Simulation Lab Term Project

TRUCK MOVEMENT IN HIGH ALTITUDE AREAS

Indian Institute of Technology, Kharagpur

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Overview

In Himalayan region logistics is carried out through trucks only. In that region very narrow roads are available where only one truck can pass at a time. For crossing there are locations/junctions at some intervals where the crossing can be done. If two trucks face one another in midway of the road then one truck has to move backward to a location where the crossing is possible

Goals

1. To build a model for truck movement in the Himalayan region that is single lane road with lay-by junctions
2. To be able to understand the issues in developing and applying simulation to real world systems

Constraints and Assumptions

Constraints:-

- Only one truck can be present at one position on road
- Trucks can only cross at junctions

Assumptions:-

- Junction Capacity = infinite (#trucks that can stand by)
- Speed of trucks to be equal and uniform throughout
- Speed of truck moving forward = Speed of truck moving backward
- Trucks are considered as point size entities for ease
- A small precision band(δ distance) is considered while calculation of positions in order to perform continuous simulation

Approach

Below are discussed the required variables and parameters for our simulation

Variables

- Every Truck dictionary contains following variables :-
  - *x_curr- The current coordinate/position of the truck*
  - *Curr_dirn- Represents the direction in which the truck is moving. +1 indicates forward movement (along positive x-axis) while -1 indicates backward movement.*
  - *Root_dirn- The direction in which the truck needs to travel with respect to the origin to reach the destination*
  - *Speed- Represents the speed of the truck*
  - *Reverse Speed*
  - *Arr_time- The time at which truck arrives at origin*
  - *depart_time- The time at which the truck reaches its destination*
  - *For_dist- Total forward distance travelled by the truck*
  - *Back_dist- Total backward distance travelled by the truck*

Parametres

- Time_delta - a very small increment to run simulation
- No_of_junctions - #junctions including start and end
- Position_of_junct - [position of junctions on axis] (~Normal dist.)
- No_of_trucks_to_sim_each_dir - no of trucks that will arrive
- For_truck_arr_times = [arrival times for forward moving trucks] (~uniform dist)
- Back_truck_arr_times = [arrival times for backward moving trucks] (~uniform dist)
- Sim_run_totaltime - total simulation time limit decided

Now let's jump to our approach, basically

- Trucks arrive according to uniform distribution at their respective origins
- Trucks keep moving in their root direction until confronts another truck
- Here a decision needs to made which sets of trucks will move reverse - done on the basis of total reverse distance to be travelled by each set of trucks moving in corresponding directions, changing current directions of a set of trucks
- After they reach nearby junction, they start moving back to their root direction as junction clears traffic
- This run continues until
    - Total simulation time is complete (pre-defined)
    - All trucks reach their destination

Following functions were defined in order to simulate our process :-

I. **Next_position -** Updates the current position of the truck

x_curr= x_curr + (curr_dirn*speed*time)

II. **for_truck_arr -** Appends a new truck whose root direction is +1 in the list of currently active trucks

III. **back_truck_arr -** Appends a new truck whose root direction is -1 (whose destination is along negative x- axis) in the list of currently active trucks

IV. **not_near_junction -** Checks whether any of the colliding trucks are near the junction or not

V. **dist_from_left_junc** and **dist_from_right_junc -** Calculates distance of truck from nearest left and right junction

VI. **Movement decision -** Checks for the pair of trucks with collision and assigns them direction of movement based on cumulative **dist_from_left_junc** and **dist_from_right_junc functions.**

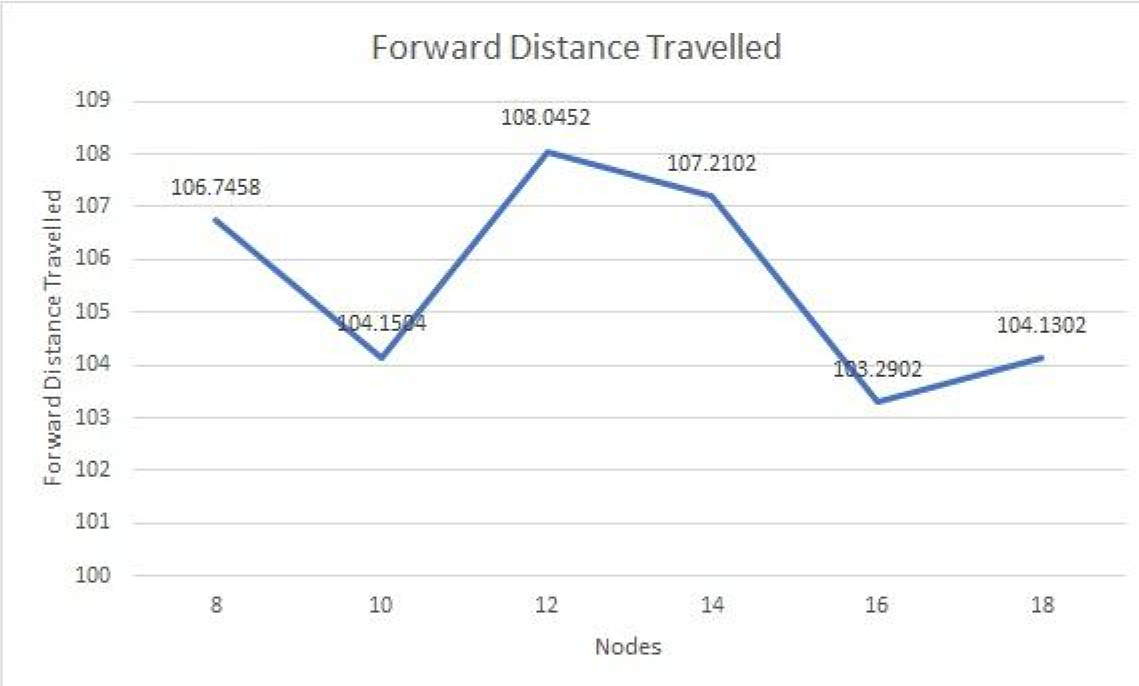
Observations

For Uniform Distribution of Junction Points

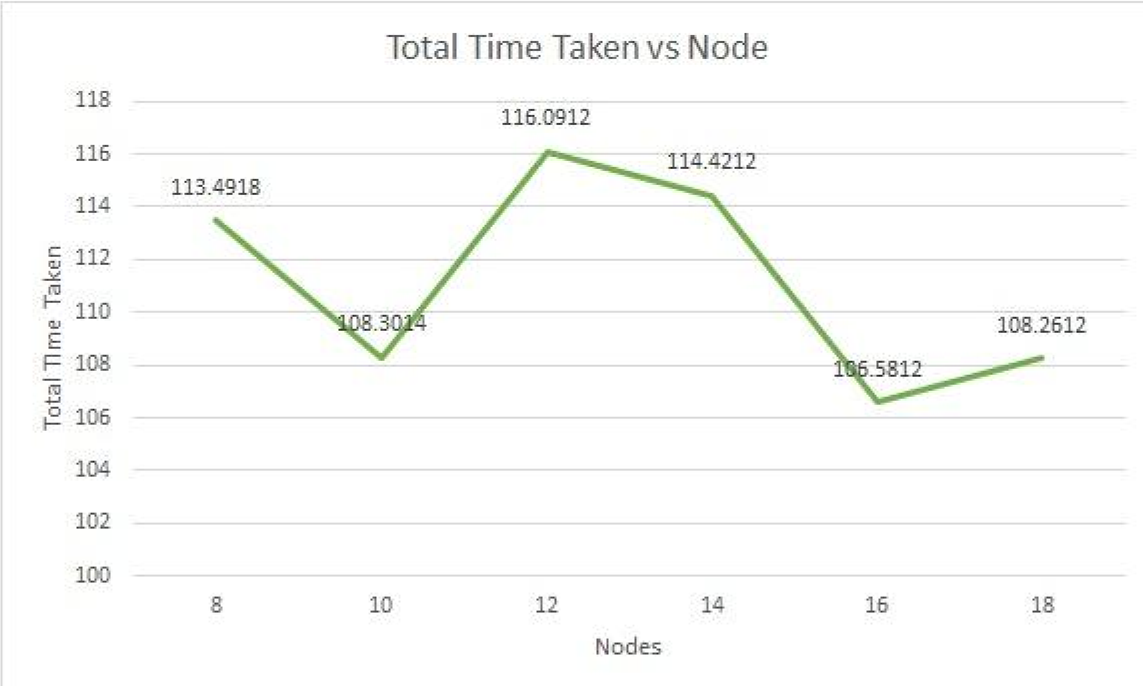
Nodes	Forward Distance Travelled	Backward Distance Travelled	Total Time Taken	Total Distance Travelled
8	106.7458	6.745	113.4918	113.4908
10	104.1504	4.15	108.3014	108.3004
12	108.0452	8.045	116.0912	116.0902

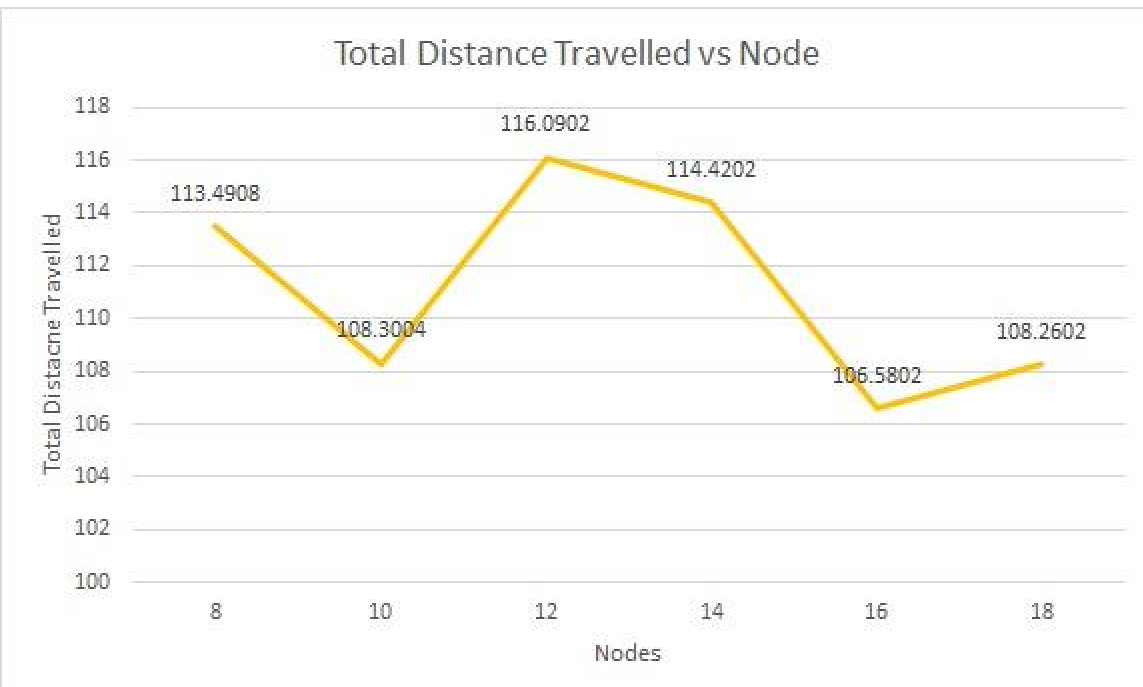
14	107.2102	7.21	114.4212	114.4202
16	103.2902	3.29	106.5812	106.5802
18	104.1302	4.13	108.2612	108.2602

Nodes	Average Forward Distance	Average Backward Distance	Average Time	Average Total Distance
8	10.67458	0.6745	11.34918	11.34908
10	10.41504	0.415	10.83014	10.83004
12	10.80452	0.8045	11.60912	11.60902
14	10.72102	0.721	11.44212	11.44202
16	10.32902	0.329	10.65812	10.65802
18	10.41302	0.413	10.82612	10.82602


Forward Distance Travelled
109
108
107
106
105
104
103
102
101
100
Forward Distance Travelled
106.7458
104.1504
108.0452
107.2102
103.2902
104.1302
8
10
12
14
16
18
Nodes


Backward Distance Travelled
9
8
7
6
5
4
3
2
1
0
Backward Distance Travelled
6.745
4.15
8.045
7.21
3.29
4.13
8
10
12
14
16
18
Nodes



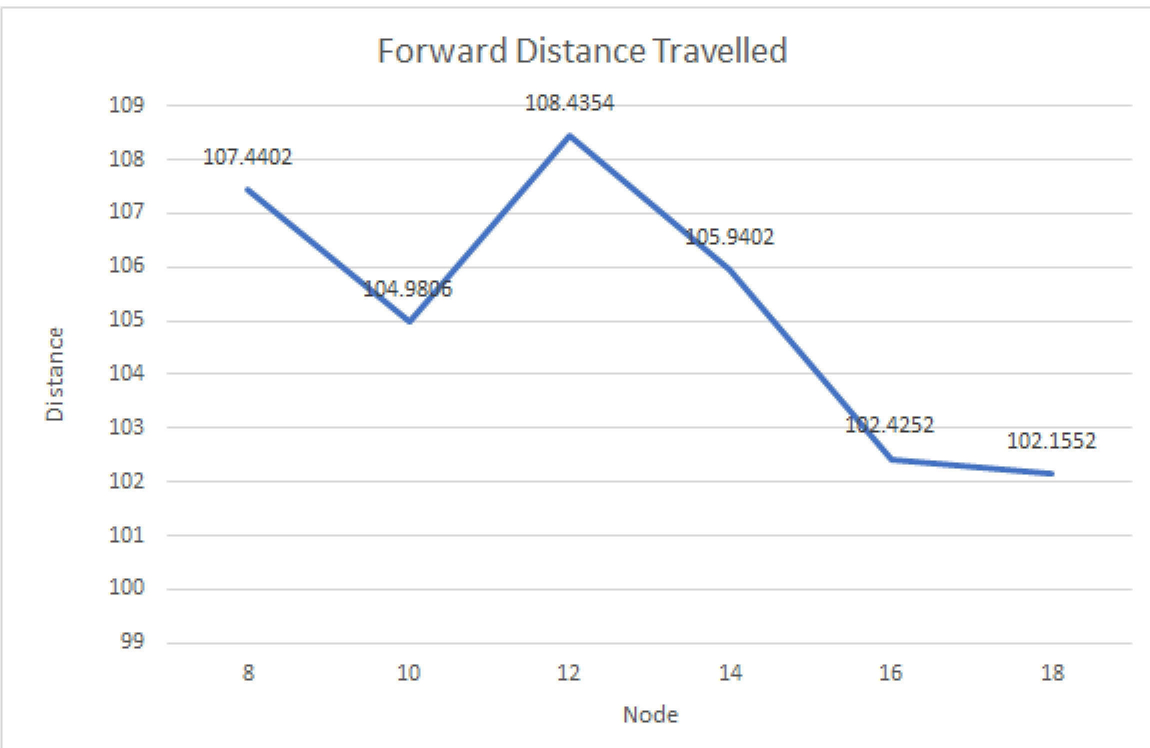


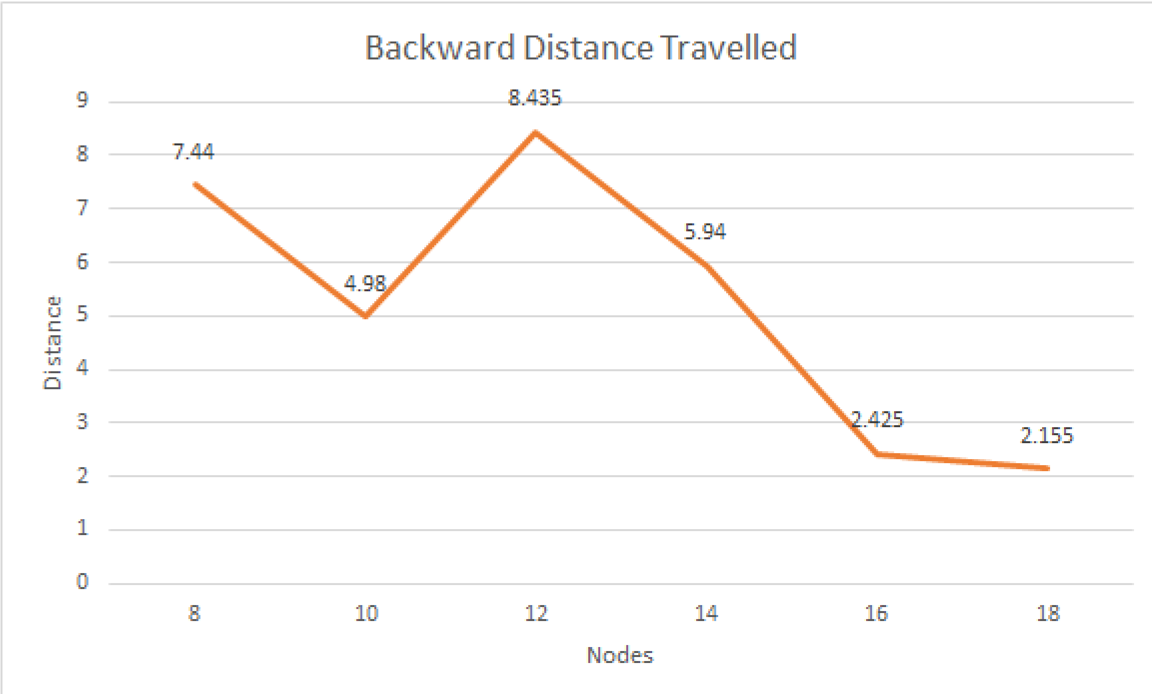
For Normally Distributed Junction Points

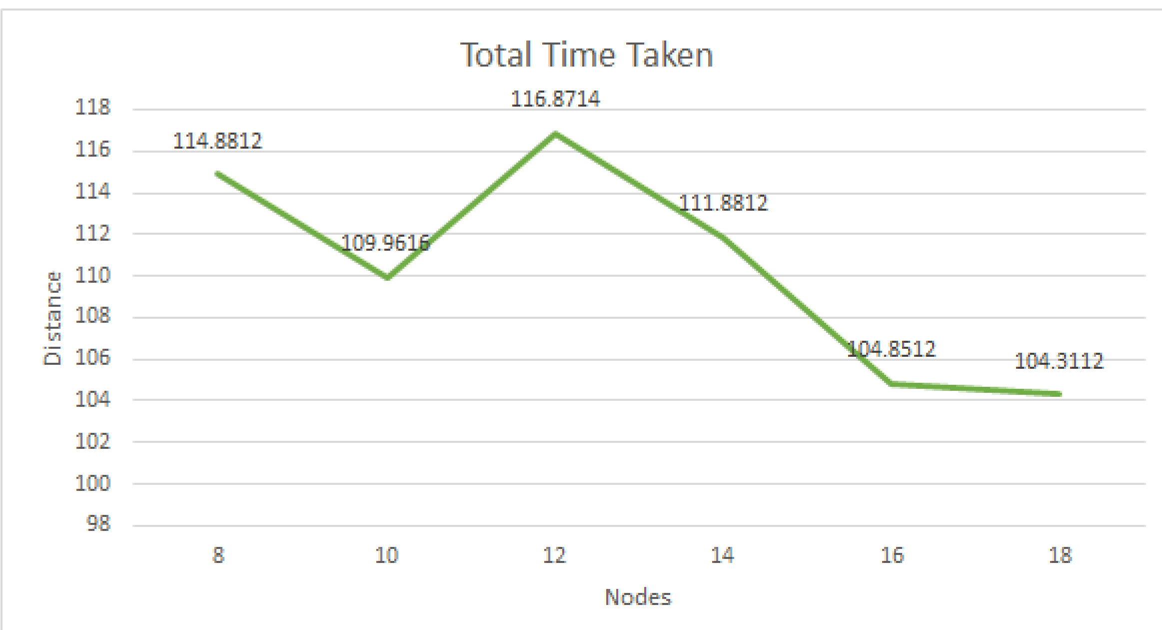
Nodes	Forward Distance Travelled	Backward Distance Travelled	Total Time Taken	Total Distance Travelled
8	107.4402	7.44	114.8812	114.8802
10	104.9806	4.98	109.9616	109.9606
12	108.4354	8.435	116.8714	116.8704
14	105.9402	5.94	111.8812	111.8802
16	102.4252	2.425	104.8512	104.8502
18	102.1552	2.155	104.3112	104.3102

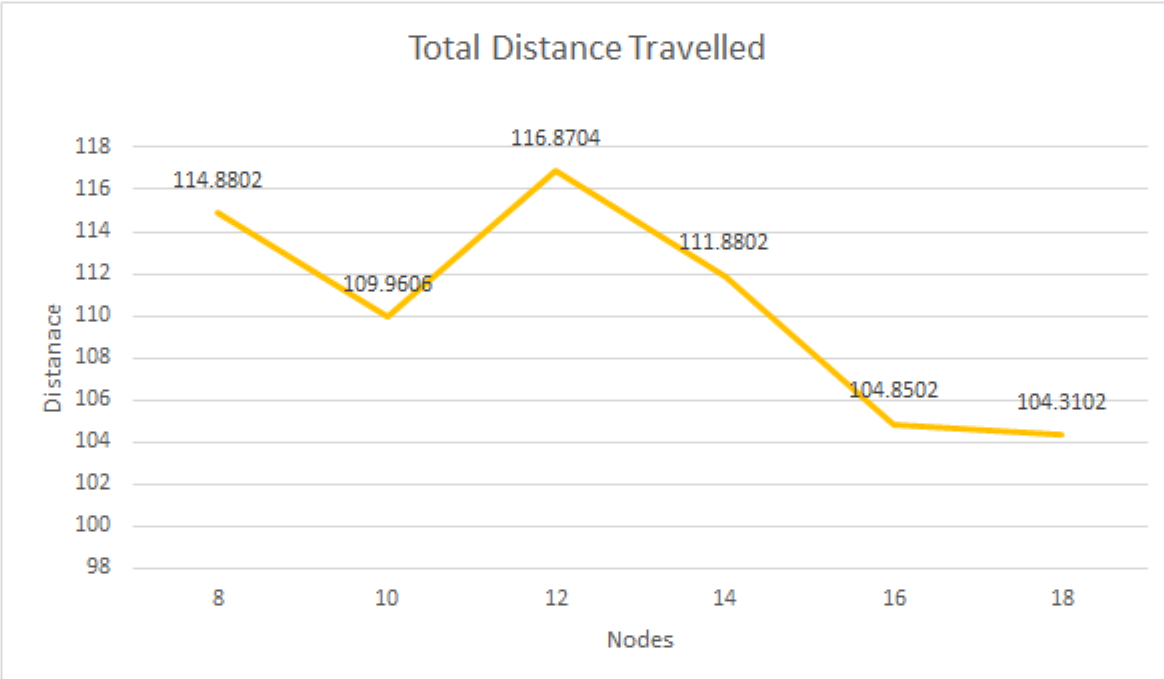
Nodes	Average Forward Distance	Average Backward Distance	Average Time	Average Total Distance
8	10.74402	0.744	11.48812	11.48802
10	10.49806	0.498	10.99616	10.99606

12	10.84354	0.8435	11.68714	11.68704
14	10.59402	0.594	11.18812	11.18802
16	10.24252	0.2425	10.48512	10.48502
18	10.21552	0.2155	10.43112	10.43102

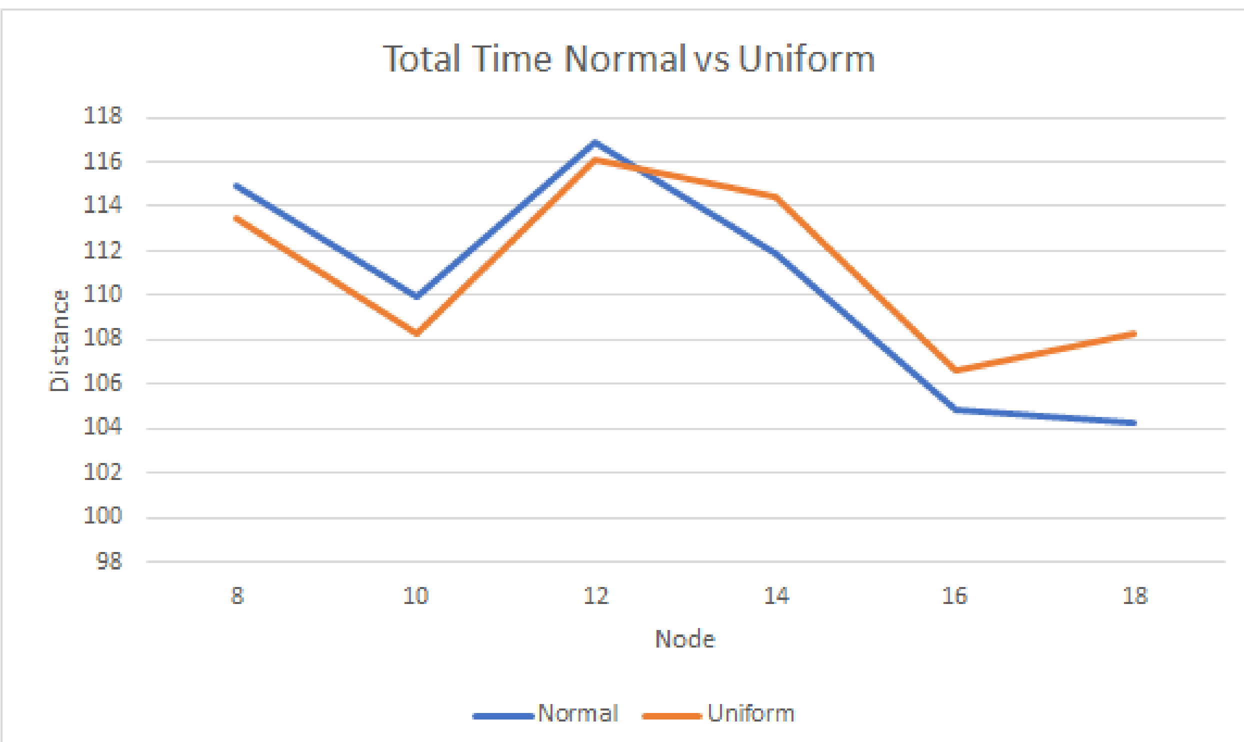



Backward Distance Travelled
Distance
Nodes
7.44
4.98
8.435
5.94
2.425
2.155
0 1 2 3 4 5 6 7 8 9
8 10 12 14 16 18


Total Time Taken
Distance
Nodes
114.8812
109.9616
116.8714
111.8812
104.8512
104.3112
98 100 102 104 106 108 110 112 114 116 118
8 10 12 14 16 18



Normal Distribution vs Uniform Distribution



Observations

We had three variables namely number of backward and forward trucks, number of nodes and speed of each truck.

We used a number of forward and backward trucks as [5,5] and varied the number of nodes with time of arrival of trucks modeled by **Uniform(0,25)** and **Normal distribution(μ=5,σ=2)**.

Number to nodes varied between the **range of [8-18]** and data were collected . Using the collected data we calculated total **forward distance travelled , Backward distance travelled , Total time taken** etc.

From the Graph we can see that all the metrics follow the same pattern for both the considered distributions.

Results

I. Dependency on distribution

We can see that the total time decreases when we increase the number of nodes from 16 in case of normal distribution whereas in uniform sixteen number of nodes is the most optimum number as it further starts increasing.

Uniform Distribution (0,25) =Optimum number of nodes = 16

Normal Distribution (5,2) =Optimum number of nodes = 18

II. Dependency of metrics on distribution

For Normal distribution the values of metrics were greater than one obtained from Uniform distribution for the nodes 8,10 and 12 but when we increase the number of nodes from 12 to 18 we can see that truck arrival time modelled Normal distribution performs better.

Conclusion and Further work

I. Different objectives to be fulfilled

- Our distribution of junctions might be required to change when our objective varies from say minimizing distance to minimizing time
- Arrival of trucks distribution might change according to times, again demanding change in junctions distribution

All this can be done by merely changing input parameters to our model

II. Tolerance for backward distance travelling

- This can be one of our constraints, as harsh conditions may not support reverse movement of trucks on such high altitude areas
- Arrival of trucks distribution should be kept more than anticipated so as to avoid any risk

A lot of constraints can be added to make our simulation model more realistic or bend it according to specific requirements to be fulfilled