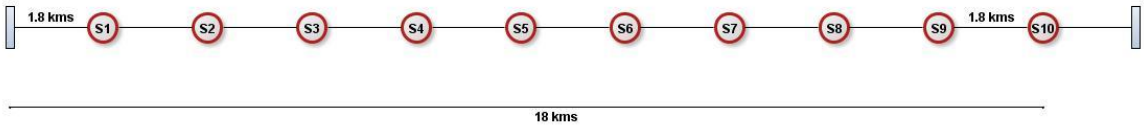
Simulating 4 – Aspect Multi Coloured Signalling

1.0. Introduction :

The basic algorithm developed solves the problem of simulating trains on a single linear track stretched across a distance of 18 kms with 10 signals separated uniformly at 1.8 kms. The type of signalling used is 4-aspect multi coloured signalling.



Before we describe the algorithm, let us define the indications shown by the signals here. They are :

- ***<u>Stop</u> :*** This requires a train to stop dead and not pass the signal under special instructions or emergency procedures. (Stop signals may be passed after halting and waiting in automatic block territory – usually 1 min. during the day & 2 min. during the night.)
- ***<u>Caution</u> :*** This allows a train to proceed past the signal with caution (at reduced speed), being prepared to stop at the next signal.
- ***<u>Attention</u> :*** This allows a train to proceed past the signal, being prepared to slow down to an appropriate speed for the next signal. It means that the next signal will be at Caution which requires reduced speed.
- ***<u>Proceed</u> :*** This allows the train to proceed past the signal without slowing down or stopping.

2.0. Assumptions :

- The uniform speed and the restricted speed with which the trains move are taken to be the same i.e. **'60 km/hr'** and **'36 km/hr'** respectively.
- The trains reach the stretch or S1 after a fixed interval of time, say '3.6 minutes'.
- The train starts applying brakes as soon as gets 'Attention' signal or 'Caution' signal (in some cases) and take 1.8 kms to come to the restricted speed or a halt.

3.0. The Algorithm :

This algorithm runs for a train and simulates all the signals between it and the train just ahead of it. Therefore, to simulate all the signals on the track, we have to run the algorithm for all the trains present on the track simultaneously.

We use three arrays for this process, namely Signal array, Distance array and the Time array. The use of these arrays are described as follows :

- The Signal array s[i] contains the type of signal at 'i+1'$_{th}$ signal.

s[i]	Meaning
0	Stop
1	Caution
2	Attention
3	Proceed

- The Distance array d[i] contains the distance travelled by the 'i+1'$_{th}$ train.
- The Time array t[i] finally contains the time taken by the 'i+1'$_{th}$ train to cover the whole track.

3.1. Simulating Signals :

We run this algorithm for a train when it is just about to reach a signal i.e. if (d[i]/1.8) belongs to the set N where N contains {0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0}. Then, we check the distance of the closest train ahead of it i.e. d[i-1]. We define a new variable p where p = d[i-1] – d[i].

Now, depending upon the value of p, there exists 4 cases which are :

Case 1 : **0 < p < 1.8**

This means that the closest train ahead is just on the next track from the respective train. Therefore, here s[j] = 0 which means that the 'j+1'$_{th}$ signal displays Red i.e. Stop.

Case 2 : **1.8 < p < 3.6**

This means that the closest train ahead is on the next to next track. Therefore, here s[j] = 1 and s[j+1] = 0 i.e. the signal at the 'i+1'$_{th}$ train displays Caution and the next signal displays Stop.

Case 3 : **3.6 < p < 5.4**

This means that the closest train ahead is on the third next track. Therefore, here s[j] = 2 and s[j+1] = 1 and s[j+2] = 0 i.e. the signal at the 'i+1'$_{th}$ train displays Attention, the next signal displays Caution and the next signal displays Stop.

Case 4 : **p > 5.4**

This means that the closest train ahead is beyond the third next track. We find the signal k by k = [d[i-1]/1.8] where [ ] = G.I.F. Therefore, here s[k-1] = 0 and s[k-2] = 1 and s[k-3] = 2 and all s[m]'s = 3 where j <= m <= k-4 i.e. the signal before train 'i' displays Stop, the signal before displays Caution , the signal before displays Attention and all signals between the Attention signal and the train 'i+1' displays Proceed.

3.2. Calculating Time :

Once we get the signals on all the signal posts, the next thing we want to know is the time taken by the train to cover the next stretch of 1.8 kms and finally the whole track of 18 kms. The equation used to calculate the time taken by the train to come from a speed of u to a final speed of v is given by t = 2s/(u+v) where t = time taken, s = 1.8 kms, u = initial speed and v = final speed. Depending upon the *type of signal* and the *speed* with which the train crosses the signal, there are a total of 7 cases which are possible. They are :

Case 1 : **Attention and Speed = 60 km/hr**

This case occurs when a train comes to a signal showing Attention from a signal showing Proceed. Since the train passed a signal showing Proceed, it must be travelling with the speed of 60 km/hr. As it encounters the Attention signal, the train must now reduce its speed from 60 km/hr to the restricted speed of 36 km/hr within the next 1.8 kms according to the assumptions taken earlier. Therefore, the time taken by the train to come to a speed of 36 km/hr given by the equation is 2.25 minutes. Therefore, everytime the train encounters this case, a total of 2.25 min are added to the total time of the train i.e.

t[i] = t[i] + 2.25;

Case 2 : **Attention and Speed = 36 km/hr**

To explain this case, let us take a small example. Let us assume that trains enter the stretch after every 3.6 minutes.

So, when the first train passes S3, the second train will be just passing S1. So the signals which will be displayed will be :

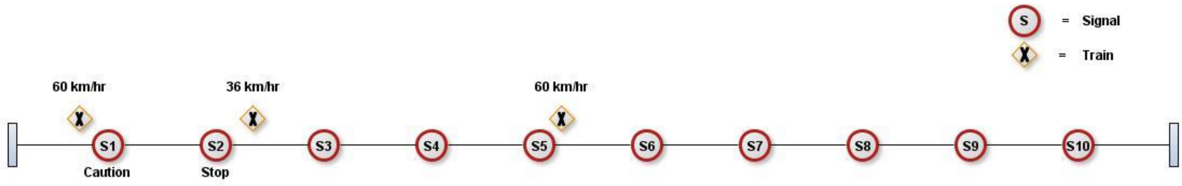
Now, for the distance of S1 to S2, the second train reduces its speed from 60 km/hr to 36 km/hr and takes 2.25 min to do so. In this time, the first train travels a distance of 2.25 kms ahead of S3. Therefore, when the second train reaches S2, the first train reaches between S4 and S5. Therefore, now the signals will show Attention at S2, Caution at S3 and Stop at S4. Hence, the second train reaches Attention signal at 36 km/hr.

Since the train is already travelling at a speed of 36 km/hr, there is no need to reduce its speed. So, it travels with the same speed from S2 to S3 and the time taken by it is added to the total time where u = 36 km/hr and v = 36 km/hr i.e.

t[i] = t[i] + 3;

Case 3 : **Caution and Speed = 60 km/hr**

To explain this case, we take the help of the previous example. When the third train reaches S1, the second train travels 0.81 kms further from S2. Therefore, for the third train, the signals are :



Therefore, as soon as the train passes the Caution signal, it applies brakes to stop at S2 because the next track is not clear. Therefore, the time taken is calculated and added to the total time i.e.

t[i] = t[i] + 3.6;

Case 4 : **Caution and Speed = 36 km/hr**

This case occurs when a train comes to a signal showing Caution from a signal showing Attention. Since the train passed a signal showing Attention, it must be travelling with the speed of 36 km/hr. As it encounters the Caution signal, the train must now reduce its speed from 36 km/hr to 0 km/hr within the next 1.8 kms according to the assumptions taken earlier. Therefore, the time taken by the train to come to a stop given by the equation is 6 minutes. Therefore, everytime the train encounters this case, a total of 6 min are added to the total time of the train i.e

t[i] = t[i] + 6;

Case 5 : **Proceed and Speed = 60 km/hr**

This case occurs when a train comes to a signal showing Proceed from a signal showing Proceed. Since the train passed a signal showing Proceed, it must be travelling with the speed of 60 km/hr. As it encounters the Proceed signal, the train must not reduce its speed from 60 km/hr. Therefore, the time taken by the train to come to the next signal given by the equation is 1.8 minutes. Therefore, everytime the train encounters this case, a total of 1.8 min are added to the total time of the train i.e

t[i] = t[i] + 1.8;

Case 6 : **Proceed and Speed = 36 km/hr**

This case occurs when a train comes to a signal showing Proceed from a signal showing Attention. Since the train passed a signal showing Attention, it must be travelling with the speed of 36 km/hr. As it encounters the Proceed signal, the train must now increase its speed from 36 km/hr to 60 within the next 1.8 kms according to the assumptions taken earlier. Therefore, the time taken by the train to come to a speed of 60 km/hr given by the equation is 2.25 minutes. Therefore, everytime the train encounters this case, a total of 2.25 min are added to the total time of the train i.e t[i] = t[i] + 2.25;

Case 7 : **Stop and Speed = 0 km/hr**

This case occurs when a train comes to a signal showing Stop from a signal showing Caution. Since the train passed a signal showing Caution, it must be reducing its speed from 36 km/hr to 0 km/hr. As it encounters the Stop signal, the train must now stop dead and wait there till any further notice or may pass after halting and waiting in automatic block territory – usually 1 min. during the day & 2 min. during the night and then increase its speed to 36 km/hr within the next 1.8 kms. Therefore, the time taken by the train to reach 36 km/hr given by the equation is 6 minutes. Therefore, everytime the train encounters this case, a total of 6 min and an extra time t' (1 min for day and 2 mins for night) are added to the total time of the train i.e

t[i] = t[i] + 6 + t'

Hence, using the array t[i], we can have the time taken by train 'i+1' to travel the whole track of 18 kms.

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