

SYSTEM SIMULATION CNG 476

M/M/1

QUEUE IMPLEMENTATION

WITH SMPL

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CNG 476 TERM PROJECT

Code
Information

CODE FILES & THEIR DETAIL INFORMATIONS

<u>File Name</u>	<u>Information</u>
main.c	Main source file which operates whole simulation. Since R = 5
mm1.c	mm1.c file manages queue operations for each run. It relies on smpl library. Further information in ReadMe file.
rand.c	rand.c is smpl's random number generator source file. In this file, smpl generates pseudo random numbers and using functions inside the file makes them random variables with respect to some distributions such as, exponential which we used in our M/M/1 queue.
ReadMe.txt	Further information about files in the project.

samples.txt	Sample queue result output file. It contains , model name, facility name, time value, interval value, utility value, mean busy period, mean queue length, resealed package amount, queued package amount information with a pre-ordered structure.
smpl.c	smpl library source file.
smpl.h	smpl library header file.

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EXPERIMENTAL VS SIMULATION MEAN QUEUE LENGTH CALCULATIONS

This calculations stated that there are little difference between TP and EP values. This shows us the simulation is correct for given Rho values. There is a difference because of the situational error.

TS is theoretical rho value.

EP is experimental rho value.



$$\frac{\lambda^2}{4(4-\lambda)}$$

42.25
51.84
www.metutech.metu.edu.tr
54.76
60.84

Calculations

$$P_1^{0.1}$$

0.013
0.012
0.011
0.010
0.009

$$P_2^{0.4}$$

0.288
0.232
0.259
0.267
0.273

$$P_3^{0.6}$$

0.823
0.862
0.863
0.845
0.847

$$P_4^{0.65}$$

1.243
1.233
1.066
1.343
1.173

$$P_5^{0.7}$$

1.358
1.719
1.647
1.478
1.696

$$P_6^{0.72}$$

1.846
1.738
2.072
1.729
1.646

$$P_7^{0.74}$$

2.255
1.861
1.809
2.027
2.256

$$P_8^{0.78}$$

2.523
2.266
2.729
3.085
2.219

$$P_9^{0.79}$$

3.079
2.988
3.157
2.690
3.138

$$P_{10}^{0.8}$$

3.176
2.873
2.939
2.927
3.257

$$\frac{TP1}{1^2} = 0.0111$$

$$\frac{EP1}{0.012}$$

$$\frac{TP2}{4^2} = 0.2666$$

$$\frac{EP2}{0.2638}$$

$$\frac{TP3}{6^2} = 0.9$$

$$\frac{EP3}{0.8468}$$

$$\frac{TP4}{6.5^2} = 1.2071$$

$$\frac{EP4}{1.2176}$$

$$\frac{TP5}{7^2} = 1.6333$$

$$\frac{EP5}{1.6196}$$

$$\frac{TP6}{2.2^2} = 1.8514$$

$$\frac{EP6}{1.8062}$$

$$\frac{TP7}{7.4^2} = 2.1061$$

$$\frac{EP7}{2.0404}$$

$$\frac{TP8}{2.8^2} = 2.7654$$

$$\frac{EP8}{2.6744}$$

$$\frac{TP9}{7.9^2} = 2.9719$$

$$\frac{EP9}{3.0084}$$

$$\frac{TP10}{8^2} = 3.2000$$

$$\frac{EP10}{3.0344}$$

Gerçekleşmeyecek kadar büyük hayal, hayal edilemeyecek inovasyon, ulaşılamayacak sınır yoktur

John S. Herringto

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Analyses

SIMULATION RUN ANALYSIS

In this session, we found the \bar{y} from experimental utility values and calculated the acceptance according to Chi - Distribution.

$$\rho_1 = 0,1 = \{0,1013, 0,1009, 0,0961, 0,1007, 0,0990\}$$

$$\bar{y} = \frac{0,5}{5} = 0,1$$

$$N = \frac{0,1}{1-0,1} = \frac{0,1}{0,9} = \frac{1}{9} = 0,12$$

$$\lambda = 0,1 \times 10 = 1$$

$$s^2 = \frac{1}{(5-1)} \cdot \left[(0,1013 - 0,1)^2 + (0,1009 - 0,1)^2 + (0,0961 - 0,1)^2 + (0,1007 - 0,1)^2 + (0,0990 - 0,1)^2 \right]$$

$$s^2 = \frac{1}{4} \cdot \left[0,00000169 + 0,00000081 + 0,00001521 + 0,00000049 + 0,00000001 \right]$$

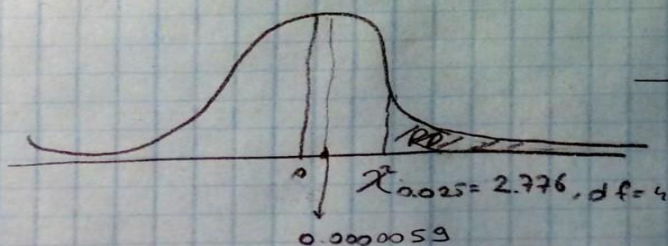
$$s^2 = \frac{1}{4} \cdot [0,00002361] \Rightarrow s^2 = \frac{0,0000059025}{\chi^2} \Rightarrow s = 0,00242950623$$

$$\chi_{0,025}^{(df=5-1)} = 2,776$$

$$H = 2,776 \times \frac{0,0024295}{\sqrt{5} \rightarrow 2,23607} = 0,003016$$

$$C.I = 0,1 \pm 0,003016 \rightarrow (0,096984, 0,103016)$$

$$ACIH = \frac{0,003016}{0,1} = 0,03016 = 3\%$$



→ Not in Rejection Region so don't reject the null.

$$\rho_{\frac{2}{0,4}} = \{ 0.4084, 0.3896, 0.4042, 0.3955, 0.4074 \}$$

$$2.0051$$

$$\lambda_2 = 0.4 \times 10 = 4$$

$$\bar{y} = \frac{2.0051}{5} = 0.40102$$

$$N = \frac{0,4}{0,6} = 0.6667$$

$$s^2 = \frac{1}{4} \cdot \left[(0.00000000) + (0.000013) + (0.00001012) + (0.00003047) + (0.0000407044) \right]$$

$$s^2 = \frac{1}{4} [0.0002658] \Rightarrow s = 0.0081516$$

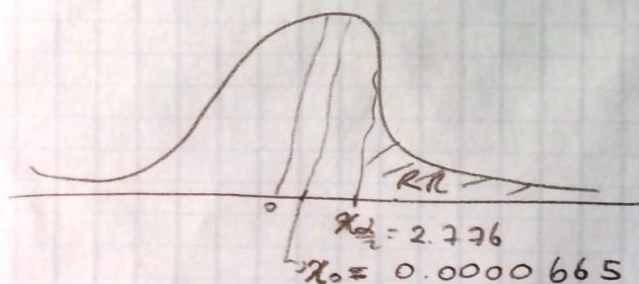
$$s^2 = 0.000066486$$

$$\chi^2_{0.025} = 2.776$$

$$H = 2.776 * \frac{0.0081516}{\sqrt{5}} = 0.01012$$

$$CI = \bar{y} \pm H \rightarrow (0.40102 \pm 0.01012) \Rightarrow (0.39, 0.41)$$

$$P_{CIH} = \frac{0.01012}{0.40102} = 0.025 \Rightarrow \%2.5$$



DOAT reject the NULL

$$\rho = 0.6 = \{0.5832, 0.6007, 0.5857, 0.5861, 0.5843\}$$

$$2.95$$

$$\lambda_3 = 0.6 \times 10 = 6$$

$$N = \frac{0.6}{0.4} = 1.5$$

$$\bar{y} = \frac{2.95}{5} = 0.588$$

$$S^2 = \frac{1}{4} [0.00002304 + 0.00016129 + 0.00000529 + 0.00000361 + 0.00001369]$$

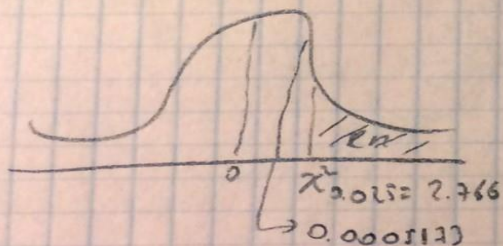
$$S^2 = \frac{1}{4} [0.00020632] = 0.00005158 \Rightarrow S = 0.00719$$

$$\chi_{0.025}^2 = 2.776$$

$$H = 2.776 \times \frac{0.00719}{\sqrt{5}} = 0.00893$$

$$CI = \bar{y} \pm H \rightarrow 0.588 \pm 0.893 \Rightarrow (0.5791, 0.5969)$$

$$RCIH = \frac{0.00893}{0.588} = 0.0152 \Rightarrow \% 1.5$$



DONT reject the null.

$$P_4 = 0.65 = \{0.6509, 0.6588, 0.6402, 0.6512, 0.6422\}$$

$$n_4 = 0.65 \times 10 = 6.5$$

$$N = \frac{0.65}{0.35} = 1.857$$

$$\bar{y} = \frac{3.243}{5} = 0.64886$$

$$S^2 = \frac{1}{4} \left[(0.0000041616) + (0.0001196386) + (0.00007499) + (0.0000054756) + (0.0000444) \right]$$

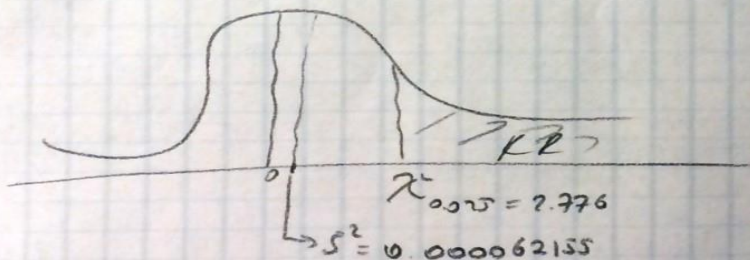
$$S^2 = \frac{1}{4} [0.0002486] = 0.000062155$$

$$S = 0.0078839$$

$$H = 2.776 * \frac{0.0078839}{\sqrt{5}} = 0.0097876$$

$$CI = \bar{y} \pm H \rightarrow (0.64886 \pm 0.0097876) \Rightarrow (0.639; 0.6587)$$

$$RCIH = \frac{0.0097876}{0.64886} = 0.01508 = \% 1.5$$



SO DONT reject the NULL

$$P_s = 0.7 = \{0.7016, 0.7102, 0.6944, 0.6842, 0.7053\}$$

$$\lambda_s = 0.7 \times 10 = 7$$

$$N = \frac{0.7}{0.3} = 2.333$$

$$\bar{y} = \frac{3.4957}{5} = 0.69914$$

$$s^2 = \frac{1}{4} [(0.0000060516) + (0.0001223) + (0.0000224676) + (0.00022320) + (0.00003795)]$$

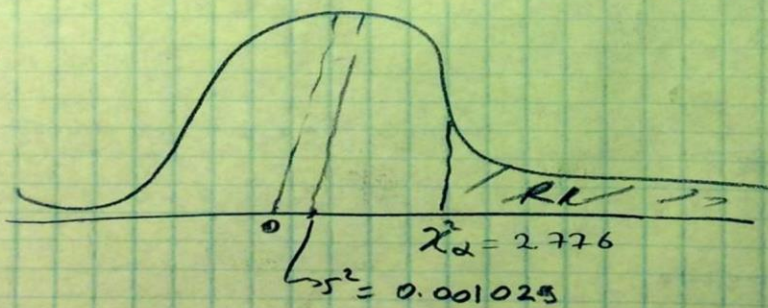
$$s^2 = \frac{1}{4} [0.000419647] \Rightarrow s^2 = 0.00010299 ; s = 0.010149$$

$$H = 2.333 \times \frac{0.010149}{\sqrt{s^2}} = 0.01259$$

$$\chi^2_{\alpha=0.025} (df=4) = 2.776$$

$$CI = \bar{y} \pm H = (0.69914 - 0.01259), (0.69914 + 0.01259) \\ = (0.6865, 0.71174)$$

$$RCIH = \frac{0.01259}{0.69914} = 0.01802 = 1.8\%$$



Don't reject H_0 the null.

$$p_0 = 0.72 = \{0.7158, 0.6956, 0.7376, 0.7175, 0.7108\}$$

$$x_0 = 0.72 \times 10 = 7.2$$

$$N = \frac{0.72}{0.28} = 2.571$$

$$\bar{y} = \frac{3.5773}{5} = 0.71546$$

$$s^2 = \frac{1}{4} \left[(0.0000001156) + (0.0003944) + (0.0004801736) + (0.00000041616) + (0.0000217156) \right]$$

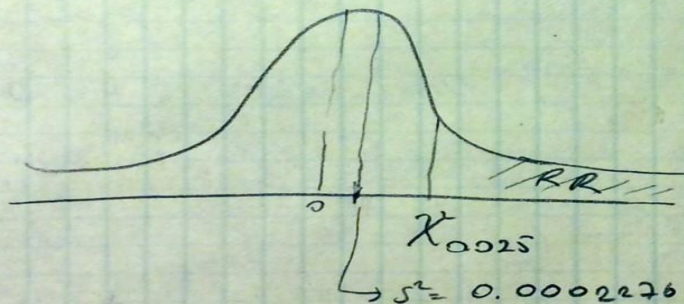
$$s^2 = \frac{1}{4} [0.0009106] = 0.0002276$$

$$s = 0.01509$$

$$H = 0.0187$$

$$CI = \bar{y} \pm H \Rightarrow (0.71546 \pm 0.0187) \rightarrow (0.6967, 0.7342)$$

$$RCIH = \frac{0.0187}{0.71546} = 0.0262 \rightarrow \% 2.6$$



Don't reject the null.

$$p = 0.74 - \{0.7467, 0.7335, 0.7206, 0.7327, 0.7451\}$$

$$\lambda_2 = 0.74 \times 10 = 7.4$$

$$N = \frac{0.74}{0.26} = 2.8462$$

$$\bar{y} = \frac{3.6786}{5} = 0.73572$$

$$S^2 = \frac{1}{5} \left[0.0001205604 + 0.0000049284 + 0.0002286144 + 0.00000912 + 0.00008798 \right]$$

$$S^2 = \frac{1}{5} \left[0.000512076 \right] = S^2 = 0.0001128$$

$$S = 0.01062$$

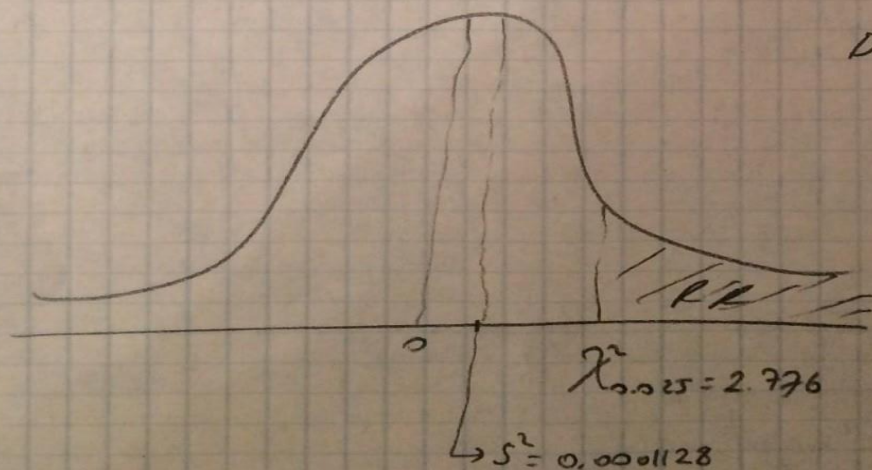
$$\chi^2_{0.025} = 2.776$$

$$H = 0.01318538$$

$$CI = \bar{y} \pm H \Rightarrow 0.73572 \pm 0.01318538$$

$$(0.72253462, 0.74890538)$$

$$RCIH = \frac{0.01318538}{0.73572} = 0.017922 \rightarrow \% 1.7$$



Do not reject the null.

$$\rho_8 = 0.78 = \{0.7815, 0.7753, 0.7806, 0.7731, 0.7612\}$$

$$\bar{y} = \frac{3.8717}{5} = 0.77434$$

$$x' = \frac{0.78}{0.22} = 3.545$$

$$\lambda_8 = 0.78 \times 10 = 7.8$$

$$s^2 = \frac{1}{4} [0.0000512656 + 0.000009216 + 0.000138384 + 0.0000015376 + 0.00017266]$$

$$s^2 = \frac{1}{4} [0.00024022] \Rightarrow s^2 = 0.0000600558$$

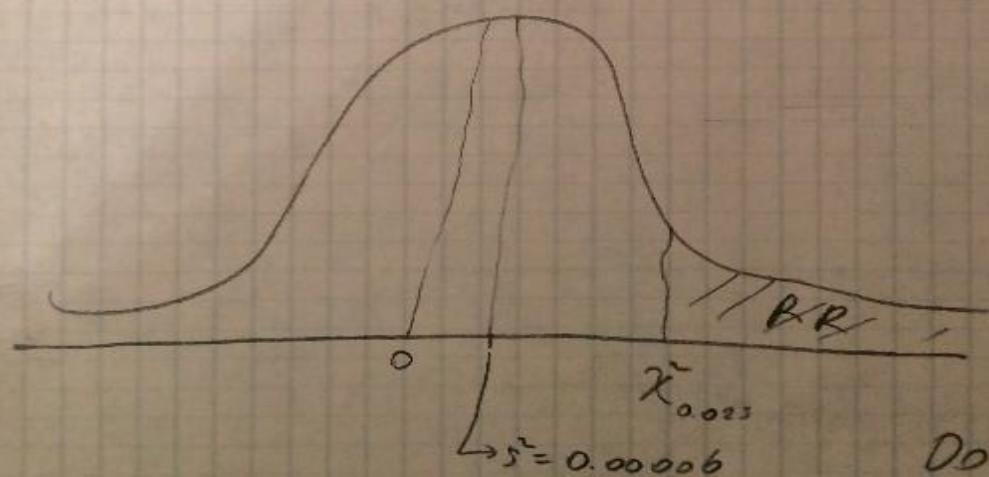
$$s = 0.00774957$$

$$H = 0.009621$$

$$C.I = \bar{y} \pm H \Rightarrow 0.77434 \pm 0.009621$$

$$(0.76472, 0.783961)$$

$$PCIH = \frac{0.009621}{0.77434} = 0.012425 \rightarrow \% 1.2$$



Do not reject the H_0

$$p_9 = 0.79 = \{0.7814, 0.8026, 0.7947, 0.7841, 0.7984\}$$

$$\lambda_9 = 0.79 \times 10 = 7.9$$

$$N = \frac{0.79}{0.21} = 3.762$$

$$\bar{y} = \frac{3.9612}{5} = 0.79224$$

$$S^2 = \frac{1}{4} \left[0.0001175 + 0.00010733 + 0.0000060516 + 0.0000662596 + 0.0000379456 \right]$$

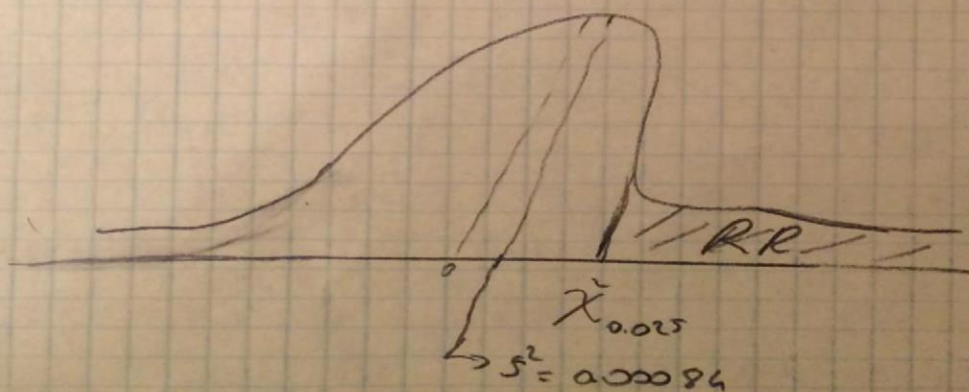
$$S^2 = \frac{1}{4} [0.00035087] \Rightarrow S^2 = 0.0000837717$$

$$S = 0.0091527$$

$$H = 0.0113627$$

$$CI = (0.79224 \pm 0.0113627) \Rightarrow (0.780877, 0.8036)$$

$$RCIH = \frac{0.0113627}{0.79224} = 0.01434255 \rightarrow \%1.4$$



Do not reject the NULL.

$$P_{70} = 0.8 = \{ 0.7954, 0.7953, 0.7770, 0.7961, 0.7907 \}$$

$$\bar{y} = \frac{3.9545}{5}$$

$$\bar{y} = 0.7909$$

$$\chi_{10} = 0.8 \times 10 = 8$$

$$N = \frac{0.8}{0.2} = 4.00$$

$$s^2 = \frac{1}{4} [0.00002025 + 0.00001936 + 0.00019321 + 0.00002704 + 0.00000004]$$

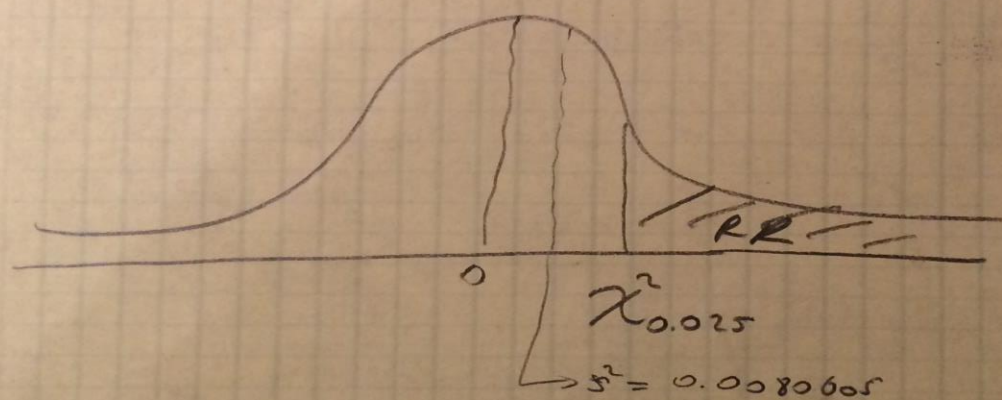
$$s^2 = \frac{1}{4} [0.00025989] \Rightarrow s^2 = 0.0000649725$$

$$s = 0.0080605$$

$$H = 0.010006828$$

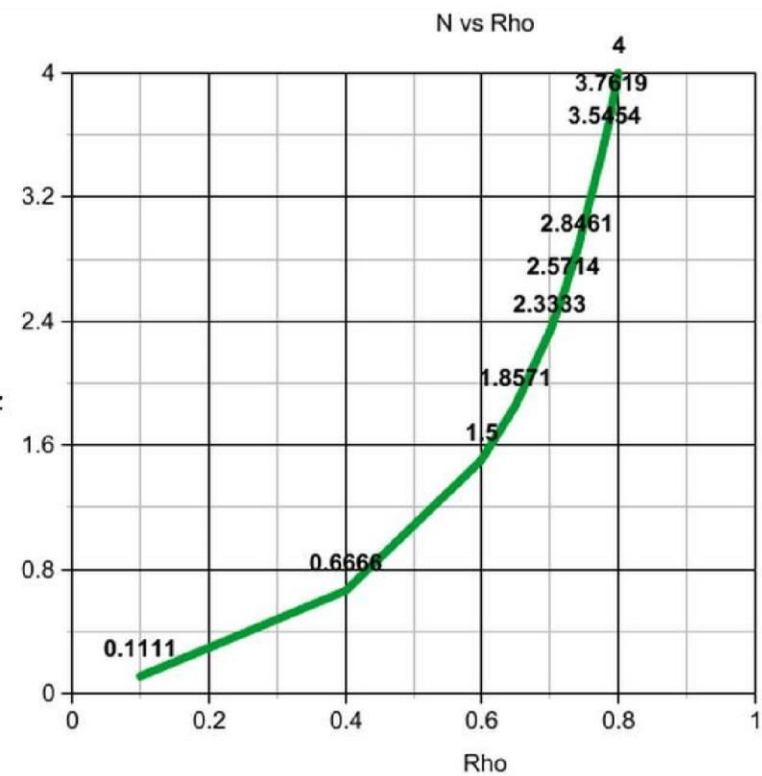
$$CI = \bar{y} \pm H \rightarrow (0.7809, 0.8009)$$

$$RCIH = 0.0127 \rightarrow \% 1.27$$



Do not reject the H_0 .

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Screen
Shots

SCREEN SHOTS

Sample.txt screen shot

FACILITY	UTIL.	MEAN BUSY PERIOD	MEAN QUEUE LENGTH	RELEASE	PREEMPT	QUEUE
server	0.3896	0.098236	0.232	10000	0	3828
smp1 SIMULATION REPORT						
MODEL: M/M/1 Queue				TIME: 14095.846		
				INTERVAL: 1675.262		
FACILITY	UTIL.	MEAN BUSY PERIOD	MEAN QUEUE LENGTH	RELEASE	PREEMPT	QUEUE
server	0.6007	0.100635	0.862	10000	0	5981
smp1 SIMULATION REPORT						
MODEL: M/M/1 Queue				TIME: 15610.142		
				INTERVAL: 1514.296		
FACILITY	UTIL.	MEAN BUSY PERIOD	MEAN QUEUE LENGTH	RELEASE	PREEMPT	QUEUE
server	0.6598	0.099918	1.233	10000	0	6603
smp1 SIMULATION REPORT						
MODEL: M/M/1 Queue				TIME: 17024.181		
				INTERVAL: 1414.040		
FACILITY	UTIL.	MEAN BUSY PERIOD	MEAN QUEUE LENGTH	RELEASE	PREEMPT	QUEUE
server	0.7102	0.100423	1.719	10000	0	7112

Sample Simulationrun screen shot from
command line.

```

C:\Users\admin\Desktop\smp1_new\tp1.exe
Simulation started!
Please wait, simulation has been started.
Simulation for rho = 1 finished!
Simulation for rho = 2 finished!
Simulation for rho = 3 finished!
Simulation for rho = 4 finished!
Simulation for rho = 5 finished!
Simulation ended!
output file "samples.txt" has been created.
Simulation will be terminated.Thank you!
-----
Process exited after 0.1828 seconds with return value 10
Press any key to continue . . .

```