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Operating Systems Laboratory Project

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1- The purpose of the project :

The purpose of the project is to simulate the behavior of a set of trains that cross multiple track segments. The railway mission of each train is to reach a specific station. The main constraint on train movement is that each track segment can be occupied by only one train at a time. Each train receives permission to access the next track segment during its railway mission. The project implements the above schema in two different ways.

2- The tools:

The tools used to implement the project are Ubuntu OS installed on virtualbox and C language.

3- How I organized my code :

3-1- main.c :

The main process from there, if not RBC, I launch the train_father process with MODE, MAP arguments, else I launch the RBC process (rbc.c) with MAP argument. I proceed with fork() then execl() to launch these processes.

3-2- train_process.c :

Here first I create a log/Tx.log file then separate functions depending on the mode :

A- If mode is ETCS1 : I first retrieve an itinerary string in the register/MAPx.txt file, saving only the line relevant to the train name (Tx) and skipping the other lines, so now I have an itinerary string.

B- If mode is ETCS2 : first I connect up to the RBC server, then I send a message, « ASKMAP <map> <train_name> », to the server. It sends back an itinerary string.

For both modes, then I transform this string into a linked list. The current stop is the list's head (its first node), the next stop is the list's second node. A train has arrived to destination if there is no second node. Now begins the main loop for each train process, that runs while the train hasn't arrived to its destination :

If mode is ETCS1 : first I wait <train_number>*2 seconds, so that the timing is different for each train_process while reading the MAPx segment files. I check the next stop. If the stop is not a segment, we can go to it, else if the file corresponding to that stop is 0 so the train can go to it. If the train can go to the next stop, then it check if the current stop is a segment. If yes, put 0 inside. Then check if the next stop is a segment. If yes, put 1 inside. Loop back after 2 seconds of waiting time.

If mode is ETCS2 : I should still be connected to the RBC server. The train process sends a message to RBC : « REQ <train_name> <current_stop> <next_stop> ». If the RBC server answers « 0 », the train

across to the next segment else the answer «1» so wait in the same segment. Loop back after 2 seconds. End the server connection if not looping back.

3-3- train_father.c :

from there, I create 16 MAX.txt files in the Max folder, all initialized with 0 inside. then fork() 5 times to concurrently launch 5 train_processes with execl(). I give as argument the MODE, MAP and their train name (T1 to T5) to the train_processes.

3-4- train_process_utils.c :

This file is linked list implementation, used in train_process.c.

3-5- rbc.c :

I first create the socket server. Then wait for 5 connections (the train processes). then begin a loop that continuously reads incoming data from the train processes, runs as long as receive data from them. if I receive « ASKMAP <map> <train_name> », then I retrieve the corresponding itinerary string in the same manner, in the register/MAPx.txt files. I then send it back to the train process.

If I receive « REQ <train_name> <current_stop> <next_stop> », then check to see if the segment is free from the MAX files in the same manner as the train_process does when launched in ETCS1 mode. If next segment is free, then mark it as busy (1) and mark the old one as free (0), of course only if they are segments, otherwise if they are stations I do nothing. Whenever stop receiving data, the RBC server is stopped.

3-6- *.h :

header files, function prototypes for each file.

4- Execution:

Run «make » in the project directory to compile the code.

```
make -f Makefile
```

Then to choose one of those modes:

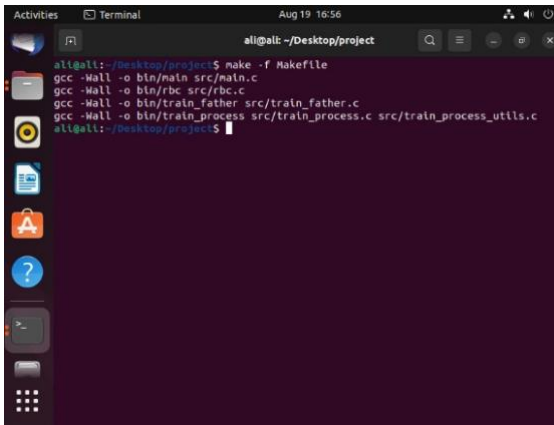
A- ./bin/main ETCS1 MAP1

B- ./bin/main ETCS1 MAP2

C- ./bin/main ETCS2 MAP1 and ./bin/main ETCS2 RBC MAP1 in the same time but in two shells.

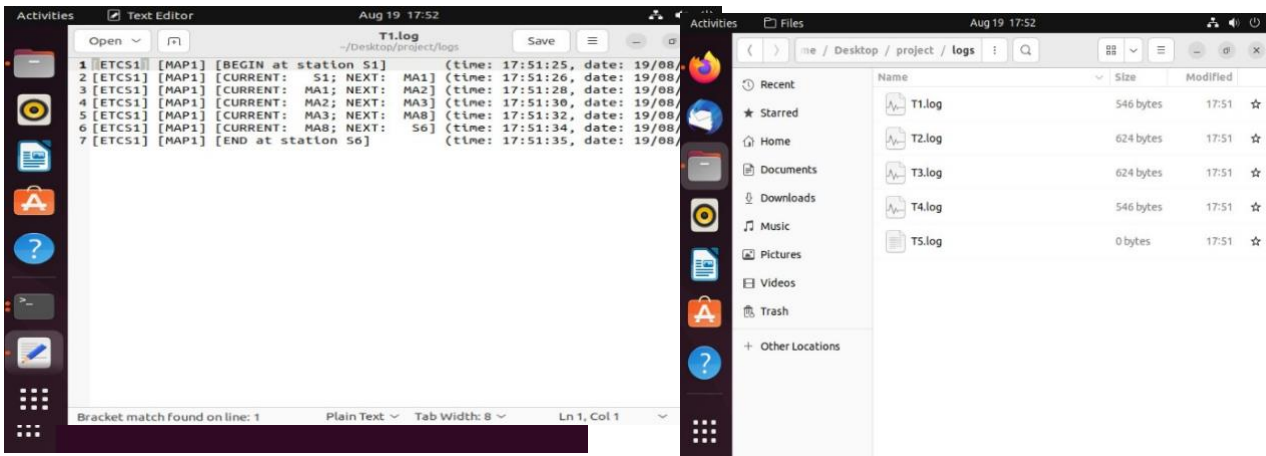
D- ./bin/main ETCS2 MAP2 and ./bin/main ETCS2 RBC MAP2 in the same time but in two shells.

5- The results after execution for each mode:



```
all@ali: ~/Desktop/project
all@ali:~/Desktop/project$ make -f Makefile
gcc -Wall -o bin/main src/main.c
gcc -Wall -o bin/rbc src/rbc.c
gcc -Wall -o bin/train_father src/train_father.c
gcc -Wall -o bin/train_process src/train_process.c src/train_process_utils.c
all@ali:~/Desktop/project$
```

5-1- ./bin/main ETCS1 MAP1



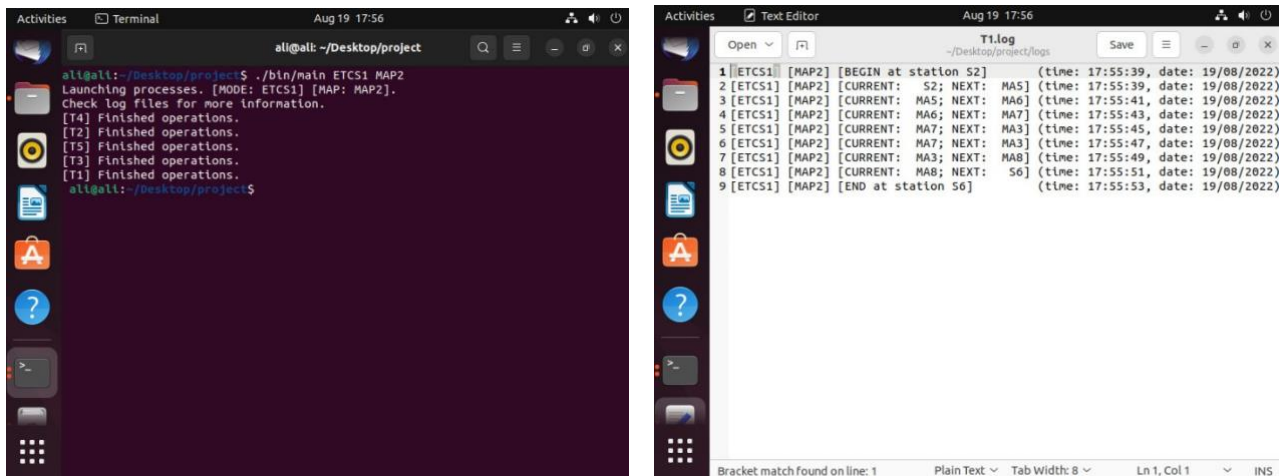
The terminal window shows the execution of the program with the following output:

```
1 [ETCS1] [MAP1] [BEGIN at station S1] (time: 17:51:25, date: 19/08/2022)
2 [ETCS1] [MAP1] [CURRENT: S1; NEXT: MA1] (time: 17:51:26, date: 19/08/2022)
3 [ETCS1] [MAP1] [CURRENT: MA1; NEXT: MA2] (time: 17:51:28, date: 19/08/2022)
4 [ETCS1] [MAP1] [CURRENT: MA2; NEXT: MA3] (time: 17:51:30, date: 19/08/2022)
5 [ETCS1] [MAP1] [CURRENT: MA3; NEXT: MA8] (time: 17:51:32, date: 19/08/2022)
6 [ETCS1] [MAP1] [CURRENT: MA8; NEXT: S6] (time: 17:51:34, date: 19/08/2022)
7 [ETCS1] [MAP1] [END at station S6] (time: 17:51:35, date: 19/08/2022)
```

The file manager window shows the generated log files:

Name	Size	Modified
T1.log	546 bytes	17:51
T2.log	624 bytes	17:51
T3.log	624 bytes	17:51
T4.log	546 bytes	17:51
T5.log	0 bytes	17:51

5-2- ./bin/main ETCS1 MAP2



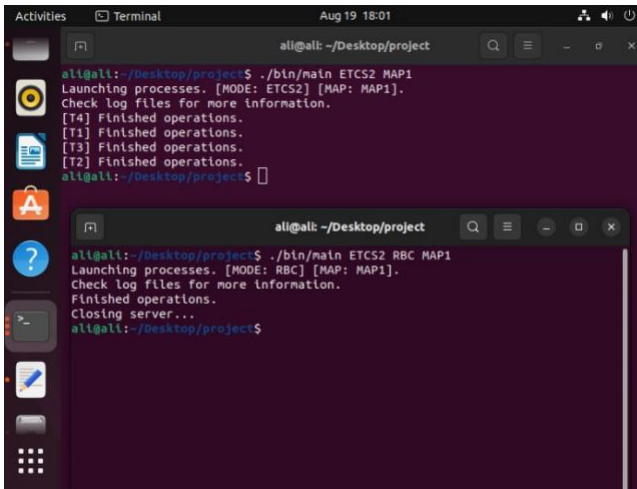
The terminal window shows the execution of the program with the following output:

```
all@ali:~/Desktop/project$ ./bin/main ETCS1 MAP2
Launching processes. [MODE: ETCS1] [MAP: MAP2].
Check log files for more information.
[T4] Finished operations.
[T2] Finished operations.
[T5] Finished operations.
[T3] Finished operations.
[T1] Finished operations.
all@ali:~/Desktop/project$
```

The file manager window shows the generated log files:

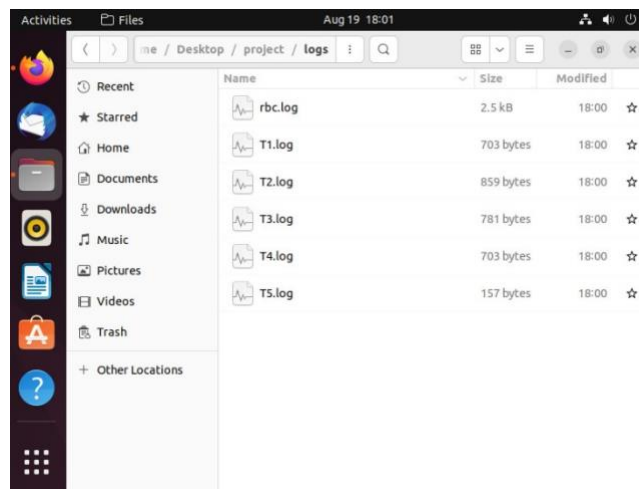
Name	Size	Modified
T1.log	546 bytes	17:55
T2.log	624 bytes	17:55
T3.log	624 bytes	17:55
T4.log	546 bytes	17:55
T5.log	0 bytes	17:55

5-3-. In/main ETCS2 MAP1 and ./bin/main ETCS2 RBC MAP1



```
ali@ali: ~/Desktop/project
ali@ali:~/Desktop/project$ ./bin/main ETCS2 MAP1
Launching processes. [MODE: ETCS2] [MAP: MAP1].
Check log files for more information.
[T4] Finished operations.
[T1] Finished operations.
[T3] Finished operations.
[T2] Finished operations.
ali@ali:~/Desktop/project$

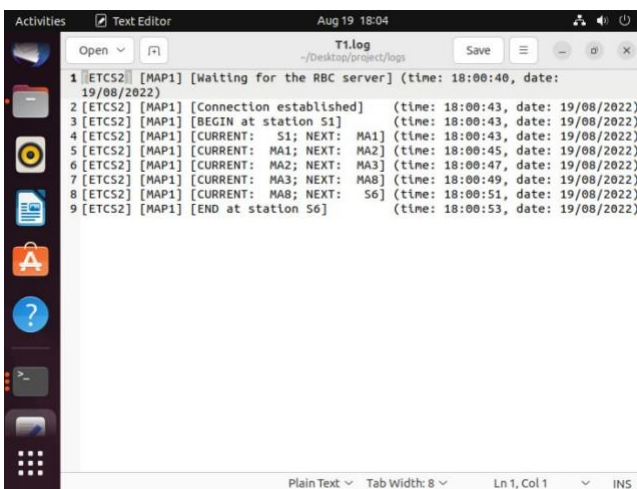
ali@ali:~/Desktop/project$ ./bin/main ETCS2 RBC MAP1
Launching processes. [MODE: RBC] [MAP: MAP1].
Check log files for more information.
Finished operations.
Closing server...
ali@ali:~/Desktop/project$
```



```
1 [ETCS2] [MAP1] [Waiting for the trains to connect] (time: 18:00:43, date: 19/08/2022)
2 [ETCS2] [MAP1] [All connections established] (time: 18:00:43, date: 19/08/2022)
3 [ETCS2] [MAP1] [T2] [FROM: S2, REQ: MA5] [ACCEPTED: YES] (time: 18:00:43, date: 19/08/2022)
4 [ETCS2] [MAP1] [T3] [FROM: S7, REQ: MA13] [ACCEPTED: YES] (time: 18:00:43, date: 19/08/2022)
5 [ETCS2] [MAP1] [T4] [FROM: S4, REQ: MA14] [ACCEPTED: YES] (time: 18:00:43, date: 19/08/2022)
6 [ETCS2] [MAP1] [T1] [FROM: S1, REQ: MA1] [ACCEPTED: YES] (time: 18:00:43, date: 19/08/2022)
7 [ETCS2] [MAP1] [T2] [FROM: MA5, REQ: MA6] [ACCEPTED: YES] (time: 18:00:45, date: 19/08/2022)
8 [ETCS2] [MAP1] [T3] [FROM: MA13, REQ: MA12] [ACCEPTED: YES] (time: 18:00:45, date: 19/08/2022)
9 [ETCS2] [MAP1] [T4] [FROM: MA14, REQ: MA15] [ACCEPTED: YES] (time: 18:00:45, date: 19/08/2022)
10 [ETCS2] [MAP1] [T1] [FROM: MA1, REQ: MA2] [ACCEPTED: YES] (time: 18:00:45, date: 19/08/2022)
11 [ETCS2] [MAP1] [T2] [FROM: MA6, REQ: MA7] [ACCEPTED: YES] (time: 18:00:47, date: 19/08/2022)
12 [ETCS2] [MAP1] [T3] [FROM: MA12, REQ: MA11] [ACCEPTED: YES] (time: 18:00:47, date: 19/08/2022)
13 [ETCS2] [MAP1] [T4] [FROM: MA15, REQ: MA16] [ACCEPTED: YES] (time: 18:00:47, date: 19/08/2022)
14 [ETCS2] [MAP1] [T1] [FROM: MA2, REQ: MA3] [ACCEPTED: YES] (time: 18:00:47, date: 19/08/2022)
```

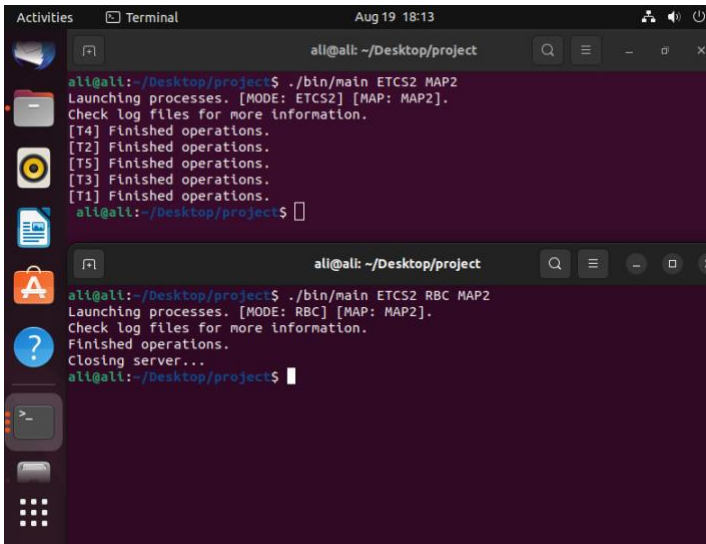


```
13 [ETCS2] [MAP1] [T4] [FROM: MA15, REQ: MA16] [ACCEPTED: YES] (time: 18:00:47, date: 19/08/2022)
14 [ETCS2] [MAP1] [T1] [FROM: MA2, REQ: MA3] [ACCEPTED: YES] (time: 18:00:47, date: 19/08/2022)
15 [ETCS2] [MAP1] [T2] [FROM: MA7, REQ: MA3] [ACCEPTED: NO] (time: 18:00:49, date: 19/08/2022)
16 [ETCS2] [MAP1] [T3] [FROM: MA11, REQ: MA10] [ACCEPTED: YES] (time: 18:00:49, date: 19/08/2022)
17 [ETCS2] [MAP1] [T4] [FROM: MA16, REQ: MA12] [ACCEPTED: YES] (time: 18:00:49, date: 19/08/2022)
18 [ETCS2] [MAP1] [T1] [FROM: MA3, REQ: MA8] [ACCEPTED: YES] (time: 18:00:49, date: 19/08/2022)
19 [ETCS2] [MAP1] [T2] [FROM: MA7, REQ: MA3] [ACCEPTED: YES] (time: 18:00:51, date: 19/08/2022)
20 [ETCS2] [MAP1] [T3] [FROM: MA10, REQ: MA9] [ACCEPTED: YES] (time: 18:00:51, date: 19/08/2022)
21 [ETCS2] [MAP1] [T4] [FROM: MA12, REQ: S8] [ACCEPTED: YES] (time: 18:00:51, date: 19/08/2022)
22 [ETCS2] [MAP1] [T1] [FROM: MA8, REQ: S6] [ACCEPTED: YES] (time: 18:00:51, date: 19/08/2022)
23 [ETCS2] [MAP1] [T2] [FROM: MA3, REQ: MA8] [ACCEPTED: YES] (time: 18:00:53, date: 19/08/2022)
24 [ETCS2] [MAP1] [T3] [FROM: MA9, REQ: S3] [ACCEPTED: YES] (time: 18:00:53, date: 19/08/2022)
25 [ETCS2] [MAP1] [T2] [FROM: MA8, REQ: S6] [ACCEPTED: YES] (time: 18:00:55, date: 19/08/2022)
26 [ETCS2] [MAP1] [Finished job. Closing server] (time: 18:00:57, date: 19/08/2022)
```



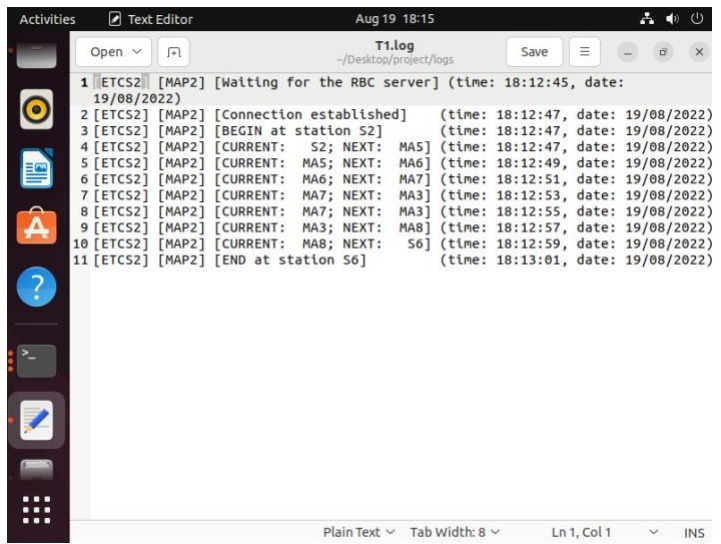
```
1 [ETCS2] [MAP1] [Waiting for the RBC server] (time: 18:00:40, date: 19/08/2022)
2 [ETCS2] [MAP1] [Connection established] (time: 18:00:43, date: 19/08/2022)
3 [ETCS2] [MAP1] [BEGIN at station S1] (time: 18:00:43, date: 19/08/2022)
4 [ETCS2] [MAP1] [CURRENT: S1; NEXT: MA1] (time: 18:00:43, date: 19/08/2022)
5 [ETCS2] [MAP1] [CURRENT: MA1; NEXT: MA2] (time: 18:00:45, date: 19/08/2022)
6 [ETCS2] [MAP1] [CURRENT: MA2; NEXT: MA3] (time: 18:00:47, date: 19/08/2022)
7 [ETCS2] [MAP1] [CURRENT: MA3; NEXT: MA8] (time: 18:00:49, date: 19/08/2022)
8 [ETCS2] [MAP1] [CURRENT: MA8; NEXT: S6] (time: 18:00:51, date: 19/08/2022)
9 [ETCS2] [MAP1] [END at station S6] (time: 18:00:53, date: 19/08/2022)
```


5-4- in/main ETCS2 MAP2 and ./bin/main ETCS2 RBC MAP2



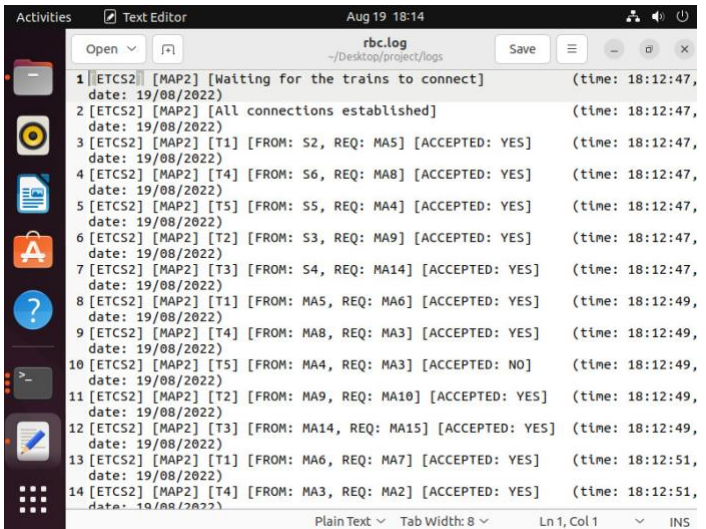
```
ali@ali: ~/Desktop/project
ali@ali:~/Desktop/project$ ./bin/main ETCS2 MAP2
Launching processes. [MODE: ETCS2] [MAP: MAP2].
Check log files for more information.
[T4] Finished operations.
[T2] Finished operations.
[T5] Finished operations.
[T3] Finished operations.
[T1] Finished operations.
ali@ali:~/Desktop/project$

ali@ali:~/Desktop/project$ ./bin/main ETCS2 RBC MAP2
Launching processes. [MODE: RBC] [MAP: MAP2].
Check log files for more information.
Finished operations.
Closing server...
ali@ali:~/Desktop/project$
```



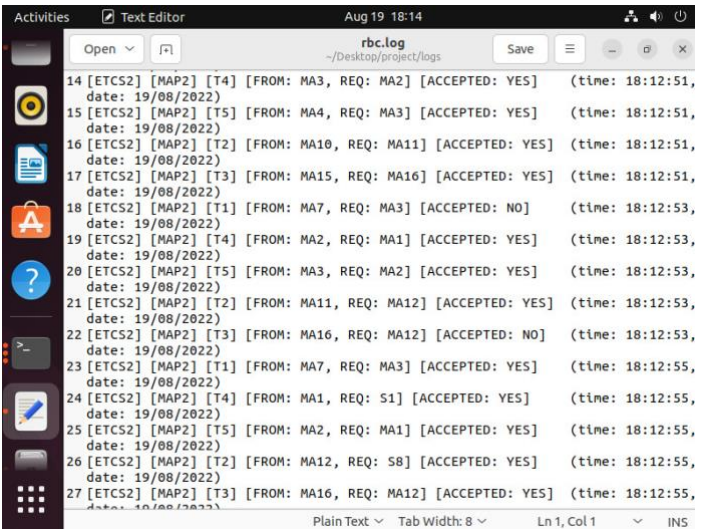
```
T1.log
~/Desktop/project/logs

1 [ETCS2] [MAP2] [Waiting for the RBC server] (time: 18:12:45, date: 19/08/2022)
2 [ETCS2] [MAP2] [Connection established] (time: 18:12:47, date: 19/08/2022)
3 [ETCS2] [MAP2] [BEGIN at station S2] (time: 18:12:47, date: 19/08/2022)
4 [ETCS2] [MAP2] [CURRENT: S2; NEXT: MA5] (time: 18:12:47, date: 19/08/2022)
5 [ETCS2] [MAP2] [CURRENT: MA5; NEXT: MA6] (time: 18:12:49, date: 19/08/2022)
6 [ETCS2] [MAP2] [CURRENT: MA6; NEXT: MA7] (time: 18:12:51, date: 19/08/2022)
7 [ETCS2] [MAP2] [CURRENT: MA7; NEXT: MA3] (time: 18:12:53, date: 19/08/2022)
8 [ETCS2] [MAP2] [CURRENT: MA7; NEXT: MA3] (time: 18:12:55, date: 19/08/2022)
9 [ETCS2] [MAP2] [CURRENT: MA3; NEXT: MA8] (time: 18:12:57, date: 19/08/2022)
10 [ETCS2] [MAP2] [CURRENT: MA8; NEXT: S6] (time: 18:12:59, date: 19/08/2022)
11 [ETCS2] [MAP2] [END at station S6] (time: 18:13:01, date: 19/08/2022)
```



```
rbc.log
~/Desktop/project/logs

1 [ETCS2] [MAP2] [Waiting for the trains to connect] (time: 18:12:47, date: 19/08/2022)
2 [ETCS2] [MAP2] [All connections established] (time: 18:12:47, date: 19/08/2022)
3 [ETCS2] [MAP2] [T1] [FROM: S2, REQ: MA5] [ACCEPTED: YES] (time: 18:12:47, date: 19/08/2022)
4 [ETCS2] [MAP2] [T4] [FROM: S6, REQ: MA8] [ACCEPTED: YES] (time: 18:12:47, date: 19/08/2022)
5 [ETCS2] [MAP2] [T5] [FROM: S5, REQ: MA4] [ACCEPTED: YES] (time: 18:12:47, date: 19/08/2022)
6 [ETCS2] [MAP2] [T2] [FROM: S3, REQ: MA9] [ACCEPTED: YES] (time: 18:12:47, date: 19/08/2022)
7 [ETCS2] [MAP2] [T3] [FROM: S4, REQ: MA14] [ACCEPTED: YES] (time: 18:12:47, date: 19/08/2022)
8 [ETCS2] [MAP2] [T1] [FROM: MA5, REQ: MA6] [ACCEPTED: YES] (time: 18:12:49, date: 19/08/2022)
9 [ETCS2] [MAP2] [T4] [FROM: MA8, REQ: MA3] [ACCEPTED: YES] (time: 18:12:49, date: 19/08/2022)
10 [ETCS2] [MAP2] [T5] [FROM: MA4, REQ: MA3] [ACCEPTED: NO] (time: 18:12:49, date: 19/08/2022)
11 [ETCS2] [MAP2] [T2] [FROM: MA9, REQ: MA10] [ACCEPTED: YES] (time: 18:12:49, date: 19/08/2022)
12 [ETCS2] [MAP2] [T3] [FROM: MA14, REQ: MA15] [ACCEPTED: YES] (time: 18:12:49, date: 19/08/2022)
13 [ETCS2] [MAP2] [T1] [FROM: MA6, REQ: MA7] [ACCEPTED: YES] (time: 18:12:51, date: 19/08/2022)
14 [ETCS2] [MAP2] [T4] [FROM: MA3, REQ: MA2] [ACCEPTED: YES] (time: 18:12:51, date: 19/08/2022)
```



```
rbc.log
~/Desktop/project/logs

14 [ETCS2] [MAP2] [T4] [FROM: MA3, REQ: MA2] [ACCEPTED: YES] (time: 18:12:51, date: 19/08/2022)
15 [ETCS2] [MAP2] [T5] [FROM: MA4, REQ: MA3] [ACCEPTED: YES] (time: 18:12:51, date: 19/08/2022)
16 [ETCS2] [MAP2] [T2] [FROM: MA10, REQ: MA11] [ACCEPTED: YES] (time: 18:12:51, date: 19/08/2022)
17 [ETCS2] [MAP2] [T3] [FROM: MA15, REQ: MA16] [ACCEPTED: YES] (time: 18:12:51, date: 19/08/2022)
18 [ETCS2] [MAP2] [T1] [FROM: MA7, REQ: MA3] [ACCEPTED: NO] (time: 18:12:53, date: 19/08/2022)
19 [ETCS2] [MAP2] [T4] [FROM: MA2, REQ: MA1] [ACCEPTED: YES] (time: 18:12:53, date: 19/08/2022)
20 [ETCS2] [MAP2] [T5] [FROM: MA3, REQ: MA2] [ACCEPTED: YES] (time: 18:12:53, date: 19/08/2022)
21 [ETCS2] [MAP2] [T2] [FROM: MA11, REQ: MA12] [ACCEPTED: YES] (time: 18:12:53, date: 19/08/2022)
22 [ETCS2] [MAP2] [T3] [FROM: MA16, REQ: MA12] [ACCEPTED: NO] (time: 18:12:53, date: 19/08/2022)
23 [ETCS2] [MAP2] [T1] [FROM: MA7, REQ: MA3] [ACCEPTED: YES] (time: 18:12:55, date: 19/08/2022)
24 [ETCS2] [MAP2] [T4] [FROM: MA1, REQ: S1] [ACCEPTED: YES] (time: 18:12:55, date: 19/08/2022)
25 [ETCS2] [MAP2] [T5] [FROM: MA2, REQ: MA1] [ACCEPTED: YES] (time: 18:12:55, date: 19/08/2022)
26 [ETCS2] [MAP2] [T2] [FROM: MA12, REQ: S8] [ACCEPTED: YES] (time: 18:12:55, date: 19/08/2022)
27 [ETCS2] [MAP2] [T3] [FROM: MA16, REQ: MA12] [ACCEPTED: YES] (time: 18:12:55, date: 19/08/2022)
```



```
rbc.log
~/Desktop/project/logs

19 [ETCS2] [MAP2] [T4] [FROM: MA2, REQ: MA1] [ACCEPTED: YES] (time: 18:12:53, date: 19/08/2022)
20 [ETCS2] [MAP2] [T5] [FROM: MA3, REQ: MA2] [ACCEPTED: YES] (time: 18:12:53, date: 19/08/2022)
21 [ETCS2] [MAP2] [T2] [FROM: MA11, REQ: MA12] [ACCEPTED: YES] (time: 18:12:53, date: 19/08/2022)
22 [ETCS2] [MAP2] [T3] [FROM: MA16, REQ: MA12] [ACCEPTED: NO] (time: 18:12:53, date: 19/08/2022)
23 [ETCS2] [MAP2] [T1] [FROM: MA7, REQ: MA3] [ACCEPTED: YES] (time: 18:12:55, date: 19/08/2022)
24 [ETCS2] [MAP2] [T4] [FROM: MA1, REQ: S1] [ACCEPTED: YES] (time: 18:12:55, date: 19/08/2022)
25 [ETCS2] [MAP2] [T5] [FROM: MA2, REQ: MA1] [ACCEPTED: YES] (time: 18:12:55, date: 19/08/2022)
26 [ETCS2] [MAP2] [T2] [FROM: MA12, REQ: S8] [ACCEPTED: YES] (time: 18:12:55, date: 19/08/2022)
27 [ETCS2] [MAP2] [T3] [FROM: MA16, REQ: MA12] [ACCEPTED: YES] (time: 18:12:55, date: 19/08/2022)
28 [ETCS2] [MAP2] [T1] [FROM: MA3, REQ: MA8] [ACCEPTED: YES] (time: 18:12:57, date: 19/08/2022)
29 [ETCS2] [MAP2] [T5] [FROM: MA1, REQ: S1] [ACCEPTED: YES] (time: 18:12:57, date: 19/08/2022)
30 [ETCS2] [MAP2] [T3] [FROM: MA12, REQ: S8] [ACCEPTED: YES] (time: 18:12:57, date: 19/08/2022)
31 [ETCS2] [MAP2] [T1] [FROM: MA8, REQ: S6] [ACCEPTED: YES] (time: 18:12:59, date: 19/08/2022)
32 [ETCS2] [MAP2] [Finished job. Closing server] (time: 18:13:01, date: 19/08/2022)
```