Example on Calculating the Average Travelling Time
Example on Evaluating the Average Travelling Time Using Monte Carlo Simulation

In this document, I will show how to find the average travelling time for passengers served by a number of elevators in a building with a single entrance and incoming traffic. It will be assumed that floor heights are equal and that top speed is attained in one floor journey.

Let us take a building with 10 floors above ground N. (N = 10). The building has a single entrance, the floor height is 4.5 m. The elevator rated speed is 1.6 m/s, acceleration is 1 m/s² and the jerk is 1 m/s³. The door opening time is 2 seconds and the door closing time is 3 seconds. The passenger transfer time in and out is 1.2 seconds. Let us assume that P = 6 passengers.

Let us assume that floor populations are equal. We shall first generate random destinations for the six passengers.
Let us take 6 random numbers in order to generate passenger destinations:

\[ \text{Rend}() = 0.387, 0.781, 0.682, 0.047, 0.166, 0.830 \]

So for the 6 passengers:

\[ \begin{align*}
P_1 & \rightarrow 4 \\
P_2 & \rightarrow 8 \\
P_3 & \rightarrow 7 \\
P_4 & \rightarrow 1 \\
P_5 & \rightarrow 2 \\
P_6 & \rightarrow 9 \\
\end{align*} \]

\[ G \rightarrow 1 \rightarrow 2 \rightarrow 4 \rightarrow 7 \rightarrow 8 \rightarrow 9 \]

\[ \begin{align*}
t_{01} &= \frac{4.5}{1.6} + \frac{1.6}{1} + \frac{1}{1} = 5.4125 \text{ s} \\
t_{2} &= 5.4125 \text{ s} \\
t_{24} &= \frac{9}{1.6} + \frac{1.6}{1} + \frac{1}{1} = 8.225 \text{ s} \\
t_{47} &= 13.5 \left( \frac{1.6}{1} + \frac{1}{1} \right) = 11.0375 \text{ s} \\
t_{78} &= 5.4125 \text{ s} \\
t_{89} &= 5.4125 \text{ s} \\
\end{align*} \]

\[ T_{1} = t_{p1} + s t_{p1} + t_{dc} + t_{01} + t_{d0} + t_{p0} + t_{12} + t_{d10} + t_{p0} + t_{24} + t_{p0} \]

\[ = 1.2 + (5)(1.2) + 3 + 5.4125 + 3 + 2 + 1.2 + 5.4125 + \]
\[ P_1 \downarrow P_2 \downarrow P_3 \downarrow P_4 \downarrow P_5 \downarrow P_6 \]
\[ P_4 \downarrow \]
\[ h_1 c + h_2 c + h_3 c + h_4 c + h_5 c + h_6 c + t_{o1} + t_{a0} + t_{p0} + t_{d0} + h_{12} + t_{d0} + t_{p0} + h_{12} + t_{d0} + h_{12} + t_{d0} + t_{p0} + h_{12} + t_{d0} + h_{12} + t_{d0} + t_{p0} + h_{12} + t_{d0} + t_{p0} \]
\[ P_3 \downarrow \]
\[ h_{47} + h_{12} + t_{d0} + t_{p0} + h_{61} c + h_{78} + t_{d0} + t_{p0} + h_{61} c + h_{78} + t_{d0} + t_{p0} \]
\[ P_6 \downarrow \]

\[ TT_1 = 44.85 \text{ s} \]
\[ TT_2 = 72.5 \text{ s} \]
\[ TT_3 = 59.6875 \text{ s} \]
\[ TT_4 = 15.2125 \text{ s} \]
\[ TT_5 = 25.625 \text{ s} \]
\[ TT_6 = 79.3125 \text{ s} \]

\[ ATT = \sum_{i=1}^{P} TT_i = 49.53125 \text{ s} \]