Problem 1

a) Please refer to the R code
b) For the process of generating the plot please refer to the R code.

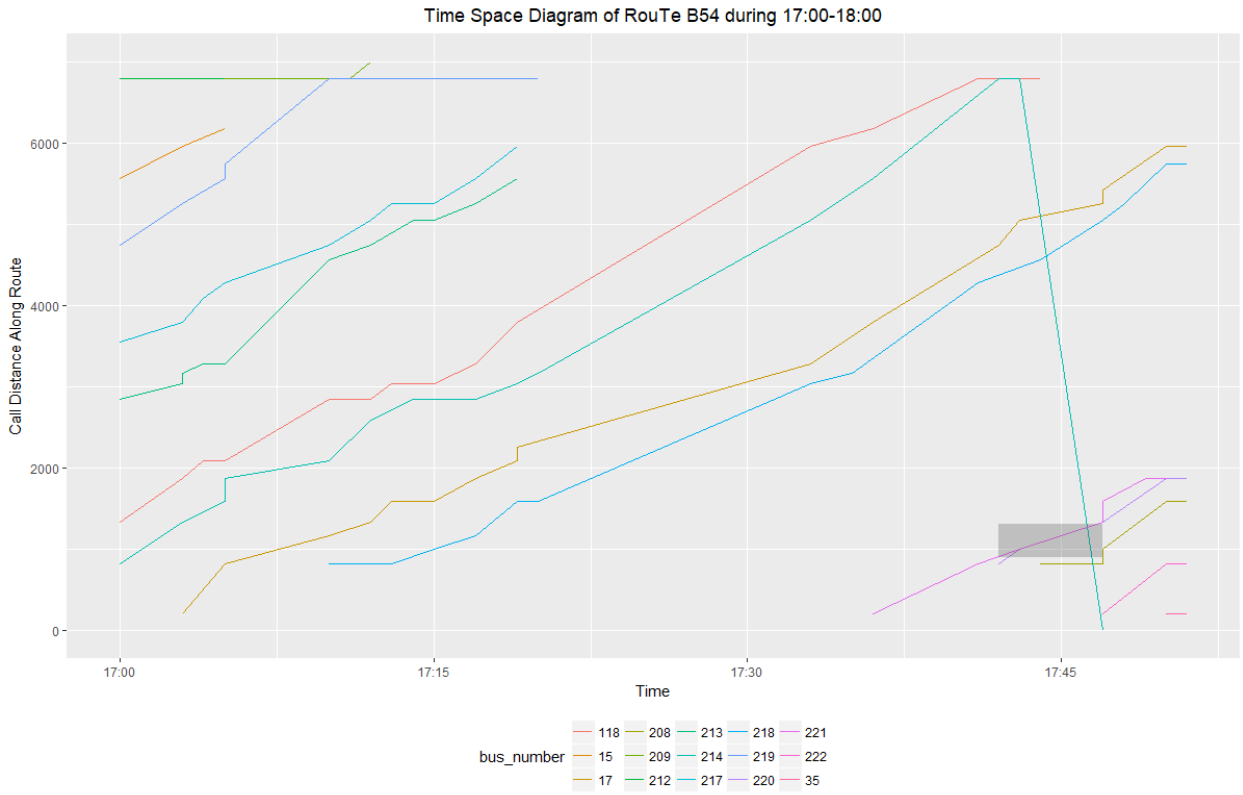

Fig1: Time Space Diagram of Route B54 filtered by given conditions in problem 1 a

c) The bus bunching event was highlighted in the plot using a grey transparent rectangular box. Here the term “bus bunching” is defined as two buses consecutively on duty “collides” with each other when operating normally in their planned directions (both “0” or both “1”). Any accidents such as crashing, or rescheduling, are not taken into consideration.

Problem2

a) Extrapolation was needed to estimate the times at which the buses entering or exiting the space range 0 – 6000. Linear regression was performed to achieve the extrapolation. However, the number of observations during 17:00-18:00 was too small. To obtain better regression results, all observations of the buses selected in problem 1a was used to build the linear regression model, regardless of the time range. The time space diagram of these new dataset is demonstrated as follows:

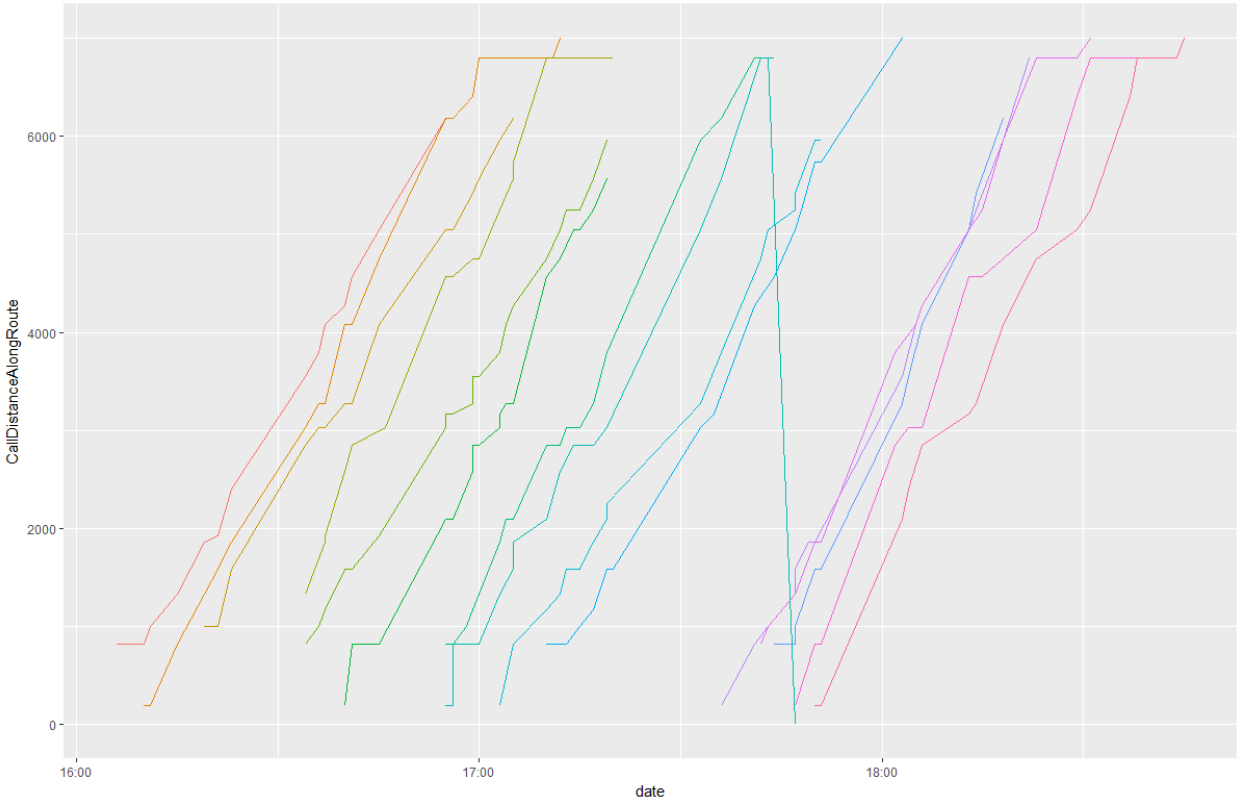

Fig2: Time Space Diagram of Route B54 of all records

Since no monitoring spot was specified for calculating time mean speed, the average speed of each bus over 0 to 6000 was used instead, which is calculated as:

Average speed = 6000/(time span over the length)

The unit for length was also not specified. The records of the "date" column was transformed to numeric values with unit of second. Hence the unit of both resulting speeds was unit length/sec. The time and space mean speed were calculated using the following formula:

$$\overline{v_t} = \frac{1}{N}\sum_{n=1}^{N} v_n$$

$$\ell_s = \frac{L}{\bar{t}}$$

Where $\bar{t}$ is the average time span of all buses.

The results are:

time mean speed = 2.292175 (unit length/sec)
space mean speed = 2.193592 (unit length/sec)

b) Time mean speed and space mean speed can be related by the formula:

$$\overline{v_t} = \overline{v_s} + \frac{\sigma_s^2}{\overline{v_s}}$$

Where sigma is the standard deviation of spot speed. Since the second term at the right hand side of the equation is always equal or larger than 0, time mean speed is always equal or larger than space mean speed.

Difference: Time mean speed is the average speed of all vehicles passing a monitored spot, whereas the space mean speed is the average speed of all vehicles along a given length.