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Mars Exploration Project

Introduction

In the hope of getting to know more about Mars and the possibility of life on its surface, a number of exploratory missions to different regions of the planet need to be conducted. Imagine that we have several rovers of different types and capabilities on the surface of Mars ready to carry out missions to its different regions. There is a base station which acts as the central point from which the different rovers begin their exploratory missions and to which they return after mission completion. The base station basically assigns missions to the different rovers.

Using our programming skills and our knowledge of the different data structures, we developed a program that simulates the mission assignment process, the rover assignment process and the rover maintenance process. To be realistic, we included the possibility of mission failure and made the program perform the necessary steps for the occurrence of such event.

Missions

The following pieces of information are available for each mission:

- Formulation Day: the day when the mission formulation is finalized and the mission becomes ready to be assigned to a rover.

- Mission Type: There are 2 types of missions: Emergency and Polar missions.

● Emergency missions must be assigned first before polar missions.

● Polar missions are missions to the polar ice caps of Mars and must be conducted by rovers equipped to navigate in such regions.

- Target Location: The distance (in kilometers) from the base station to the target location of the mission.

- Mission Duration: The number of days needed to fulfill the mission requirements at the target location (assumed constant regardless of rover type).

- Significance: A number representing the importance of the mission and how beneficial it is (the higher the number, the more significant it is).

Mission failure

With a probability of 4%, a mission might fail due to problems in rovers executing it.

In this case:

(1) The rover should be moved to checkup,

(2) The mission is not completed and needs to be re-formulated and added to the list of waiting missions to be assigned later to another rover of the same type.

Rovers

At startup, the system loads (from a file) information about the available rovers. For each rover, the system will load the following information:

- Rover Type: There are 2 types of rovers: Emergency rovers and Polar rovers.

● Emergency rovers are rovers which are over-equipped and ready for emergency missions in almost any region.

● Polar rovers are rovers which can navigate in polar regions.

- Checkup Duration: The duration (in days) of checkups that a rover needs to perform after completing N missions.

- Speed: in kilometers/hour. (Note that a day on Mars is 25 hours.)

Missions Assignment Criteria

To determine the next mission to assign (if a rover is available), the following assignment criteria should be applied for all the formulated un-assigned missions on each day:

1. First, assign emergency missions to ANY available rover of any type. However, there is a priority based on the rover type: first choose from emergency rovers THEN polar rovers. This means that we do not use polar rovers unless all emergency rovers are busy.

2. Second, assign polar missions using the available polar rovers ONLY. If all polar rovers are busy, wait until one is available.

3. If a mission cannot be assigned on the current day, it should wait for the next day. On the next day, it should be checked whether the mission can be assigned now or not. If not, it should wait again and so on.

Notes: If missions of a specific type cannot be assigned on the current day, try to assign the other types (e.g. if polar missions cannot be assigned on the current day, this does NOT mean not to assign the emergency missions).

This is how we prioritize the assignment of missions of different types, but how will we prioritize the assignment of missions of the same type?

● For polar missions, assign them based on a first-come first-served basis. Missions that are formulated first are assigned first.

● For emergency missions, you should design a priority equation for deciding which of the available emergency missions should be assigned first. Emergency missions with a higher priority are the ones to be assigned first.

Note: You should develop a reasonable weighted priority equation depending on at least the following factors: the mission formulation day, how far is the mission's target location, the mission's duration, and the mission's significance.

Simulation Approach & Assumptions

You will use incremental day steps. Simulate the changes in the system every 1 day.

Some Definitions

❑ Formulation Day (FD):

The day on which the mission is formulated and is ready to be assigned.

❑ Waiting Mission:

The mission that has been formulated (i.e. mission's FD < current day but the mission is not assigned yet). On each day, you should choose the mission(s) to assign from the waiting missions.

❑ In-Execution Mission:

The mission that has been assigned to a rover but is not completed yet.

❑ Completed Mission:

The mission that has been completed.

❑ Waiting Days (WD):

The number of days from the formulation of a mission until it is assigned to a rover.

❑ Execution Days (ED):

The days that a rover needs to complete a mission (the days it takes to reach the target location, fulfill mission requirements, and then get back to the base station).

❑ Completion Day (CD):

The day at which the mission is successfully completed by the rover.

(CD = FD + WD + ED)

Assumptions

- If the rover is available on day D, it can be assigned to a new mission starting from that day.

- More than one mission can be formulated on the same day. Also, more than one mission can be assigned to different rovers on the same day as long as there are available rovers.

- A rover can only be executing one mission at a time.

- A rover cannot be assigned a mission during its checkup time

- Checkup duration and rover speed are the same for all rovers of the same type.

Input/output File Formats

Your program should receive all information to be simulated from an input file and produces an output file that contains some information and statistics about the missions. This section describes the format of both files and gives a sample for each.

The Input File

❑ First line contains two integers. Each integer represents the total number of rovers of each type.

▪ P: for polar rovers

▪ E: for emergency rovers

❑ The 2nd line contains two integers:

▪ SP: is the speed of all polar rovers (kilometers/hour)

▪ SE: is the speed of all emergency rovers (kilometers/hour)

❑ The 3rd line contains three integers:

▪ N: is the number of missions the rover completes before performing a checkup

▪ CP: is the checkup duration in days for polar rovers

▪ CE: is the checkup duration in days for emergency rovers

❑ The 4th line contains a number E which represents the number of events following this line.

❑ Then the input file contains E lines (one line for each event).

NOTE: The input lines of all events are sorted by the event day in ascending order.

Events

❑ Formulation event line has the following information:

▪ F (letter F at the beginning of the sentence) means a mission formulation event.

▪ TYP is the mission type (P: polar, E: emergency).

▪ ED is the event day.

▪ ID is a unique sequence number that identifies each mission.

▪ TLOC is the mission's target location (in kilometers from the base station).

▪ MDUR is the number of days needed to fulfill the mission requirements at target location.

▪ SIG is the mission's significance.

Format: (Note actual input test file with output file as well is in p.8 and p.9)

Sample Input File

```
3  3                          ➔ no. of rovers of each type
1  2                          ➔ rover speeds of each type (km/h)
3  9  8                       ➔ no. of missions before checkup and the checkup durations
8                                  ➔ no. of events in this file
F  P  25  6  190  3  1
```

The Output File

The output file you are required to produce should contain M output lines of the following format:

CD ID FD WD ED

Which means that the mission identified by sequence number ID has been formulated on day FD. It then waited for a period WD to be assigned. It has then taken ED to be completed at the day CD.

(Read the "Definitions Section" mentioned above)

The output lines must be sorted by CD in ascending order. If more than one mission is completed on the same day, they should be ordered by ED.

Then the following statistics should be shown at the end of the file:

1. Total number of missions and number of missions of each type

2. Total number of rovers and number of rovers of each type

Program Interface

The program can run in one of three modes: interactive, step-by-step, or silent mode. When the program runs, it should ask the user to select the program mode. Note: No matter what mode of operation your program is running in, the output file should be produced.

1. **Interactive Mode:** Allows user to monitor the missions and rovers. A sample output like that is shown below. In this mode, the program prints the current day then pauses for an input from the user ("Enter" key) to display the output of the next day:

```
Current Day: 62
1 Waiting Missions: (160)
----------------------------------------
2 In-Execution Missions/Rovers: [150/0] (110/3)
----------------------------------------
0 Available Rovers:
----------------------------------------
2 In-Checkup Rovers: [1] (2)
----------------------------------------
13 Completed Missions: [10,40,60,120,90,140](30,20,50,70,80,100,130)
```

Output Screen Explanation:

❑ The numbers shown are the IDs of missions and rovers printed according to their types. The IDs of [emergency missions or rovers] are printed within [ ] and the IDs of (polar ones) are printed within ( ).

❑ In line 2, a notation like [150/0] means emergency mission #150 is being executed by rover#2

2. **Step-By-Step Mode:** is identical to the interactive mode except that after each day, the program waits for one second (not for user input) then resumes automatically.
3. **Silent Mode**, the program produces only an output file (See the "File Formats" section). It does not print any simulation steps on the console. It just prints the following screen:

```
Silent Mode
Simulation Starts...
Simulation Ends, Output file created


(Please include file extension)
Enter output file name: testout2.txt
```

Sample run

Actual sample input file

```
2       2
14      17
20      25
4       6       6
20
F       E       3       10      1290    6       3
F       P       10      20      353     8       4
F       P       10      30      221     2       8
F       E       13      40      670     3       7
F       P       17      50      113     12      5
F       E       26      60      90      7       10
F       P       30      70      457     3       7
F       P       35      80      200     12      5
F       E       35      90      150     10      6
F       P       40      100     37      12      4
F       P       40      110     50      22      4
F       E       40      120     60      2       8
F       P       40      130     30      3       7
F       E       47      140     100     12      5
F       E       52      150     90      47      10
F       P       60      160     300     32      7
F       P       65      170     200     12      5
F       P       71      180     10      10      3
F       E       71      190     200     12      5
F       E       80      200     10      10      10
```

Actual sample output file

```
CD    ID    FD    WD    ED
13    30    10    0     3
16    10    3     0     13
20    20    10    0     10
20    40    13    0     7
30    50    17    0     13
34    60    26    0     8
35    70    30    0     5
43    120   40    0     3
46    90    35    0     11
48    80    35    0     13
53    100   40    0     13
57    130   40    13    4
60    140   47    0     13
71    110   40    8     23
84    190   71    0     13
90    170   65    12    13
95    200   80    4     11
97    160   60    3     34
100   150   52    0     48
101   180   71    19    11
.....

.....
Missions 20 [P :11, E:9]
Number of Failed Missions: 0
Rovers 4 [P :2, E:2]
```

Sample run 2 with failed missions: Note, we increased probability of failure (originally: 4%) to show feature.

Actual sample input file

```
3       3
5       3       9
3       2       8
2       10      10
20
F       E       3       10      1290    6       3
F       P       10      20      353     8       4
F       P       10      30      221     2       8
F       E       13      40      670     3       7
F       P       17      50      113     12      5
F       E       26      60      90      7       10
F       P       30      70      457     3       7
F       P       35      80      200     12      5
F       E       35      90      150     10      6
F       P       40      100     37      12      4
F       P       40      110     50      22      4
F       E       40      120     60      2       8
F       P       40      130     30      3       7
F       E       47      140     100     12      5
F       E       52      150     90      47      10
F       P       60      160     300     32      7
F       P       65      170     200     12      5
F       P       71      180     10      10      3
F       E       71      190     200     12      5
F       E       80      200     10      10      10
```

Actual sample output file

```
CD    ID    FD    WD    ED
18    30    10    0     8
50    90    35    2     13
53    120   40    10    3
58    60    26    24    8
62    10    3     18    41
64    140   47    3     14
66    50    17    33    16
74    40    13    31    30
84    20    10    56    18
85    190   71    0     14
91    200   80    0     11
96    70    30    44    22
101   150   52    1     48
112   80    35    59    18
116   130   40    72    4
120   100   40    66    14
134   110   40    71    23
144   170   65    61    18
145   180   71    63    11
164   160   60    60    44
.....................................................................................................

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Missions 20 [P :11, E:9]
Number of Failed Missions: 7
Rovers 6 [P :3, E:3]
```