

### Assignment #3

Analytical results: for M/D/1, n=20000 customers

Mean interarrival time ( minutes)	1.000	1.000	1.000	1.000	1.000
Mean service time minutes	0.300	0.400	0.500	0.600	0.700
Mean time an item spends in the system	$0.3 \cdot (2-0.3) / 2 \cdot (1-0.3) = 0.364$	$0.4 \cdot (2-0.4) / 2 \cdot (1-0.4) = 0.533$	$0.5 \cdot (2-0.5) / 2 \cdot (1-0.5) = 0.75$	$0.6 \cdot (2-0.6) / 2 \cdot (1-0.6) = 1.05$	$0.7 \cdot (2-0.7) / 2 \cdot (1-0.7) = 1.517$
Mean no of items waiting to be served	$0.3 \cdot 0.3 / 2 \cdot (1-0.3) = 0.064$	$0.4 \cdot 0.4 / 2 \cdot (1-0.4) = 0.133$	$0.5 \cdot 0.5 / 2 \cdot (1-0.5) = 0.25$	0.45	1.817
Mean waiting time (includes items that have to wait and items with waiting time=0)	$0.3 \cdot 0.3 / 2 \cdot (1-0.3) = 0.064$	0.133	$0.5 \cdot 0.5 / 2 \cdot (1-0.5) = 0.25$	0.45	1.817
Average delay in queue	0.064	0.133	0.250	0.450	1.817
Average number in queue	0.064	0.133	0.250	0.450	1.817

Simulation results:

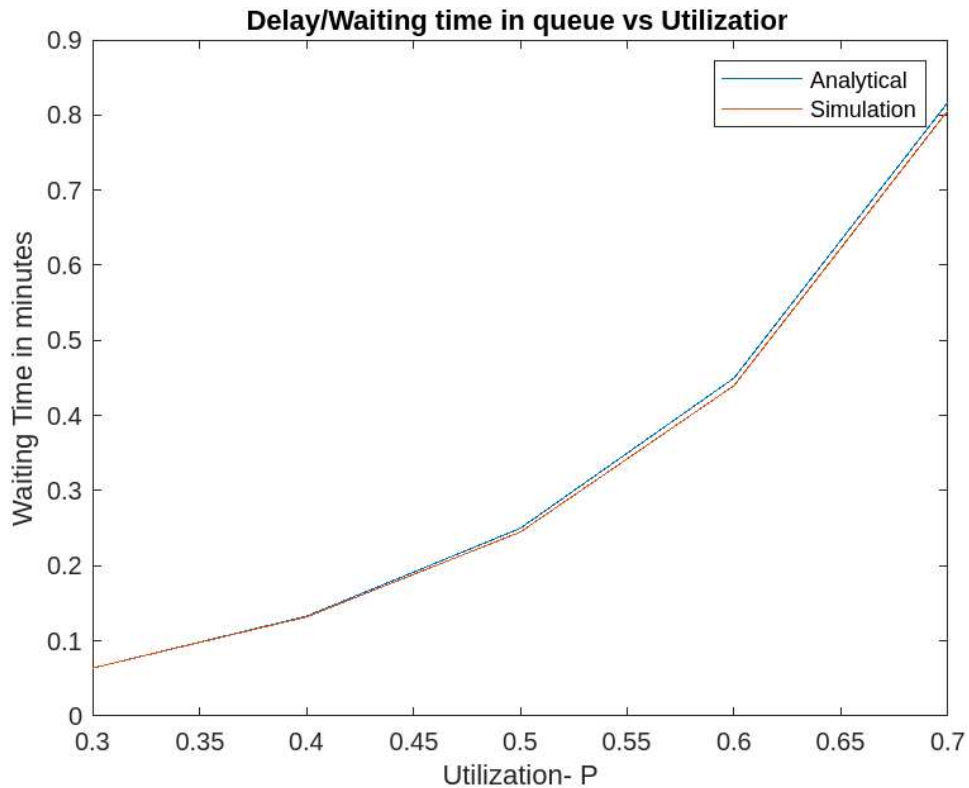
For M/D/1

Mean interarrival time ( minutes)	1.000	1.000	1.000	1.000	1.000
Mean service time minutes	0.300	0.400	0.500	0.600	0.700
Mean time an item spends in the system	$0.3*(2-0.3) / 2*(1-0.3) = 0.364$	$0.4*(2-0.4) / 2*(1-0.4) = 0.533$	$0.5*(2-0.5) / 2(1-0.5) = 0.75$	$0.6*(2-0.6) / 2(1-0.6) = 1.05$	$0.7*(2-0.7) / 2(1-0.7) = 1.517$
Mean no of items waiting to be served	$0.3*0.3/2(1-0.3) = 0.064$	$0.4*0.4/2(1-0.4) = 0.133$	$0.5*0.5/2(1-0.5) = 0.25$	0.45	0.817
Mean waiting time (includes items that have to wait and items with waiting time=0)	$0.3*0.3/2(1-0.3) = 0.064$	0.133	$0.5*0.5/2(1-0.5) = 0.25$	0.45	0.817
Average delay in queue	0.064	0.132	0.245	0.440	0.806
Average number in queue	0.065	0.133	0.247	0.444	0.812

Plot using MATLAB:

```
x = [0.3,0.4,0.5,0.6,0.7];  
y1 = [0.064,0.133,0.25,0.45,0.817];  
y2 = [0.064,0.132,0.245,0.44,0.806];  
plot(x,y1,x,y2)  
legend({'Analytical','Simulation'},'Location','northeast')  
title('Delay/Waiting time in queue vs Utilization')  
xlabel('Utilization- P')  
ylabel('Waiting Time in minutes')
```

Figure:



The above figure shows the results for the measures both analytic and from simulation as a function of  $\rho(\text{utilization}) = \lambda/\mu$  where  $\lambda$  is arrival rate(= inverse of mean interarrival time) and  $\mu$  is service rate (inverse of mean service time)

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