- Earliest starting time
- Slack
- A list of tasks (identities) which depend on this task

4 Complexity and theoretical analysis

In addition to the programming tasks above, you must deliver a short report answering the following questions:

1. What is the time complexity of your solution? You must explain the stated complexity. If you have a different complexity for each problem, you need to discuss them separately.
2. What requirements are there for the input graph in order for the project to be successfully planned? Please put the discussion in the light of graph theoretical properties.
3. What kind of the graph algorithms did you use in your implementation?

This report should have the file named `report.pdf`.

5 Guidelines & hints for the implementation

Reading input files and constructing the graph

A project is given by an input file. At the top of this file is the total number of tasks in the project. The data format of the input file will be a list of task definitions, where each of them is a sequence of the following data:

Identity of this task	integer
Name of this task	a string
Time estimate for this task	integer
Manpower requirements	integer
Dependency edges	A sequence of identities that states which tasks must be completed before this task can start (its predecessors). This list is terminated by a 0.

NOTE: Task ID's are always in the range 1 to `num_tasks`.

To represent the tasks in a graph you can use the following class:

```

class Task {
    int         id, time, staff;
    String      name;
    int         earliestStart, latestStart;
    List <Task> outEdges;
    int         cntPredecessors;
}

```

Remember to test your code thoroughly, and try to check for different corner cases. Remember that a project may have multiple starting nodes.

6 How to deliver

The assignment may be carried out by groups with up to three participants, and delivered through [Devilry](#).

- The implementation language is Java.
- Your implementation must compile on the Linux machines at the University and run with the command:

```
java Oblig2 <projectName>.txt
```

where the argument of the Oblig 2 program is input file specifying the project.

- Your delivery should contain
 - Compilable (and afterwards runnable) source file(s) of your implementation.
 - The report `report.pdf`.
 - A file named `output.txt` in which you put the feedback (print out) from system during execution of projects `buildhouse1`, `buildhouse2`, `examplefigure`, `buildgarage` and `buildrail`.
 - A README-file which contains:
 1. How to compile your program (e.g. `javac *.java`)
 2. Which file includes the main-method
 3. Any assumptions you have made when implementing the assignment
 4. Any peculiarities about your implementation
 5. The status of your delivery (what works and what does not)
 6. Give credit if your code is heavily influenced by some source (e.g. teaching material)