THE GREEN REVOLUTION GAME

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Abstract

Imagine a future in which every branch of a large global network, scattered across metropolises and small, remote centers, receives clean and sustainable energy. Each location has its own challenges: varying costs, renewable sources to integrate, and environmental conditions to be respected. The goal is ambitious: to achieve energy independence with a carbon-neutral, or even negative, footprint. However, all of this with limited resources, forcing careful choices and ingenious strategies.

Reply takes on this challenge by following an unconventional path: through innovative technologies, creative solutions and a long-term vision, it strives to build an energy ecosystem where nothing is wasted and every single Watt can make a difference. It is a story of ingenuity and responsibility in which efficiency, sustainability and adaptability intertwine in a global mosaic of operational sites. The stakes are high: achieving a perfect balance between demand, supply and budget, proving that it is possible to grow, expand and prosper without ever losing sight of the planet and future generations.

Now, imagine having to put all this into practice: activity rounds, energy resources to balance, initial and maintenance costs, life cycles, special effects. The problem is ready to reveal its complexity and test your planning skills.

1 Problem Statement

The problem unfolds over a series of turns T, each characterized by:

- a minimum number of buildings to be powered (T_M)
- a maximum number of buildings to be powered (T_X)
- a unit profit per powered building (T_R).

At the beginning of each turn, it is possible to purchase new resources by paying their activation costs. Subsequently, periodic maintenance costs must be incurred. The starting budget (D) is updated at the end of each turn based on the choices made and the ability to meet at least the minimum building target (T_M).

If the minimum T_M of buildings is not reached, the profit for that turn is zero. Otherwise, the revenue is calculated as:

$$\text{profit} = min(n, T_X) \times T_R$$

where n is the number of buildings powered during the turn.

From this profit are subtracted the periodic costs of the living resources; the result, positive or negative, updates the budget available for the following turn.

Energy Resources There are R available resources, each described by the following parameters:

- RI: Resource identifier.
- RA: Activation cost (one-time initial expenditure).
- RP: Periodic cost for each turn of life (maintenance expense).
- RW: Number of consecutive turns in which the resource is active and generates profit.
- RM: Number of downtime turns required after a full cycle of activity (maintenance).
- RL: Total life cycle of the resource (in turns), including both active and downtime periods, after which the resource becomes obsolete.
- RU: Number of buildings the resource can power in each active turn.
- RT: Special effect of the resource.

During the turn in which the resource is purchased, its first activity period automatically begins.

Each resource is classified with a type of special effect (RT) that affects the global conditions of the system while it is active. The effects can be positive ("green"), increasing efficiency and performance, or negative ("non-green"), reducing overall effectiveness but, in return, offering greater productive capacity.

Special Effect Types (RT)

A (Smart Meter):

- Green Resource: increases the number of buildings powered by the facilities by a percentage.
- Non-Green Resource: reduces the number of buildings powered by the facilities by a percentage, down to a minimum of 0.

B (Distribution Facility):

- Green Resource: increases by a percentage the minimum (T_M) and maximum (T_X) thresholds of buildings that can be powered.
- Non-Green Resource: decreases these thresholds by a percentage, narrowing maximum and minimum capacity, down to a minimum of 0.

C (Maintenance Plan):

- Green Resource: extends by a percentage the life (RL) of all resources.
- Non-Green Resource: reduces by a percentage the life (RL) of all resources, down to a minimum of 1.

The influenced resources are all and only those that are purchased during active turns of the C-type resource. The C-type resource permanently changes the lifespan of each influenced resource only once.

D (Renewable Plant)

- Green Resource: increases by a percentage the profit per building served (T_R).
- Non-Green Resource: reduces by a percentage the profit per building, down to a minimum of 0.

E (Accumulator):

This resource type does not have a non-green variant. The resource can accumulate, during its active period, the number of buildings that exceed the maximum threshold (T_X) during more productive turns, to compensate for those in which other resources do not reach the minimum threshold (T_M).

Thus, in turns where the minimum threshold is not reached and the accumulator is in its active period, you can draw from it the amount

$$q_{accumulator} = T_M - n$$

to add to n (the number of buildings served) to generate profit during the turn. This operation is valid if the E-type resource has at least $q_{accumulator}$ buildings stored.

In other words, the E resource allows you to "virtually store" surplus buildings from one turn to meet minimum requirements in subsequent, less productive turns, thereby ensuring greater stability and continuity in powering buildings.

At the end of the accumulator's life, it loses all the stored buildings. Having multiple accumulators simultaneously is equivalent to having a single one with greater capacity. Consequently, when an accumulator reaches the end of its life, it can transfer its stored charge to other available accumulators, if any are present.

X (Base Resource):
This type of resource does not have any special effect.

Resources of type A, B, C, D, E have a parameter RE specifying the impact of the resource on the ecosystem. The special effect is calculated starting from the base value of each influenced parameter, and the rounding down is applied only at the end of the calculation, after considering all special effects.

For example: For a X-type resource with $RU = 5$, the effect of two A-type resources each with an influence percentage of 75% ($RE = 75$) has the following effect:

$$RU_{new} = \lfloor RU + 0.75 \cdot RU + 0.75 \cdot RU \rfloor =$$
$$= \lfloor 2.5 \cdot RU \rfloor = \lfloor 12.5 \rfloor = 12$$

A resource's effect also applies to itself. If the parameter is positive, it is a *Green* Resource; otherwise, the resource is considered $Non - Green$.

Gameplay Sequence The sequence of each turn proceeds as follows:

1. **Start of Turn:** With the available budget at the beginning of the turn, you can purchase new resources. If the sum of the activation costs exceeds the available budget, the entire purchase of that turn is considered invalid.
2. **Periodic Costs:** You have to pay the maintenance costs (RP) for each alive resource. The operating resources provide a certain number of powered buildings (RU). In the case of a resource with effect E, it is possible to accumulate surpluses for subsequent turns.
3. **Turn Profit:** If the minimum threshold T_M of buildings is met, calculate the profit as previously described. Otherwise, profit = 0.
4. **Budget Update:** The periodic costs are subtracted from the profit. The result updates the budget for the next turn.

In this context, planning which resources to activate or when to enhance them through special effects, taking into account their life cycle and necessary maintenance, will be the key to balancing investments, efficiency, and results. Keep in mind that each resource (identified by its ID) can be purchased an unlimited number of times throughout the game.

2 Input format

The input file is an ASCII text file. Each line of the file is separated by a single "\n" character (UNIX style). If a line contains multiple values, they are separated by a single space.

The first line of the input contains 3 integer values:

- D: initial capital availability
- R: total number of available resources
- T: number of game turns

The next R lines describe the available resources. Each line represents a single resource r and is composed of:

$$RI_r \quad RA_r \quad RP_r \quad RW_r \quad RM_r \quad RL_r \quad RU_r \quad RT_r \quad RE_r$$

where:

- $RI_r, RA_r, RP_r, RW_r, RM_r, RL_r, RU_r$ are the integer parameters related to the single resource r defined in the *Problem Statement*.
- RT_r: special effect type applied by the resource (A, B, C, D, E, X), as defined above.
- RE_r: additional integer parameter (present or not, depending on the type of effect) that represents the percentage of the special effect or the battery capacity.

After defining the resources, the next T lines describe the turns. Each line represents a turn t and contains:

$$TM_t \quad TX_t \quad TR_t$$

where:

- TM_t: the minimum number of buildings to be powered in that turn
- TX_t: the maximum number of buildings that can be powered in that turn
- TR_t: the profit for each powered building in that turn

3 Output format

The output file must be an ASCII text file. Each line of the output file must be separated by the "\n" character. Each line indicates the resources acquired in a given turn.

The format of each line is:

$$t \quad R_t \quad RI_1 \quad RI_2 \quad \dots \quad RI_{R_t}$$

where:

- t: turn number (0-based, increasing)
- R_t: number of resources acquired in that turn ($R_t \leq 50$)

- RI_x: ID of the acquired resource ($x = 1...R_t$).

4 Scoring rules

The total score of the solution is given by the sum of all the profits generated over the entire horizon of the turns. In other words, the goal is to maximize earnings during the game. The scoring equation is:

$$\text{Score} = \sum_{t}^{T} profit_t$$

5 Constraints

- $D \geq 0$
- $R \geq 0$
- $0 \leq t < T$
- For each resource r:

$$RI_r, RA_r, RP_r, RW_r, RM_r, RU_r \geq 0$$

$$RW_r + RM_r > 0$$

$$RL_r > 0$$

- RT_r assumes the values A, B, C, D, E, X
- For each turn t:

$$TM_t, TX_t, TR_t \geq 0$$

$$TX_t > TM_t$$

- You can only purchase resources defined in the input file.
- The output file lists only the turns in which purchases are made. Turns are listed in ascending order.
- In the output file, the number of resource IDs listed for the turn t is exactly R_t, with $0 < R_t \leq 50$.

6 Example

Example of input

```
10 5 6
1 16 3 1 1 3 6 D 2
2 2 2 1 3 5 4 X
3 14 15 2 2 5 3 C 1
4 20 9 2 1 3 4 E 3
5 10 8 2 1 3 3 X
3 5 4
5 6 3
2 7 4
4 6 3
4 7 1
5 7 4
```

In this example:

$$D = 10, \quad R = 5, \quad T = 6.$$

The following lines represent the 5 available resources:

```
1 16 3 1 1 3 6 D 2
2 2 2 1 3 5 4 X
3 14 15 2 2 5 3 C 1
4 20 9 2 1 3 4 E 3
5 10 8 2 1 3 3 X
```

The first one is a Green Resource of type D, which increases the unit profit per powered building T_R by 2%, and is defined as follows:

$$RI = 1, \quad RA = 16, \quad RP = 3, \quad RW = 1, \quad RM = 1, \quad RL = 3, \quad RU = 6$$

After defining the resources, information about turns is provided:

```
3 5 4
5 6 3
2 7 4
4 6 3
4 7 1
5 7 4
```

In this example, on turn $t = 4$:

$$TM_4 = 4, \quad TX_4 = 7, \quad TR_4 = 1$$

Example of output

```
0 1 5
1 1 2
2 1 2
4 2 2 2
5 1 2
```

t

RI	0	1	2	3	4	5
5	A	A	M	/		
2		A	M	M	M	A
2			A	M	M	M
2					A	M
2					A	M
2						A

On the first turn $t = 0$:

- $D_i = 10$ the initial available budget is 10.
- The users bought 1 resource with $RI = 5$, so the total activation cost of the turn is $10 \geq D_i$, hence the turn is valid.
- The profit added to the final score is:

$$\text{profit} = min(n, T_X) \times T_R = min(3, 5) \times 4 = 12$$

- The maintenance cost for all the active resources in this turn is 8.
- The final budget is $D_f = 10 - 10 + 12 - 8 = 4$.

On the second turn $t = 1$:

- $D_i = 4$ the initial available budget is 4.
- The users bought 1 resource with $RI = 2$, so the total activation cost of the turn is $2 \geq D_i$, hence the turn is valid.
- The profit added to the final score is:

$$\text{profit} = min(7, 6) \times 3 = 18$$

- The maintenance cost for all the active resources in this turn is $8+2 = 10$.
- The final budget is $D_f = 4 - 2 + 18 - 10 = 10$.

By continuing the score calculation as above, a final score of 81 points is reached, and all purchases are valid.