Procrastination at its Finest

Computer Science I Program #5: Binary Heaps

Please check Webcourses for the Due Date

Read all the pages before starting to write your code

Between school, your job and your parents, many people are demanding you to do lots of jobs. Part of the reason they ask you to do so much is that they have high expectations of you.

You've recently learned about the priority queue in Computer Science I and have figured out a "fair" way to lower everyone's expectations of you. Every task that someone asks you to do can be broken down into several segments, and each of those segments takes some known amount of time (in seconds). For example, your recitation program may be done in 5 phases, the first taking 500 seconds, the second taking 1800 seconds, the third taking 5000 seconds, the fourth taking 2000 seconds and the last taking 45 seconds. Whenever working on a task, you just work on the next phase of the task to completion. We assume that no one ever interrupts you, so that you are able to complete a phase you are working on in the time listed to complete it.

With so many people piling up tasks on you, it can become hard to choose what to do. In order to lower everyone's expectations, you've decided that you want to come up with a rule to determine which task to work on next so that you don't really complete any task very quickly!

The idea is as follows:

For each task, keep track of the amount of time remaining, you need to complete the task. For example, if you had completed the first two phases of the recitation program previously mentioned, you would have to do an additional $5000 + 2000 + 45 = 7045$ seconds of work to complete the task.

Then, of all the remaining unfinished tasks, pick the one which has THE MOST work left to complete, breaking ties by the task number (each task will be given a unique identifier number), with the lower task number being chosen first.

Once you choose a task, complete the next phase of that task. If this was the last phase of that task, you've completed the task. If not, then put this task back into your list of work to do (but now it'll have fewer seconds of work left to complete it.)

Then, repeat the process again - choose the next task (could be the same one you chose last time or a different one), that has the most amount of work left to be done.

Of course, different people come to you with tasks at different times, so while you are in the middle of working on some tasks, new tasks may be added to your list of tasks to complete.

The Problem
Given a list of jobs that people hand you to do, that are broken down into phases, as well as the time people give you the task, using the mechanism described, simulate the process of executing the tasks, calculating the time at which each task will get completed. To show that progress is being made, at each time you complete any phase of any task, print out the time, the task number and the phase number that was completed.

The Input (to be read from standard input) - Your Program Will Be Tested on Multiple Files
The first line of the input contains a single positive integer, n ($n \leq 10^6$), representing the number of tasks given to you. Information for each task follows, with information about a single task on one line. The tasks are numbered 1 to n, and ae listed in order by task number.

Each of these lines will have several space separated positive integers.

The ith of these lines starts with a positive integer t_i ($t_i \leq 10^9$), representing the time the ith task is given to you. This is followed by, p_i ($p_i \leq 100$), representing the number of phases for the ith task. This is followed by p_i positive integers, representing the amount of time, in seconds, each phase of the ith task takes, in order. The sum of all the p_i's will not exceed 10^6.

It is guaranteed that the times the tasks are given to you will be in strictly increasing order. (Thus, you'll receive task 1 first, then task 2 at a later time, then task 3 at a time after that, and so forth. Mathematically, $t_i < t_{i+1}$ for all i, $1 \leq i < n$.)

The sum of the time it will take to complete all tasks will not exceed 1,000,000,000 seconds.

The Output (to be printed to standard out)
Each time a phase of a task is completed, output a single line with three space separated integers:

The time the phase was completed, the task it was taken from (in between 1 and n, inclusive), and the phase number from that task that was completed (in between 1 and p_i, inclusive).

```
5
10 3 180 3000 2000
200 5 1800 5000 7000 1000 60
1000 2 20000 1
2000 8 1000 1000 1000 1000 1000 1000 1000 1000
1000000 6 10 20 30 30 20 10
```

```
190 1 1
3190 1 2
23190 3 1
24990 2 1
29990 2 2
36990 2 3
37990 4 1
38990 4 2
39990 4 3
40990 4 4
41990 4 5
42990 4 6
44990 1 3
45990 4 7
46990 2 4
47990 4 8
48050 2 5
48051 3 2
1000010 5 1
1000030 5 2
1000060 5 3
1000090 5 4
1000110 5 5
1000120 5 6
```

Sample Explanation

At first, task 1 is the only one to do. This is true for the first two phases of it. But, after the second phase of task 1 is completed, tasks 2, 3 and 4 have already been added to the priority queue. At this point, task 3 is the furthest from being completed, so we spend 20,000 seconds on its first phase. After this, task 2 is furthers from being completed and continues to be so as we do phases 1, 2 and 3 of task 2. After completing these 3 phases, task 4, with 8,000 seconds left, takes priority. It keeps the priority for 6 consecutive phases until t = 42990. At this time, task 1 has 2000 seconds left, task 2 has 1060 seconds left, task 3 has 1 second left, and task 4 has 200 seconds left. In this case, the tie-break goes to task 1, which finally completes at time t = 44,990. After this task though, we go back to task 4 phase 7, completing that at t = 46,990. At this point in time, task 2 has 1060 seconds left, task 3 has 1 second left and task 4 has 1000 seconds left. Task 2 is chosen. Then, in succession, task 4 completes, followed by task 2 and lastly by task 3. After much idle time, task 5 runs from start to finish.

Implementation Restrictions, Assignment Details

1) You must create a struct to store information about a task:

      a) Its ID Number
      b) Time Assigned
      c) Number of Phases
      d) Integer array, dynamically allocated storing the lengths of each phase
      e) Total Time Left to Complete the Task
      f) 0-based number of which task to complete next.

2) Write a compareTo function that takes in two pointers to the struct you created, and returns a negative integer if the first struct "comes first", a positive integer if the first struct "comes second", and 0 if they are identical. One struct comes before another for the purposes of this program if the total time left to complete the task is longer, or if the total time is the same and its ID number is lower.

3) Create another struct, which is a binary heap of the struct previously mentioned. This struct should store the heap in a dynamically allocated array, that gets resized as needed. Start with a default size of 10.

4) In your implementation, use a single binary heap of tasks. When a new task is given to you, the task is inserted into the binary heap. When you choose a task to work on, you remove the task from the heap. When you complete a phase of a task, if the task isn't complete, you reinsert the task in its new state (with less time left to complete it), back into the heap. Note that while you are "working" on a single phase of a task, several new tasks may be added to your heap. To make things a bit easier, I recommend reading in all of the tasks into a regular array at first, before starting the simulation, and then indexing into that array during the simulation.

5) Though all tasks are assigned at unique times, it's possible that you may complete a phase of a task (but not finish the task) at the exact same time that a new task is given to you. In this situation, add BOTH the new task AND the task with the phase you just completed to the binary heap. AFTER that, select which task to work on next. (Thus, it's possible that either the task you were just working on, OR the new task you just got, or another task will be selected at this point.)

Deliverables
You must submit a two files over WebCourses:

1) A source file, *procrastinate.c*. Please use stdin, stdout. There will be an automatic 10% deduction if you don't do so.

2) Your Process Document, which should be named LASTNAME_PROCESS.doc (or .docx or .pdf or .txt)