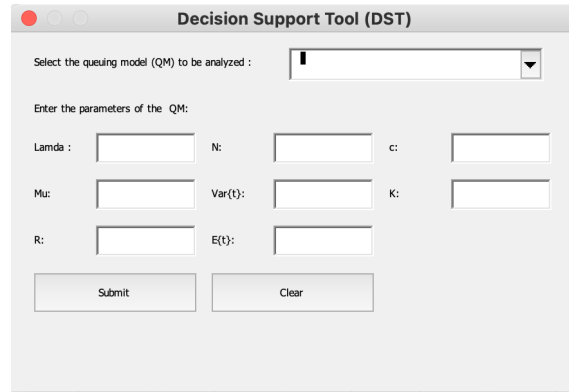


Operation Research Term Project (DST)

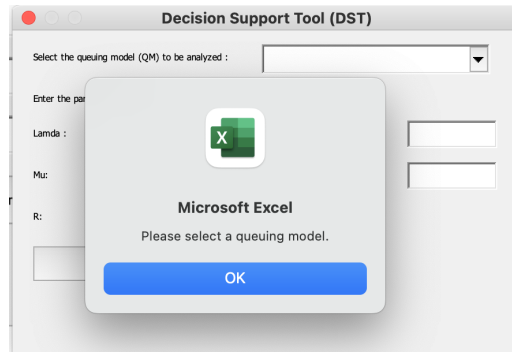
This document showcases our operation research term project decision support tool. Our DST tool was developed by using Excel VBA.



The screenshot shows the 'Decision Support Tool (DST)' window. It features a dropdown menu for 'Select the queuing model (QM) to be analyzed :'. Below this, there are input fields for parameters: 'Lamda :', 'N:', 'c:', 'Mu:', 'Var(t):', 'K:', 'R:', and 'E(t):'. At the bottom, there are 'Submit' and 'Clear' buttons.

Our user interface for decision support tool (DST)

To create this project, we used Excel VBA. Collect user data and make the necessary calculations for the desired queuing model. Our DST adapts for each selected queuing model and takes the necessary parameters from the user. It will alert the user if the user has not entered valid numbers. Our DST has two buttons, one for the submission and another for text box cleaning.



If the user clicks the submit button without entering any queuing model, our DS tool will give this alert: ***“Please select a queuing model.”***


Decision Support Tool (DST)

Select the queuing model (QM) to be analyzed :

Enter the parameters of the QM:

Lambda :

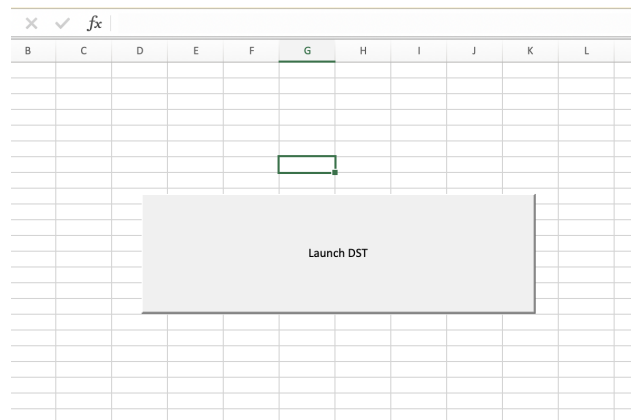
Mu:



Performance Measures

Please enter positive values for Lambda, Mu

If the user has not entered positive values for the Lambda, it will alert the user with this prompt:
“Please enter positive values for Lambda, Mu.”



We created a shortcut in our Excel sheet to launch our DS tool.

(M/M/1) Queues– Steady-State Measures of Performance

$$\lambda = 4$$

$$\mu = 6$$

$$p_0 = \frac{\mu - \lambda}{\mu} = \frac{6 - 4}{6} = 1/3$$

$$p_n = \left(\frac{\lambda}{\mu}\right)^n \frac{\mu - \lambda}{\mu} = \left(\frac{2}{3}\right)^n \frac{1}{3}$$

$$L_s = \frac{4}{6 - 4} = 2$$

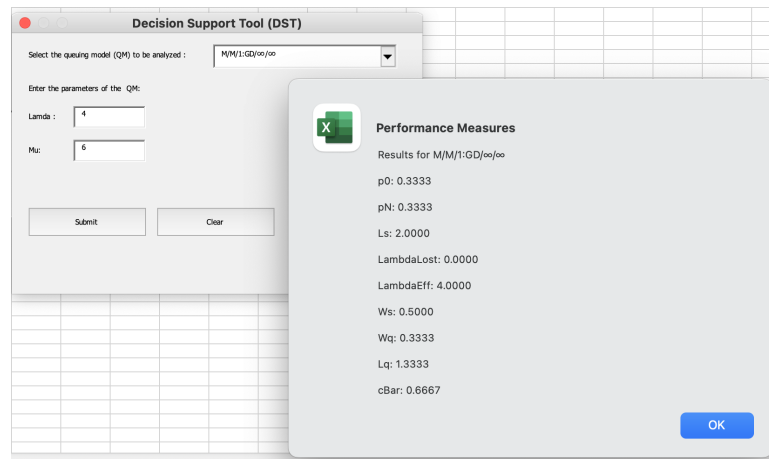
$$W_s = \frac{L_s}{\lambda} = \frac{2}{4} = 1/2$$

$$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{4}{6(6 - 4)} = 1/3$$

$$L_q = \lambda W_q = 4 \cdot (1/3) = 4/3$$

$$\bar{c} = L_s - L_q = \frac{4}{6} = 2/3$$

- (a) The probability, p_n , of n students in the system $p_n = \left(\frac{2}{3}\right)^n \frac{1}{3}$
 (b) The probability that there is no student visiting the advisor $p_0 = 1/3$
 (c) The average number of students waiting to see the advisor $L_q = 4/3$ stu.
 (d) The average time a student waits before seeing the advisor. $W_q = 1/3$ hr
 (e) The average time spent in the campus including queue + visit time $W_s = \frac{1}{2}$ hr
 (f) The average occupancy of the advisor $\bar{c} = 2/3$



Here are the outputs for the first model (M/M/1:GD/infinity/infinity).

(M/M/1):(GD/*N*/∞) Queues– Example // Comparison with last week

$\lambda = 4$
 $\mu = 6$
 $N = 5 \text{ or } \infty$

(M/M/1):(GD/∞/∞)

$$L_s = 2$$

$$\lambda_{lost} = 0 \text{ cars/hr}$$

$$\lambda_{eff} = 4 \text{ cars/hr}$$

$$W_s = 0.5 \text{ hr} = 30 \text{ minutes}$$

$$W_q = 0.3333 \text{ hr} = 20 \text{ minutes}$$

$$L_q = 1.333 \text{ cars/hr}$$

$$\bar{c} = 0.666$$

(M/M/1):(GD/*N*/∞)

$$L_s = 1.422$$

$$\lambda_{lost} = 0.1925 \text{ cars/hr}$$

$$\lambda_{eff} = 3.8075 \text{ cars/hr}$$

$$W_s = 0.3736 \text{ hr} = 22.4 \text{ mins}$$

$$W_q = 0.2069 \text{ hr} = 12.4 \text{ mins}$$

$$L_q = 0.7879 \text{ cars/hr}$$

$$\bar{c} = 0.634$$

Decision Support Tool (DST)

Select the queuing model (QM) to be analyzed : $M/M/1:GD/N/\infty$

Enter the parameters of the QM:

Lambda : 4 N : 5

Mu : 6

Submit

Performance Measures

Results for $M/M/1:GD/N/\infty$

p0: 0.3654
pN: 0.0481
Ls: 1.4226
LambdaLost: 0.1925
LambdaEff: 3.8075
Ws: 0.3736
Wq: 0.2070
Lq: 0.7880
cBar: 0.6346

OK

Here are the outputs for the second QM ($M/M/1$):($GD/N/\infty$)

| c | Lambda | Mu | p0 | Ls | Ws | Lq | Wq |
|---|--------|-------|-------|-------|-------|-------|-------|
| 2 | 8.000 | 5.000 | 0.110 | 4.444 | 0.556 | 2.844 | 0.356 |
| 4 | 16.000 | 5.000 | 0.027 | 5.586 | 0.349 | 2.386 | 0.149 |

Expected answers for the third queuing model ($M/M/c$):($GD/\infty/\infty$)

Decision Support Tool (DST)

Select the queuing model (QM) to be analyzed : $M/M/c:GD/\infty/\infty$

Enter the parameters of the QM:

Lambda : 8 c: 2

Mu: 5

Submit Clear

Performance Measures

Results for $M/M/c:GD/\infty/\infty$

p0: 0.1111
Ls: 4.4444
LambdaLost: 0.0000
LambdaEff: 0.0000
Ws: 0.5556
Wq: 0.3556
Lq: 2.8444

OK

Our answers for the ($M/M/c$):($GD/\infty/\infty$)

| | (M/M/4):(GD/10/∞) | (M/M/4):(GD/∞/∞) |
|------------------|------------------------------|------------------------|
| p_0 | 0.03121 | 0.027 |
| λ_{eff} | 15.42815 | 16 |
| λ_{lost} | 0.57184 | 0 |
| L_s | 4.23984 customers | 5.586 customers |
| L_q | 1.15421 customers | 2.386 customers |
| W_s | 0.27481 hrs | 0.349 hrs |
| W_q | 0.07481 hrs ~ 5 mins. | 0.149 hrs ~9 mins. |
| \bar{c} | 3.17479 | 3.2 |

Decision Support Tool (DST)

Select the queuing model (QM) to be analyzed : M/M/c:GD/N/∞

Enter the parameters of the QM:

Lambda : 16 N: 10 c: 4

Mu: 5

Submit

Performance Measures

Results for M/M/c:GD/N/∞

p0: 0.0312
pN: 0.0357
Ls: 4.2398
LambdaLost: 0.5719
LambdaEff: 15.4281
Ws: 0.2748
Wq: 0.0748
Lq: 1.1542
cBar: 3.0856

OK

Expected Results for (M/M/c):(GD/N/∞)

**Answers for the following queuing model
(M/M/c):(GD/N/∞)**

Example

Consider the car washing facility where customers arrive with exponential interarrival times of 15 minutes and the facility now uses a robot to wash the cars, which takes exactly 10 minutes with no variance.

$$\lambda = 4 \text{ cars/hr}$$

$$p_0 = 1 - \lambda E\{t\} = 1 - \frac{4}{6} = \frac{1}{3}$$

$$L_s = \lambda E\{t\} + \frac{\lambda^2 (E\{t\}^2 + \text{var}\{t\})}{2(1 - \lambda E\{t\})} = 1.33 \text{ cars}$$

$$W_s = \frac{L_s}{\lambda} = \frac{1.33}{4} = 1/3 \quad L_q = \lambda W_q = \frac{4.1}{6} = 2/3$$

$$W_q = \frac{1}{3} - \frac{1}{6} = 1/6 \quad \bar{c} = L_s - L_q = 4/3 - 2/3 = 2/3$$

Decision Support Tool (DST)

Select the queuing model (QM) to be analyzed : M/G/1:GD/∞/∞ (P-K formula)

Enter the parameters of the QM:

Lambda : 4

Var(t): 0

E(t): 0.16666

Submit Clear

Performance Measures

Results for M/G/1:GD/∞/∞ (P-K formula)

p0: 0.3334
Ls: 1.3332
LambdaLost: 0.0000
LambdaEff: 4.0000
Ws: 0.3333
Wq: 0.1666
Lq: 0.6666
cBar: 0.6666

OK

Expected results for (M/G/ 1):(GD/∞/∞)

**Outputs that our DST gets
(M/G/ 1):(GD/∞/∞)**

To conclude, our project has successfully calculated all 7 different queuing models. In addition, with the built-in error check, users cannot enter non-valid inputs.