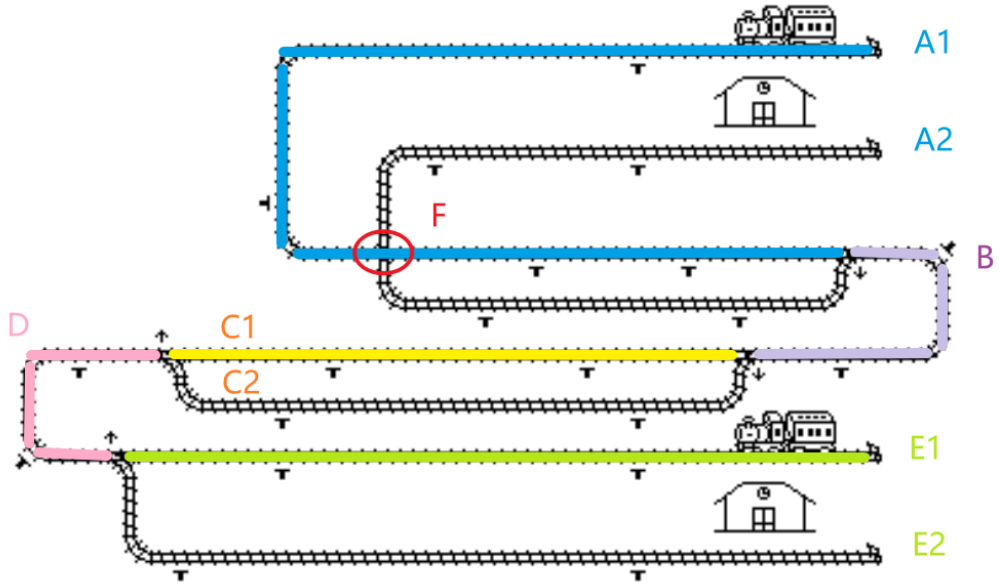
Lab1 - Trainspotting

Group 13

Choice of critical sections



Each track segment (A1/A2/B/C1/C2/D/E1/E2) represents a critical section where only one train is allowed at a time. Since tracks A1 and A2 cross each other, the railway crossing point (F) also forms a critical section that requires exclusive access.

In the appendix, we provide the locations of all sensors in our map, with red text indicating positions adjusted during testing.

Placement of the sensors

We use sensors to monitor trains entering and leaving critical sections. Sensors are positioned before and after each track segment endpoint (near the switches). For the railway crossing, we place four sensors around it, one on each side. Additionally, sensors are positioned before each station to detect arriving trains.

We initially placed the sensors at a distance of 2 units to detect trains entering and leaving segments. However, to ensure trains completely pass the switches/crossing before triggering sensors, we moved the sensors on the parallel tracks and near the crossing further away, adjusting the distance to 3 units.

Each critical section corresponds to one semaphore. Initially, the semaphores for the segments where trains start (A1 and E1) are initialized with a capacity of 0, indicating that these track segments are already occupied by trains.

Before entering the next track segment or crossing, a train must stop and acquire the semaphore for that segment or crossing. For parallel track segments, the train first attempts to acquire the semaphore of the main segment (the northern one). If successful, it enters the main segment. Otherwise, it acquires the semaphore of the side segment and enters that.

Before leaving the parallel track segments, the train stops and attempts to acquire the semaphore of the next single track segment. Only after successfully acquiring it, the train releases the current semaphore and moves forward. After leaving a single track segment, the train releases the semaphore of the single track segment.

When entering the stations, the train stops, waits for 1–2 seconds, and then turns around.

Maximum train speed and the reason for it

Braking Distance and Sensor Placement: The distance between sensors and switches must be sufficient for trains to stop completely before entering critical sections. If train speed exceeds a certain threshold, trains may be unable to stop in time when reaching critical track segments or switches, potentially causing collisions. Higher speeds require longer braking distances, which directly relates to sensor detection and response time.

System Response Time: Train speed affects the simulation's ability to process sensor events and execute control commands. If trains move too fast, the program may not have enough time to update speeds or switch tracks before the train reaches the next sensor, causing trains to overshoot critical sections.

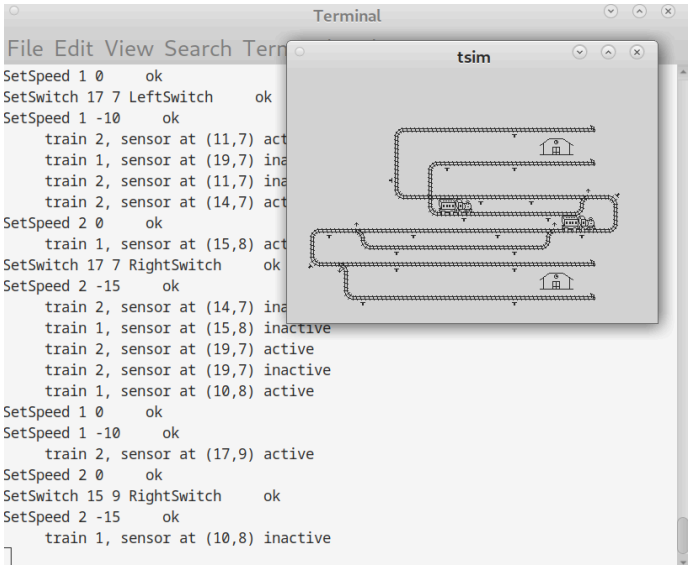
How you tested your solution

We conducted testing with similar speed combinations (e.g., (5, 5), (10, 10), (15, 15)) and different speed combinations (e.g., (5, 10), (5, 15), (10, 15), (1, 5), (1, 10), (1, 15), (15, 1), (15, 5)) for a long time at a high simulation speed.

We encountered "train on switch" errors, which occurred when one train attempted to set the switch direction while another train had not yet completely passed the switch. To resolve this issue, we modified the sensor positions on the parallel tracks, placing them further away from the switches to ensure that trains have completely passed the switch before reaching the sensors. Similarly, at the crossing, trains could collide because another train did not pass through the crossing completely, so we also moved the sensors around the crossing farther away. Finally, we repeated the above experiment with the same speed pair and succeeded.

```
SetSwitch 3 11 RightSwitch     ok
SetSpeed 2 -15     ok
     train 2, sensor at (1,11) inactive
     train 2, sensor at (3,13) active
SetSwitch 3 11 LeftSwitch     train on switch
TSim.CommandException: train on switch
        at TSim.TSimInterface.setSwitch(TSimInterface.java:210
```

```
     train 1, sensor at (10,7) inactive
     train 2, sensor at (9,8) active
SetSpeed 2 0     ok
     train 1, sensor at (6,7) active
SetSpeed 2 5     ok
     Fatal error for train 2 : train collision
Fatal error for train 2 : train collision
```



Appendix

North Station: (15,4) terminal sensor position:(13,3) (13,5)
South Station: (15,12) terminal sensor position:(13,11) (13,13)
Switch: (3,11) (4,9) (15,9) (17,7) crossing: (8,7)

Other sensor position:
A1: (15,7) → (14, 7)
A2: (16,8) → (15, 8)
B: (19,7) (17,9)
C1: (13,9) (6,9) → (12,9) (7,9)
C2: (13,10) (6,10)
D: (2,9) (1,11)
E1: (5,11) → (6, 11)
E2: (3,13) → (4, 13)
F(crossing): (6,7) (8,5) (9,8) (10,7) → (6,6) (9,5) (10,8) (11,7)