Changes to the problem

1. Since the entire train can have only a single speed at any instant, the leading and trailing edge need to have the same speed at a point in time. This makes the formulation complicated if the train is occupying main track, switch arcs and sidings at the same time while moving.

In order to simplify it. We would like to make following assumption to our problem:

- For train speed purpose, assume that the train speed is with reference to the lead engine of the train (train is moving like a dot)
- Provide the entry/exit times at arcs with reference to the lead engine of the train.
- There must be 5 minutes separation between trains (to avoid collision). The separation needs to be considered in 3 distinct cases:

1) Crossover and Switch arc usage in diverging paths:

   Take a look at arc (12,13) in Figure 2 in the problem statement. In order for Train D to arrive in node 13 by moving on arc (12,13), the rear end of Train E must clear from arc (13,28), so that there is no collision or scraping while Train D may be on (12,13) and Train E is partially on (13,28) while exiting. Since we are now asking you to provide the entry/exit times at arcs with reference to the lead engine of the trains, we can safely assume that given the arc lengths, train lengths, and train speeds, if a separation of 5 minutes is enforced, such a collision cannot happen. Namely, when we know the exit time (say at time t) of Train E on arc (13,28), the earliest Train D can occupy arc (12,13) is from time t+5.

2) Trailing:

   Let us assume, there is another Train G, trailing Train D on the same route. Then, Train G would only be allowed to enter arc (12,13) after:

   = exit time of Train D from arc(12,13) + 5 minutes

   = t+5+(traversal time of Train D on arc (12,13))+5. The second “5” in the formula is for the separation between Train G and Train D.

3) Crossover and Switch arc usage in converging paths:

   Let us further assume that, there is another Train H, coming from node 28 to node 13, right after Train G, to follow Train G. Then, the 5-minute separation rule would suggest that the earliest time Train H can enter arc (28,13) is:

   = exit time of Train G from (12,13) + 5 minutes
   = t+5+(traversal time of Train D on arc (12,13))+5 +(traversal time of Train G on arc (12,13))+ 5

2. In Figure 1, the following situation is not allowed where a train occupies arc 54-> 58 and the other train occupies arc 56->57. This physical structure is called “double crossover” in railroad terms.

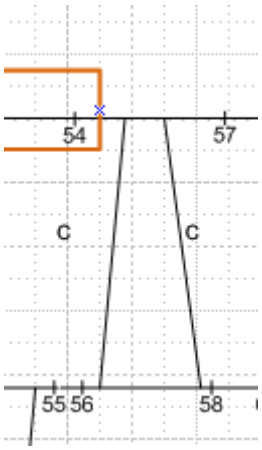


Figure 1: part of the network of competition datasets

Impact on the current problem statement

The above assumptions modifies the following statements in the problem statement document

On page 3:

Old: For Train E to continue on Main Track 2 (start to occupy track 23-20), the rear end of Train C must clear from the track on arc 20-21.

New: For Train E to continue on Main Track 2 (start to occupy track on arc 23-20) it must wait until at least 5 minutes have passed after the Train C has cleared from the track on arc 20-21.

On page 5:

Old: the second train cannot enter a track arc occupied by the first train until the rear end of the first train clears and exits this arc.

New: the second train cannot enter a track arc occupied by the first train until the first train clears and exits this arc and uses the 5 minutes separation rules as defined previously.

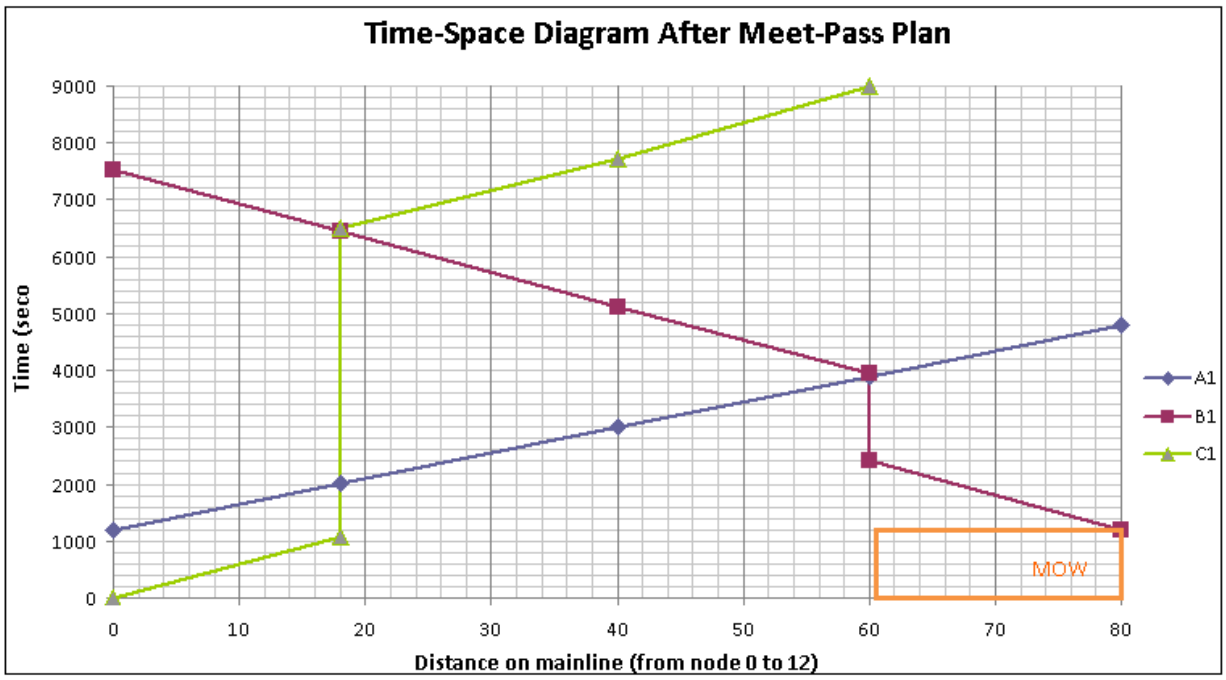
On page 6:

Old: **Train entry and exit time:** Train is assumed to enter a track arc when the leading end of train enters into the arc. Train is assumed to leave a track arc when entire train length exited the arc.

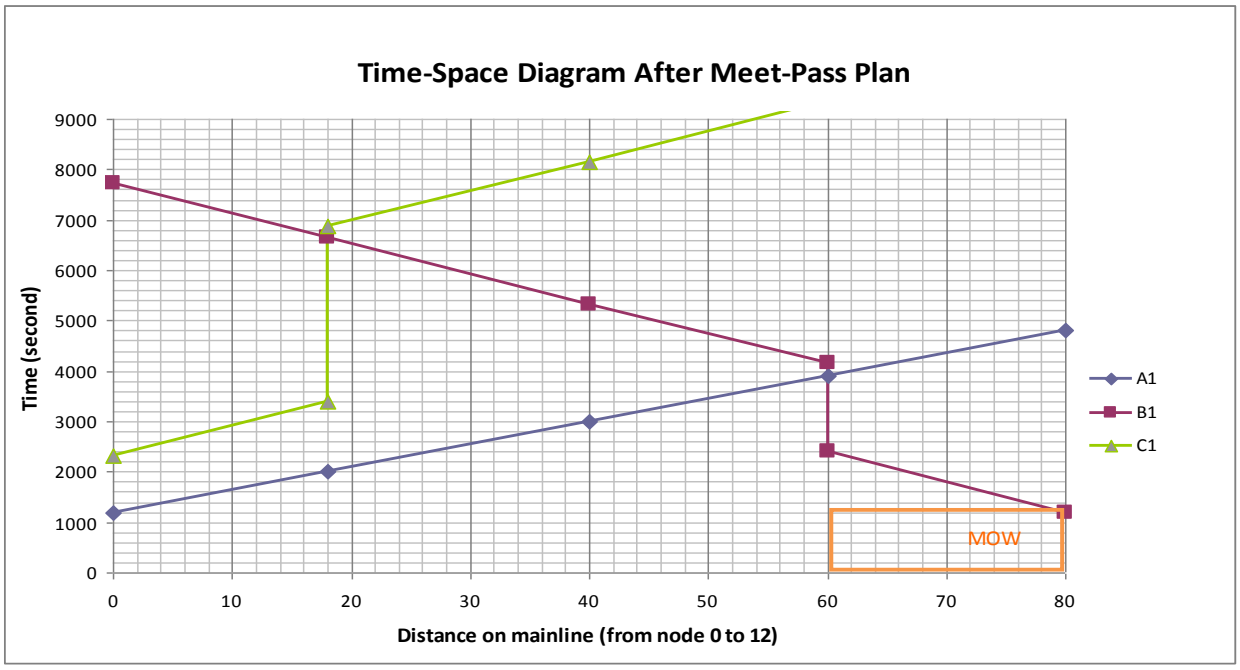
New: **Train entry and exit time:** Train is assumed to enter a track arc when the leading end of train enters into the arc. Train is assumed to leave a track arc when leading end of the train exited the arc.

On page 12:

Old:



New:



On page 13:

Old:

	Delay Time	Arrive at	Arrive Time	Required SA	SA diff	SA Penalty (> 2 hrs)	Required TWT	TWT diff	TWT penalty (outside 4 hr window)	Unpreferred Track
Train C1	4929.668									0
		node 6	7713.668	3000	-4713.668	0				
		node 12	10113.670	6000	outside planning horizon		7200	outside planning horizon		
Train A1	0									0
		node 6	3000	2400	-600	0				
		node 12	4800	4800	0	0	8700	3900	300	
Train B1	2307.416									0
		node 6	5110.576	-3000	-8110.576	-910.576				
		node 0	7530.744	5400	-2130.744	0	4800	-2730.744	0	

New:

	Delay Time	Arrive at	Arrive Time	Required SA	SA diff	SA Penalty (> 2 hrs)	Required TWT	TWT diff	TWT penalty (outside 4 hr window)	Unpreferred Track
Train C1	**5374.664**									**0**
		node 6	**8158.664**	**3000**	**-5158.664**	**0**				
		node 12	**10558.664**	**6000**	**outside planning horizon**		**7200**	**outside planning horizon**		
Train A1	**0**									**0**
		node 6	**3000**	**2400**	**-600**	**0**				
		node 12	**4800**	**4800**	**0**	**0**	**8700**	**3900**	**300**	
Train B1	**2512.916**									**0**
		node 6	**5316.076**	**-3000**	**-8316.076**	**-1116.08**				
		node 0	**7736.244**	**5400**	**-2336.244**	**0**	**4800**	**-2936.244**	**0**	

Old:

Total Cost = (Total Delay * Delay Penalty/Hour) +
(Schedule deviance over 2 hours for SA Trains * Penalty over 2-hour deviance/Hour) +
(Terminal Want Time deviance beyond the 4-hour window * Penalty for TWT/Hour) +
(Unpreferred Track Time * Penalty for Unpreferred Track Utilization/Hour)
= ((4929.668/3600) * 400) + (0 * 600) + ((2307.416/3600) *500) +
((910.576/3600) * 200) +

((300/3600) * 75) +
(0 * 50)
= $925.053

New:

Total Cost = (Total Delay * Delay Penalty/Hour) +
(Schedule deviance over 2 hours for SA Trains * Penalty over 2-hour deviance/Hour) +
(Terminal Want Time deviance beyond the 4-hour window * Penalty for TWT/Hour) +
(Unpreferred Track Time * Penalty for Unpreferred Track Utilization/Hour)
= ((5374.664/3600) * 400) + (0 * 600) + ((2512.916/3600) *500) +
((1116.07563/3600) * 200) +
((300/3600) * 75) +
(0 * 50)
= $1014.455