Problem Statement

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Version 1.3, updated on 10 September 2019

Subway station

This is the description of an automated fare collection (AFC) system and a ticket vending machine installed at each station of a subway line as the below pictures.

Figure 1. Automated Fare Collection (AFC).

Figure 2. Ticket Vending Machine.

This line has two terminus stations, i.e. *Cat Linh* and *Ha Đong*. For simplification, we assume that lines between stations are straight, and we can calculate directly on the distances between stations. For instance, the distance between the station *Thai Ha* and the station *Thuong Dinh* can be calculated as the sum of the distance between *Thai Ha* and *Lang Ha* AND the distance between *Lang Ha* and *Thuong Dinh*, or the difference of the distance between *La Thanh* and *Thuong Dinh* AND the distance between *La Thanh* and *Thai Ha*.

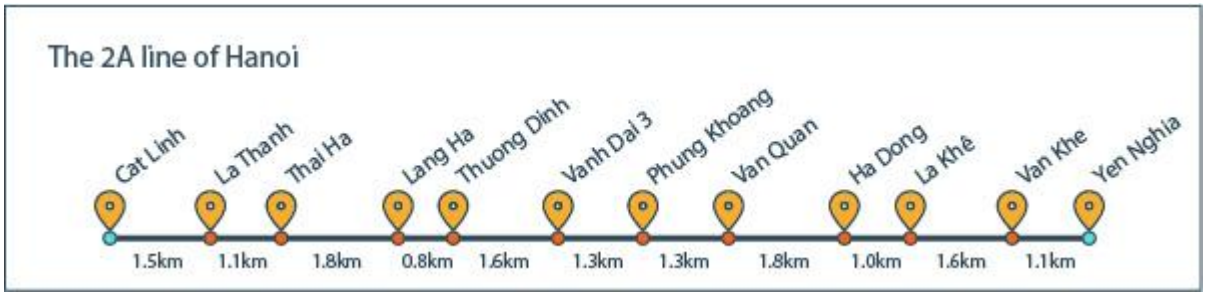

Figure 3. Subway map.

A. A fare of an itinerary is decided based on the distance between stations. The fare for up to 5 kilometers is 10.000 VND (this is called the base fare). An amount of 2.000 VND is added for each additional 2 kilometers. Any additional distance less than 2 kilometers is rounded up to 2 kilometers. For example, if the distance is 8 kilometers, the fare is 14.000 VND.

B. In a ticket vending machine, passengers can choose to buy a type of traveling certificates in the menu: one-way ticket, twenty-four-hour ticket or prepaid card. For a one-way ticket, passengers need to choose the start station (embarkation) and the end station (disembarkation). The system then calculates the fare and display to them. The passengers now can enter the number of tickets that they want to buy and confirm to buy in a confirmation screen with all necessary information about tickets, e.g. price, quantity, amount and total amount. For the twenty-four-hour tickets, the system displays a price of this type (i.e. 45.000 VND) to passengers. Passengers can buy multiple tickets or cards in one order, but only one type in one order. Prepaid cards can be bought in the selling machine with the default balance of 30.000 VND. After confirming the order, passengers can pay by a credit card by connecting to a credit card operator. After the payment, the system prints tickets or issues cards. For simplification, the id of a ticket or card is 8-digit numbers, which can be automatically generated.

C. The station of embarkation is recorded on a ticket or a card when a passenger passes through the automated fare collection system in that station to enter the platform area. A passenger can enter the platform area through the automated fare collection system in any station, thus being able to embark, regardless of the station that issued the ticket. For instance, with a ticket issued at the Station *Thai Ha*, a passenger can enter the platform area through the automated fare collection system at the Station *Lang Ha*. Passengers put the ticket to a slot of the ticket recognizer to open that gate, then get it back on the other side of the gate. If they use a card, they need to put the card to the card scanner for checking its id.

D. Whenever passengers enter or exit the station, if the gate is opened, the system displays “Opening ticket/card”, otherwise “Invalid ticket/card” with a reason. In any case, the system always displays with some basic information of the ticket/card such as id, balance / valid until, status.

E. Passengers can use one-way tickets only one time. Once a one-way ticket is used, it becomes invalid. The passengers can enter a station in between the two stations allowing for that ticket and travel in any direction. When they leave a station, the fare between the starting and the ending station is smaller than or equal to the ticket fare, the gate is opened. Otherwise, it is closed.

F. A twenty-four-hour ticket permits a passenger to freely embark or disembark multiple times at all stations within 24 hours from the time that the passenger uses it for the first time. After twenty-four hours from the first-time usage, the passenger can leave the platform area in any station but cannot enter any such area.

G. The station of embarkation is recorded on a prepaid card when a passenger enters the platform area through the automated fare collection system in that station. At this time, if the balance on the card is less than the base fare, the gate is closed to prevent him/her from entering the platform area. When he/she leaves the platform area through the automated fare collection system in the station of disembarkation, a balance adjustment is processed. Namely, the fare is calculated and is subtracted from the balance on the card. At this time, if this balance is less than the amount of the fare, the gate is closed to prevent him/her from leaving the platform area.

H. If the gate is not opened, the passenger may charge more money to the card at a ticket vending machine to open the gate. To charge more money to the prepaid cards, the passenger can put a prepaid card on the screen so that the system can scan the card id for further processing. These tasks can be done at either the selling machines inside the platform area or the ones outside the platform area (before entering a gate).

Please do the following tasks to have the expected outputs below.

1. Draw use case diagrams for the automated fare collection system and the selling ticket machine: at least one diagram for each system.
   Assume that there is a specialized printer and a card issuer that connect to each ticket vending machine; a ticket recognizer, card scanner and a gate that connect to each automated fare collection system. These equipments are provided with SDKs for communication.

2. **You are asked to develop a program** that is limited to use cases described in sections C to G of the automated fare collection system. However, to test the program when a passenger moves from this station to another station, you must provide command-line GUIs. To simulating user operations at stations, the program displays a list of stations to users for selection. Users can choose to enter or exit a station. The program reads from files, creates and displays some existing tickets and cards with their types, status, and necessary information. You have to follow sample screens and flows of the program that can be found at the end of the problem statement (*).

Please develop the following items for all use cases from C to G:

- Use case specifications
- State machine diagrams for states of tickets/cards
- Class diagram with full attributes and methods
- Interaction diagrams (Sequence diagrams or Communication diagrams)
- Source code (in Java)

*** Sample screens of the program**

1. Main screen

These are stations in the 2A line of Hanoi:

a. Cat Linh
b. La Thanh
c. Thai Ha
d. Lang Ha

e. Thuong Dinh
f. Vanh Dai 3
g. Phung Khoang
h. Van Quan
i. Ha Dong
j. La Khe
k. Van Khe
l. Yen Nghia

Available actions: 1-enter station, 2-exit station

You can provide a combination of numbers (1 or 2) and a letter from (a to i) to enter or exit a station (using a hyphen in between). For instance, the combination “2-d” will bring you to exit the station Lang Ha.

Your input:

2. Choosing a ticket/card:

These are existing tickets/cards:

- 22918291: One-way ticket between Cat Linh and La Thanh: New – 10.000 vnd
- 13829402: 24h tickets: New
- 11728192: Prepaid card: 40.000 vnd
- 11830291: 24h tickets: Valid until 14:35 - 16th of May, 2019

Please provide an id of the ticket you want to enter/exit:

3. Choosing a ticket/card (update 1):

These are existing ticket/card ids:

- 22918291: One-way ticket between Cat Linh and La Thanh: In station – 10.000 vnd
- 13829402: 24h tickets: New
- 11728192: Prepaid card: 40.000 vnd
- 11830291: 24h tickets: Valid until 14:35 - 16th of May 2019

Please provide an id of the ticket you want to enter/exit:

4. Choosing a ticket/card (updated 2):

These are existing ticket/card ids:

- 22918291: One-way ticket between Cat Linh and La Thanh: Destroyed – 10.000 vnd
- 13829402: 24h tickets: New
- 11728192: Prepaid card: 40.000 vnd
- 11830291: 24h tickets: Valid until 14:35 - 16th of May, 2019

Please provide an id of the ticket you want to enter/exit:

5. Opening gate screen for entering a station with a one-way ticket: Opening gate with one-way ticket ID: 22918291, balance: 16.000 vnd **Press any key to continue…**
6. Opening gate screen for exiting a station with a one-way ticket: Opening gate with one-way ticket ID: 22918291, balance: 6.000 vnd **Press any key to continue…**
7. Opening gate screen for entering a station with a 24h ticket: Opening gate with 24h ticket ID: 11830291, valid until 14:35 - 16th of May, 2019 **Press any key to continue…**
8. Invalid one-way ticket Invalid one-way ticket ID: 22918291, balance: 10.000 vnd Not enough balance: Expected 16.000 vnd **Press any key to continue…**
9. Invalid 24h ticket Invalid 24h ticket ID: 11830291, valid until 14:35 – 16th of May, 2019 Expired: Try to enter at 16:00 – 16th of May, 2019 **Press any key to continue...**

*** Example flows of the program**

1 (enter: 1-e) => 2 (enter: 22918291) => 5 (press any key) => 1 (enter: 2-i) => 3 (enter: 22918291) => 6 (press any key) => 1 (enter: 1-b) => 4 (enter: 11830291) => 7 (press any key) => 1 (enter 2-c) => …

base fare: 10.000 vnd / upto 5km

added fare: 2.000 vnd / 2km

From	To	Distance
Cat Linh	La Thanh	1.5 km
La Thanh	Thai Ha	1.1 km
Thai Ha	Lang	1.8 km
Lang	Thuong Dinh	0.8 km
Thuong Dinh	Vanh Dai 3	1.6 km
Vanh Dai 3	Phung Khoang	1.3 km
Phung Khoang	Van Quan	1.3 km
Van Quan	Ha Đong	1.8 km
Ha Đong	La Khê	1.0 km
La Khe	Van Khe	1.6 km
Van Khe	Yen Nghia	1.1 km