Tutorial of Simulation using Excel Spreadsheet

Using Excel, we can conduct simulation in two ways.

1. Conduct simple simulation in a spreadsheet.
2. Conduct complicated simulation using Visual Basic for Application (VBA) programming language.

This tutorial provides a minimum guide for a beginner to conduct simple simulation in a spreadsheet.

In Excel, we can use the built-in worksheet functions in a formula in a cell. Some basic functions commonly used in simulation are as follows.

1. Generate a random number (uniformly between 0 and 1):

   =RAND()

2. IF function

   =IF(logical_test,[value_if_true],[value_if_false])

   checks a condition in its first argument, and if the condition is true returns the first value; otherwise it returns the second value.
   - Example: =IF(RAND()<=0.5,0,1) returns 0 if the random number is smaller than 0.5; returns 1 otherwise.
   - Example: =IF(A1<=0.5,0,IF(AND(A1>0.5,A1<=0.8),1,2)) returns 0 if A1<=0.5, 1 if 0.5<A1<=0.8, and 2 if A1>0.8.
3. Generate a uniformly distributed integer value in an interval:

   =RANDBETWEEN(bottom,top)

4. Exponential distribution and normal distribution:

   EXPON.DIST(x,lambda,cumulative), NORMDIST(x,mean,standard_dev,cumulative)

   If cumulative == “TRUE”, returns the cdf; if cumulative == “FALSE”, returns the pdf.
5. Inverse cdf of normal distribution:

   NORM.INV(probability,mean,standard_dev)

   Given a value for probability, NORM.INV seeks that value x such that NORM.DIST(x, mean, standard_dev, TRUE) = probability.
6. There is no inverse cdf for exponential distribution. For some other distributions, like t distribution and binomial distribution, there exist pdf (pmf) / cdf function and inverse cdf function.
7. To generate a standard normal random variate:

   NORM.INV(RAND(),0,1)

8. To generate an exponential random variate with rate lambda:

   =-1/lambda*LOG(RAND(),EXP(1))

9. In a worksheet cell in Excel, we can also call a user-written VBA function. The user-written VBA functions can, in turn, call an internal VBA function such as Rnd().

Note: Neither the worksheet function RAND() nor the VB function Rnd() should be used in professional work; they both have known deficiencies.

Example 1

Monte Carlo Simulation: Estimate pi from Random Points

	A	B	C	D	E	F
1	U1	U2	Distance from (0,0)	In circular sector?	n	1000
2	0.280717	0.007399	0.280814279	1	h	783
3	0.041224	0.433094	0.435051387	1	pi	3.132
4	0.74929	0.411982	0.855081898	1		
5	0.530758	0.835706	0.990003974	1		
6	0.485722	0.922722	1.042757273	0		
7	0.232218	0.260983	0.349337961	1		
8	0.512707	0.046769	0.514835292	1		
9	0.905181	0.818442	1.220327943	0		
10	0.973512	0.330192	1.027984671	0		

=SUM(D2:D1001)

=4*F2/F1

=RAND()

=SQRT(A?^2+B2^2)

=IF(C?<1,1,0)

Note: "?" in formula represents the corresponding row number.

Example 2

Discrete-Event System Simulation: $M/M/1$ Queue with $\lambda = 0.6, \mu = 1$

$$L = \frac{\rho}{1-\rho} = \frac{0.6}{1-0.6} = 1.5,\ L_Q = \frac{\rho^2}{1-\rho} = \frac{0.36}{1-0.6} = 0.9,\ W = \frac{1}{\mu-\lambda} = \frac{1}{0.4} = 2.5,\ W_Q = \frac{\rho}{\mu-\lambda} = \frac{0.6}{0.4} = 1.5.$$

	A	B	C	D	E	F	G	H	I	J	K	L
1	lambda	0.6	mu	1								
2	U1	interarrival time	U2	service time	Customer	Arrival Time	Time Service Begins	Departure Time	Waitimg Time	Sojourn Time	Wq	1.523885
3	0.210886	2.594066353	0.02589	3.65390244	1	2.59406635	2.594066353	6.247968791	0	3.653902439	W	2.528611
4	0.736247	0.510316003	0.682781	0.38158049	2	3.10438236	6.247968791	6.629549285	3.143586436	3.525166929	lambda	0.594916
5	0.018733	6.629157722	0.327849	1.11520114	3	9.73354008	9.733540077	10.84874122	0	1.115201142	Lq	0.906584
6	0.661818	0.687941575	0.364453	1.00935856	4	10.4214817	10.84874122	11.85809978	0.427259567	1.436618125	L	1.504311
7	0.873194	0.225995707	0.281741	1.26676615	5	10.6474774	11.85809978	13.12486593	1.210622418	2.47738857		
8	0.839983	0.290622405	0.759409	0.27521507	6	10.9380998	13.12486593	13.400081	2.186766165	2.461981235		
9	0.792587	0.387422122	0.766577	0.26581985	7	11.3255219	13.400081	13.66590085	2.074559113	2.340378966		
10	0.558416	0.971084659	0.334495	1.09513273	8	12.2966065	13.66590085	14.76103358	1.369294307	2.464427036		
11	0.89452	0.185780522	0.328849	1.11215617	9	12.4823871	14.76103358	15.87318975	2.278646514	3.390802682		

=-1/B$1*LOG(A?,EXP(1))

=-1/D$1*LOG(C?,EXP(1))

=F10+B11 =MAX(H10,F11) =G11+D11 =G11-F11 =H11-F11

=AVERAGE(I1002:I10002)
=AVERAGE(J1002:J10002)
=E10002/G10002
=L4*L2
=L4*L3