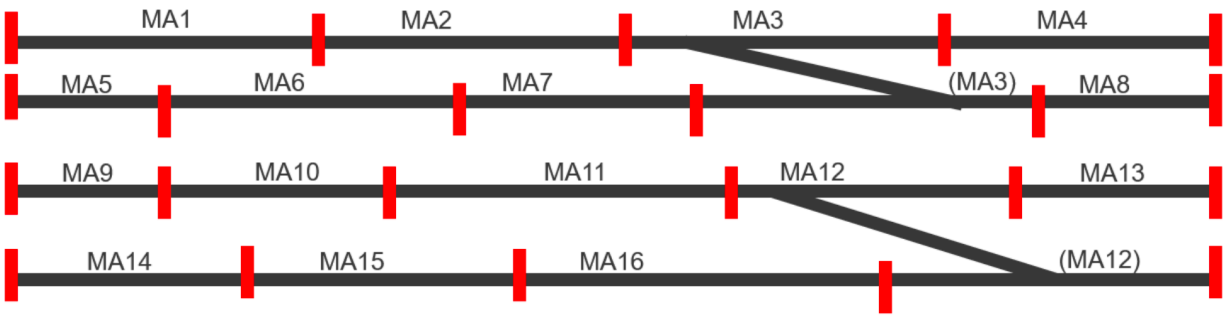
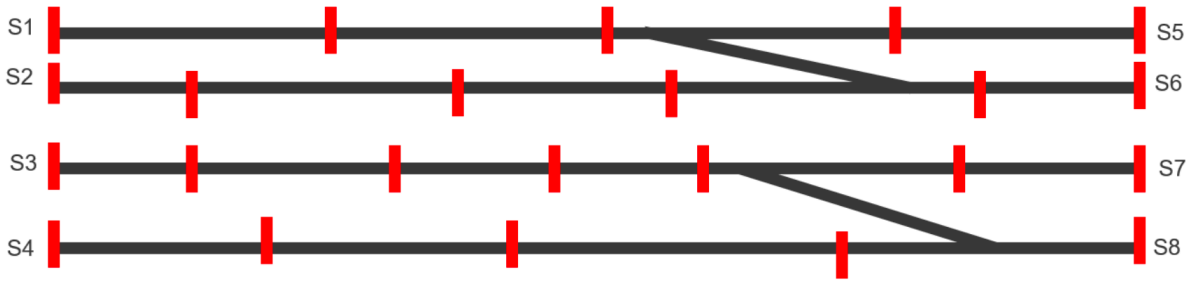
OVERALL GOAL: The aim of the project is to simulate the behavior of a set of trains which, for accomplishing their railway mission, they cross various track segments. The railway mission of each train is to reach a specific station. The main constraint on the movement of trains is that each track segment can only be occupied by one train at a time. Each train receives from time to time, during its railway mission, permission to access the next track segment. The project provides for the realization of the above scheme in two different ways, which provides for two different ways to request and obtain permission to access a track segment

DESCRIPTION OF THE SYSTEM AND ITS BEHAVIOR: In Figure 1 below, it is shown the set of tracks considered. These are 16 segments, numbered MA1 to MA16. In the rest of the document, MAx means any segment of the 16 present in Figure 1. Each segment is delimited by 2 buoys, with the exception of the segments that contain interconnections: the latter are delimited by 4 buoys, and they are the segments MA3 and MA12. In Figure 1, each buoy is represented with a vertical bar.



Eight stations are defined, one for each track term. The stations are numbered S1 to S8 as shown in Figure 2 below.



5 trains are defined, numbered from T1 to T5. Each train has an associated route, which is a station of departure, a set of MAx segments to cross, and a destination station. Two tables are defined, which associate a route to each train. In the following, we will refer to Table 1 and Table 2 with name MAP1 and MAP2, respectively.

Treno	ROUTE
T1	S1, MA1, MA2, MA3, MA8, S6
T2	S2, MA5, MA6, MA7, MA3, MA8, S6
T3	S7, MA13, MA12, MA11, MA10, MA9, S3
T4	S4, MA14, MA15, MA16, MA12, S8
T5	--

MAPPA1

Treno	ROUTE
T1	S2, MA5, MA6, MA7, MA3, MA8, S6
T2	S3, MA9, MA10, MA11, MA12, S8
T3	S4, MA14, MA15, MA16, MA12, S8
T4	S6, MA8, MA3, MA2, MA1, S1
T5	S5, MA4, MA3, MA2, MA1, S1

MAPPA2

The following rules of the railway system are defined:
• Each train starts its own railway mission from a station, and carries out its own railway mission until it reaches the destination station, following the chosen itinerary. The itinerary, i.e. the sequence of MAx segments that each train will have to cross, is defined in MAPPA1 and MAPPA2; clearly, only one map is used for each execution of the railway system.
• All trains start their railway mission at the same time; in other words, they leave at the same time.
• A train's railway mission ends when it reaches its destination station.
• MAPPA1 and MAPPA2 are kept in a register, and provided to trains upon departure. The trains cannot deviate from the itinerary specified in MAPPA1 and MAPPA2.
• A MAx segment can only be crossed by one train at a time; in other words, in a given instant, each segment MAx can be occupied by at most one train.
• It takes 2 seconds to traverse any MAx segment.
• Each train asks, upon departure from the station or at the end of the crossing of a any segment MAx, permission to traverse the next segment or to enter the destination station. The permit can be requested in two different ways, described in the rest of the project.
• Obviously, if two or more trains simultaneously request access to the same track segment MAx, only one train will be able to access (or rather, occupy) the segment; the other trains will have to remain stationary, waiting for the track segment to be free.
• Any number of trains can reside in the destination stations (the stations do not have the single access restriction which instead applies to the track segment).

IMPLEMENTATION DETAILS OF THE REQUESTED PROGRAM.
It is required to develop a program that realizes the system described above, implementing the following prescriptive requirements.

REQUIREMENTS FOR STARTING THE PROGRAM:

The itinerary set to be used, ie MAPPA1 or MAPPA2, must be specified when starting the program.
Furthermore, the program is executable in two modes, which we will call ETCS1 and ETCS2.

ETCS1 mode: The program is started from a shell, specifying the ETCS1 option
Example: shell # ./programname ETCS1 MAPPA1

ETCS2 mode: The program is started using two different shells: in a shell, the application is launched specifying the ETCS2 option, while in the other shell it is launched by specifying the ETCS2 RBC option.
Example:
shell1 # ./programname ETCS2 MAP1
shell2 # ./programname ETCS2 RBC MAP1

The role of the ETCS1, ETCS2 and ETCS2 RBC options will be described below (section How to request access).

REQUIREMENTS FOR RUNNING THE PROGRAM
The five trains are represented by 5 processes, which in the following we will call PROCESSI_TRENO. PROCESSI_TRENO are children of a single process that in the following we will call PADRE_TRENI.
PADRE_TRENI is responsible for creating 16 text files, representing the 16 MAx segments. For example, the files can have the name MA1, MA2, etc. These files are initialized with the "0" (zero) character (that is, PADRE_TRENI writes a 0 inside these files). The files are set to be accessed in reading and writing by all, and privileges set at 666.

A REGISTRO process maintains the routes MAPPA1 and MAPPA2. The REGISTRO process communicates to the various trains the itinerary, if required.
Each PROCESSI_TRENO, after its creation, asks for its own itinerary to the REGISTRO process, then it stores it in a data structure.
All PROCESSI_TRENO start their mission at the same time, unless there are inevitable delays computational.

Iteratively, each PROCESSO_TRENO:
A. Reads the next MAx segment or the next station, from its data structure where it has memorized the mission itinerary.
B. Requires authorization to access this MAx segment or station. This request is carried out differently depending on whether the program is started with the ETCS1 or ETCS2 option (see the Access request mode section).
- If PROCESSO_TRENO has requested and **gets access** to a station, PROCESSO_TRENO enter in station, sets to 0 the content of the MAx file corresponding to the segment it previously occupied then it ends (has completed its mission).
- If PROCESSO_TRENO has requested and **gets access** to a MAx segment, PROCESSO_TRENO: sets the content of the MAx file to 1. Sets to 0 the content of the MAx file corresponding to the segment it previously occupied.
C. Sleeps 2 seconds.
D. Repeat the cycle starting from point A

CLARIFICATION: *in other words, when the train moves, it sets the content of the segment it occupied to 0 previously (write 0 in the corresponding file): this means that it "frees" the segment, and other trains will be able to access it. Instead, the train sets the content of the segment in which it travels to 1, that it occupies: no other train will be able to access it. If permission to move to a new segment is denied, the train remains stationary in the current segment: it will try again to*

request access to the new segment in the iteration next one. Whether it gains access or does not gain access, the train waits for 2 seconds.

HOW TO REQUEST ACCESS:
The request for access to a MAx segment or a station is different and depends on whether the program was started with ETCS1 or ETCS2 option.

Start with ETCS1. If a PROCESSO_TRENO requires authorization to access a station, access is always guaranteed. If a train process requires authorization to access a MAx segment, the PROCESSO_TRENO checks the contents of the MAx file.
• If it is 0, the PROCESSO_TRENO has the authorization to move to the MAx segment.
• Otherwise, the authorization is denied.

Start with ETCS2. In this version, the permissions to occupy the MAx segments are granted by an AF_UNIX socket server which we will call RBC. RBC manages requests for access to segments and stations. The program started with the "ETCS2 RBC" options generates this socket server, while the program started with the "ETCS2" option only generates the PADRE_TRENI and the PROCESSI_TRENO.

At its start, RBC requests and obtains all train routes from the REGISTRO process. Furthermore, RBC creates and maintains a data structure to store the status of MAx segments and stations, according to the following rules:
1) The status of an MAx segment can be free (set to 0) or busy (set to 1). Obviously, all segments are free during the initialization phase.
2)The status of a station is the number of trains placed in that station.

A PROCESSO_TRENO must ask RCB for authorization to access a MAx segment or a station. When receiving such requests, RBC responds to PROCESSO_TRENO as follows:
1) The authorization for the request to access a station is always granted.
2) If, on the other hand, PROCESSO_TRENO requires access to the MAx segment, the RBC socket server checks the status of the segment, and grants the authorization only if the status is free. The state of the segment is then set to busy.

RBC also takes care of freeing the status of the segments: in other words, when a PROCESSO_TRENO leaves a segment, it communicates the event to RBC which consequently changes the status of the segment to *free*.
Note: PROCESSI_TRENO still continue to write values to MAx files, which in fact are not used by RBC.

DATA LOGGING:
Each PROCESSO_TRENO fills a log file, for a total of five log files named T1.log, T2.log, T3.log, T4.log, T5.log. In the log files, each PROCESSO_TRENO records information about the mission, that is, it continuously reports the sector MAx in use (or the starting station), the next sector (or the destination station), the date. As an example, a possible log file is shown for the PROCESSO_TRENO corresponding to T3 (so, T3.log):

[ACTUAL SEGMENT: S4] , [NEXT: MA14], 27 APRIL 2018 16.14.10
[ACTUAL SEGMENT: MA14], [NEXT: MA15], 27 APRIL 2018 16.14.13
[ACTUAL SEGMENT: MA15], [NEXT: MA16], 27 APRIL 2018 16:14:16
[ACTUAL SEGMENT MA16], [NEXT: MA12], 27 APRIL 2018 16:14:19
[ACTUAL SEGMENT: MA12], [NEXT: S8], 27 APRIL 2018 16:14:22
[ACTUAL SEGMENT: S8], [NEXT: —], 27 APRIL 2018 16.14.25

RBC instead writes an RBC.log file, which contains the permissions granted and denied, the recipients, and the date. As an example, a possible extract from the RBC.log log file could be:

[TRAIN REQUESTING AUTHORIZATION: T4] , [ACTUAL SEGMENT: S6], [SEGMENT REQUESTED: MA8], [AUTHORIZED: YES], [DATE: 27 APRIL 2018 16:15:22]

[TRAIN REQUESTING AUTHORIZATION: T4] , [ACTUAL SEGMENT: MA8], [SEGMENT REQUESTED: MA3], [AUTHORIZED: NO], [DATE: 27 APRIL 2018 16:15:25]

[TRAIN REQUESTING AUTHORIZATION: T4] , [ACTUAL SEGMENT: MA8, [SEGMENT REQUESTED: MA3], [AUTHORIZED: YES], [DATE: 27 APRIL 2018 16:15:28]