香港電腦奧林匹克競賽
Hong Kong Olympiad in Informatics

G265 Mini Metro

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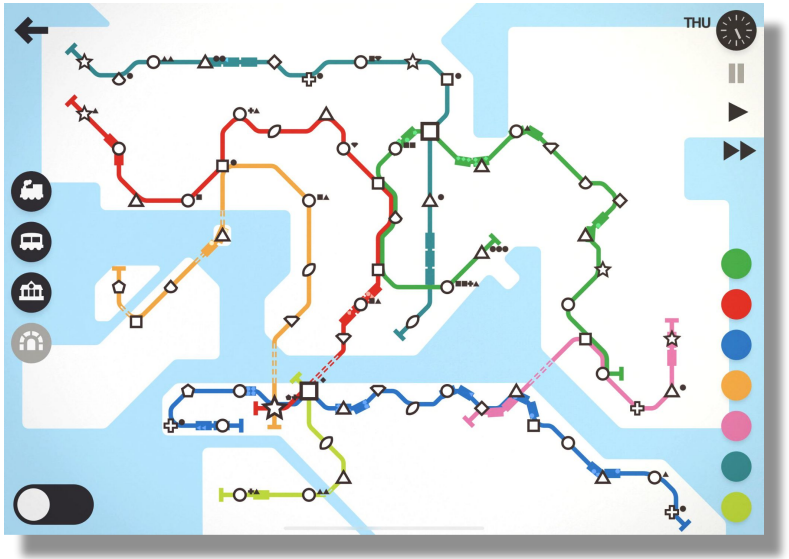
Background

Problem Idea by QwertyPi

Preparation by bedrockfake



HK MTR in the game Mini Metro

Problem Statement

- Given N stations arranged in a circle
- There are K types of stations, there are A_i stations of type i
- A passenger can be any of the K types
- A passenger starts at any station and travels clockwise until they reach a station equal to their type
- Find the **minimum travel distance** by a passenger of any type, starting from any station

Statistics

Task	Attempts	Max	Mean	Std Dev	Subtasks					
G265 - Mini Metro	54	100	9.425	18.345	7: 21	10: 15	17: 6	22: 3	23: 1	21: 1

First (and only) solved by **ywgs265** (Leung Hilary) at **2h 44m**

Subtasks

Subtask	Points	K	A_i
1	7	= 2	$A_1 = A_2$
2	10	$\leq 10^5$	All A_i are equal
3	17	= 2	$A_1 \leq A_2 \leq 2A_1$
4	22		Any
5	23	$\leq 10^5$	$A_1 \leq A_2 \leq \ldots \leq A_k \leq 2A_1$
6	21		Any

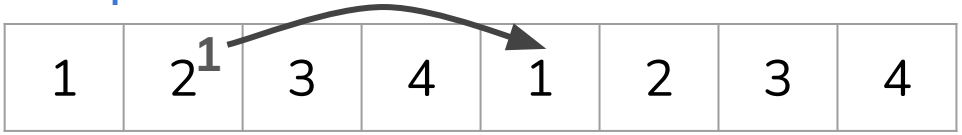
Subtask 1 (7%) : $K = 2, A_1 = A_2$

1	2	1	2	1	2	1	2

Alternate between type 1 and type 2 stations

- If a passenger starts at a station of their own type, they take no time
- Otherwise, they must get off at the next station, taking 1 unit of time

Subtask 2 (10%) : A_i is equal



- Optimal if all consecutive K stations have distinct types
  - All of the K types will get off in one of the consecutive stations

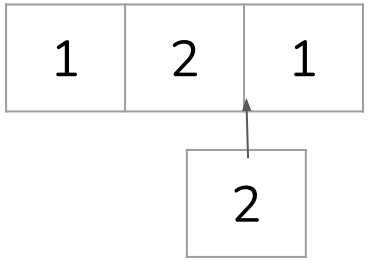
Repeat all K types in the same order

- Worst-case: a passenger starts the station right after a station equal to their type -> K-1 units of time

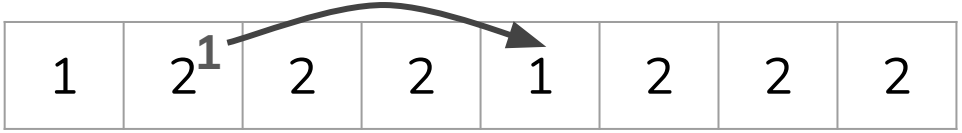
Subtask 3 (17%) : $K = 2, A_1 \leq A_2 \leq 2A_1$

- $A_1 \leq A_2$ so type 1 passengers will take more time
- $A_2 \leq 2A_1$ -> can pair up a type 1 station with 1 or 2 type 2 stations
- Type 1 passenger should only travel at most 2 units of time

Use Subtask 1's solution but insert extra type 2 stations between each pair of type 1 stations **once**

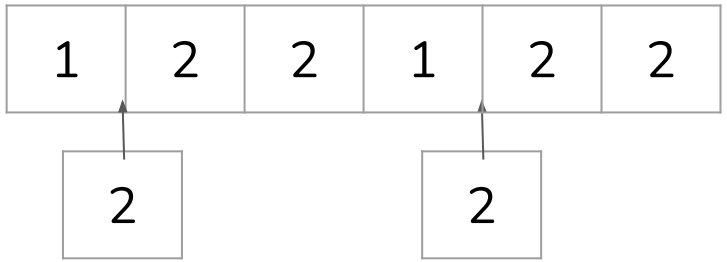


Subtask 4 (22%) : K = 2

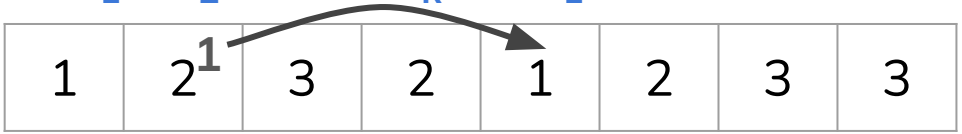


- Assume $A_1 \leq A_2$: Final answer is the length of the **longest** consecutive type 2 stations (consider the worst case)
  - Minimise this length by distributing type 2 stations between pairs of type 1 stations evenly

Use Subtask 3's solution, iterate through all pairs of type 1 stations and insert a type 2 station each time, remember to handle $A_1 > A_2$ as well

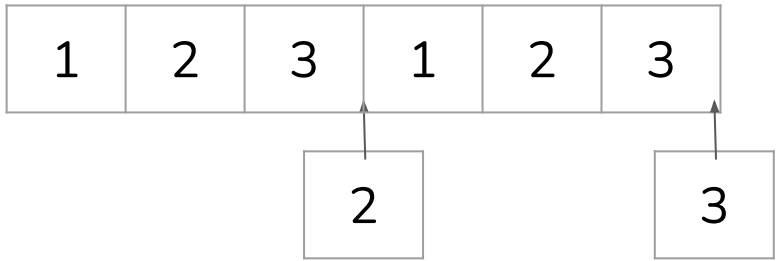


Subtask 5 (23%) : $A_1 \le A_2 \le \ldots \le A_k \le 2A_1$

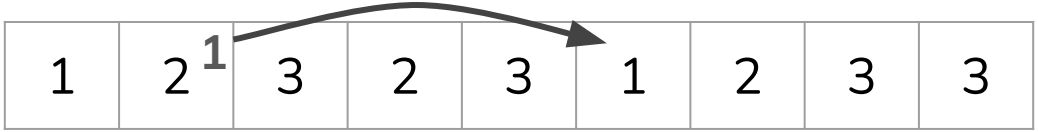


Observation: With an optimal construction, the station type with the **minimum occurrence** will require the passengers of the type to travel the longest

- Consider 1 2 3 ... K as a block, in total there are A_1 blocks
- Final answer ≤ 2K
  - Does not depend on what station types are between blocks
  - ≤ A_1 extra stations of each type
- Insert at most K stations between each block



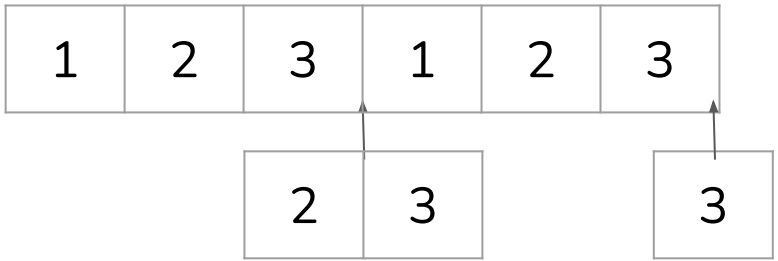
Subtask 6 (22%) : Full Solution



Observation: With an optimal construction, the station type with the **minimum occurrence** will require the passengers of the type to travel the longest

- Consider 1 2 3 ... K as a block, in total there are min(A_i) blocks
- Final answer = K + maximum no. of stations between adjacent blocks
  - Does not depend on what station types are between blocks

- Insert remaining stations between each block, minimise distance between blocks



Subtask 6 (22%) : Full Solution

Side Note: Final answer is always $\lceil N / \min(A_i) \rceil$

- Distribute N stations evenly into $\min(A_i)$ blocks