Chapter 6: Simulation Using Spread-Sheets (Excel)

Refer to Reading Assignments

Simulation Using Spread-Sheets (Excel)

- **Application#2: ATM Operation**

Consider cars arrive at a drive-through to a single ATM to have some cash. The machine serve only on car at a time. Assume that cars arrive to the ATM according to a Poisson process with rate 15 cars per hour. Each car spend a random amount of time that is exponentially distributed with rate 20 cars per hour.

Build a simulation spred-sheet file for this system using excel for 100 cars, then do the output analysis

Simulation Using Spread-Sheets (Excel)

- **Application#2: ATM Operation**

Model Concept and Logic:

- Let **T(i)** be the time between car arrivals

T(i) is random variable ~ Poisson process (λ = 15 car/hr)

- Let **ST(i)** be the service time of any car

ST(i) is random variable ~ Exp(20 car/hr)

- Let **AT(i)** be the arrival time of the car to the ATM

$$AT(i) = AT(i-1) + T(i), \quad AT(0) = 0$$

Simulation Using Spread-Sheets (Excel)

- **Application#2: ATM Operation**

Model Concept and Logic:

- Let **SST(i)** be the service starting time of car (i)
  SST(i) = AT(i) ; if waiting line = 0
  SST(i) = DT(i-1) ; if waiting line > 0 , DT(0) = 0

- Let **IT(i)** be the server idle time at the arrival of car (i)
  if AT(i) >DT(i-1) → IT(i) = AT(i) – DT(i-1) ;
  if AT(i) <= DT(i-1) → IT(i) = 0

Simulation Using Spread-Sheets (Excel)

- **Application#2: ATM Operation**

Model Concept and Logic:

- Let **DT(i)** be the departure time of any car after service

$$DT(i) = AT(i) + WT(i) + ST(i)$$

- Let **WT(i)** be waiting time of any car in line

$$WT(i) = DT(i) - SST(i)$$

Simulation Using Spread-Sheets (Excel)

- **Application#2: ATM Operation**

Excel sheet structure

car #	Time between arrivals	Arrival time	Service time	Service start	Cut. Wait?	Wait Time	Departure time	ATM Idle time

Simulation Using Spread-Sheets (Excel)

- **Application#2: ATM Operation**

Excel Sheet logic

	car #	Time between arrivals	Arrival time	Service time	Service start	Cut. Wait?	Wait Time	Departure time	ATM Idle time
7	1	=ROUNDUP((-1/$D$1)*LI	=F7	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=G7	0	0	=G7+H7	=F7
8	2	=ROUNDUP((-1/$D$1)*LI	=F8+G7	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G8>L7,G8,L7)	=IF(G8<L7,1,0)	=IF(J8,L7-G8,0)	=G8+H8+K8	=IF(J8,0,I8-L7)
9	3	=ROUNDUP((-1/$D$1)*LI	=F9+G8	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G9>L8,G9,L8)	=IF(G9<L8,1,0)	=IF(J9,L8-G9,0)	=G9+H9+K9	=IF(J9,0,I9-L8)
10	4	=ROUNDUP((-1/$D$1)*LI	=F10+G9	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G10>L9,G10,L9)	=IF(G10<L9,1,0)	=IF(J10,L9-G10,0)	=G10+H10+K10	=IF(J10,0,I10-L9)
11	5	=ROUNDUP((-1/$D$1)*LI	=F11+G10	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G11>L10,G11,L10)	=IF(G11<L10,1,0)	=IF(J11,L10-G11,0)	=G11+H11+K11	=IF(J11,0,I11-L10)
12	6	=ROUNDUP((-1/$D$1)*LI	=F12+G11	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G12>L11,G12,L11)	=IF(G12<L11,1,0)	=IF(J12,L11-G12,0)	=G12+H12+K12	=IF(J12,0,I12-L11)
13	7	=ROUNDUP((-1/$D$1)*LI	=F13+G12	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G13>L12,G13,L12)	=IF(G13<L12,1,0)	=IF(J13,L12-G13,0)	=G13+H13+K13	=IF(J13,0,I13-L12)
14	8	=ROUNDUP((-1/$D$1)*LI	=F14+G13	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G14>L13,G14,L13)	=IF(G14<L13,1,0)	=IF(J14,L13-G14,0)	=G14+H14+K14	=IF(J14,0,I14-L13)
15	9	=ROUNDUP((-1/$D$1)*LI	=F15+G14	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G15>L14,G15,L14)	=IF(G15<L14,1,0)	=IF(J15,L14-G15,0)	=G15+H15+K15	=IF(J15,0,I15-L14)
16	10	=ROUNDUP((-1/$D$1)*LI	=F16+G15	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G16>L15,G16,L15)	=IF(G16<L15,1,0)	=IF(J16,L15-G16,0)	=G16+H16+K16	=IF(J16,0,I16-L15)
17	11	=ROUNDUP((-1/$D$1)*LI	=F17+G16	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G17>L16,G17,L16)	=IF(G17<L16,1,0)	=IF(J17,L16-G17,0)	=G17+H17+K17	=IF(J17,0,I17-L16)
18	12	=ROUNDUP((-1/$D$1)*LI	=F18+G17	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G18>L17,G18,L17)	=IF(G18<L17,1,0)	=IF(J18,L17-G18,0)	=G18+H18+K18	=IF(J18,0,I18-L17)
19	13	=ROUNDUP((-1/$D$1)*LI	=F19+G18	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G19>L18,G19,L18)	=IF(G19<L18,1,0)	=IF(J19,L18-G19,0)	=G19+H19+K19	=IF(J19,0,I19-L18)
20	14	=ROUNDUP((-1/$D$1)*LI	=F20+G19	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G20>L19,G20,L19)	=IF(G20<L19,1,0)	=IF(J20,L19-G20,0)	=G20+H20+K20	=IF(J20,0,I20-L19)
21	15	=ROUNDUP((-1/$D$1)*LI	=F21+G20	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G21>L20,G21,L20)	=IF(G21<L20,1,0)	=IF(J21,L20-G21,0)	=G21+H21+K21	=IF(J21,0,I21-L20)
22	16	=ROUNDUP((-1/$D$1)*LI	=F22+G21	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G22>L21,G22,L21)	=IF(G22<L21,1,0)	=IF(J22,L21-G22,0)	=G22+H22+K22	=IF(J22,0,I22-L21)
23	17	=ROUNDUP((-1/$D$1)*LI	=F23+G22	=ROUNDUP((-1/$D$2)*LN(1-RAND())*60,0)	=IF(G23>L22,G23,L22)	=IF(G23<L22,1,0)	=IF(J23,L22-G23,0)	=G23+H23+K23	=IF(J23,0,I23-L22)

Simulation Using Spread-Sheets (Excel)

- **Application#2: ATM Operation**

Use data tables for 100 replications, evaluate the ATM operation with 95% confidence intervals

1. Average waiting time if customer waits
2. Average waiting time in general
3. Percentage of time server is idle
4. Average number of customers waiting
5. Construct a plot for each replication

Simulation Using Spread-Sheets (Excel)

- **Application#2: ATM Operation**

- Assume that the service time is Erlang with parameters r= 3 and λ = 25 car/hr. Re-do the output analysis

- Assume that the arrival rate is Erlang with parameters r= 2 and λ = 20 car/hr. Re-do the output analysis.

- Assume that that the arrival rate is Exponential with uncertain arrival rate may takes the values from 10 to 20. With the service time is Er(r= 3 and λ = 25 car/hr). Re-do the output analysis for each value of λ

Simulation Using Spread-Sheets (Excel)

- **Application#2: ATM Operation**

Decision Making using Simulation

- Assume that there are 4 types of ATM machines that the bank wants to buy one of them.
  - ATM#1: Service rate is 20 car/hr, Exponential dist. The ATM costs 80,000 SR. The maintenance cost is 1000SR/mon
  - ATM#2: Service rate is 40 car/hr, Er (r=2,λ=30) Exponential dist. The ATM costs 60,000 SR. The maintenance cost is 1500SR/mon
  - ATM#3: Service time is Uniform [4,8] min. The ATM costs 50,000 SR. The maintenance cost is 500SR/mon

Finally, The cost of waiting for each car is 50SR/hour/car