www.ijecs.in
International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 5 Issue 09 September 2016 Page No.18035-18039

Risk Analysis and Estimation of Schedule Using Monte Carlo Simulation

Heena Kashyap[1], Nitika Bansal[2] and Meenu Gupta[3]
[1]Scholar, Department of Computer Science and Engineering,Ganpati Institute of Technology and Management,Bilaspur, Haryana, India
[1]*hkheenakashyap@gmail.com*
[2]Assistant Professor, Department of Computer Science and Engineering,Ganpati Institute of Technology and Management,Bilaspur, Haryana, India
[3]Lecturer, Department of Computer Science and Engineering,Seth Jai Parkash Polytechnic, Damla, Haryana, India

Abstract:

Unwanted schedule risk and improper estimates divert a project from achieving the goal of on-time successful delivery due to the presence of uncertainties. Most of the projects get delayed or cancelled due to this. So, using Monte Carlo Simulation technique a simulator is implemented in this paper which simulates the activity durations for analyzing schedule risk and providing reliable estimates of time.

Keywords: Schedule risk analysis, Monte Carlo Simulation, Estimation, Risk index.

1. Introduction

In today's world of enormous competition, where "*meeting and beating the deadlines*" is of utmost importance, scheduling holds an extremely important place. But the presence of uncovered potential schedule risks and improper estimates adversely affect the schedule and disturb the delivery dates of the project. Present projects are facing constantly changing requirements, drifting project scope and are put under demanding schedule pressure. It is estimated that almost 70% of the projects have problems with attaining their objectives [1]. As risk and uncertainty are intrinsic in almost every project, therefore, schedules often contain significant uncertainty in them, which makes scheduling even more difficult [2]. Also, since every project is unique it becomes hard to accurately estimate the schedule at an early age. In such case, risk analysis and estimation of schedule are needed to be done efficiently and for this simulation can be used. Simulation is the representation of a reality with the use of a model or other device which will react in the same manner as the reality under a given set of conditions [3]. There are many methods to conduct the risk analysis, but in this paper use of Monte Carlo simulation is emphasized for conducting the risk analysis as well as estimation of schedule as it is highly optimized in terms of effort, cost and time and provides realistic and approximate results. Monte Carlo simulation is an influential technique. It works with multiple sets of random numbers and helps in analyzing different results collectively. Since in this technique, values are sampled at random using probability distributions and then results are recorded for each and every run after doing the calculations hundreds or thousands of times, it gives a clear view of what may happen and how likely it may happen.

2. Design of Simulator

A simulator viz. SARES (Simulator for Analyzing Risk and Estimation of Schedule) has been designed here in C language for the risk analysis and estimation of schedule. The designed simulator implements the Monte Carlo simulation technique which involves the concept of uncertainty through the generation of random numbers such as random duration [4]. The algorithm for the simulator is given below:

SARES ALGORITHM

1. *Read input variables like number of activities (NA), number of nodes (NN), starting nodes (Snodes[i]), finishing nodes (Fnodes[i]), mue[i] and sigma[i].*
2. *Repeat steps 3 to 8 for 1000 simulation runs.*

3. *Generate random samples of time in each simulation run using the box–muller transformation method.*
4. *Carry out Forward pass by traversing the network from starting node to finishing node.*
5. *Calculate pcv i.e. project completion value.*
6. *Now find out in which interval the pct value falls and update the frequency of pct in that interval accordingly, in each run.*
7. *Carry out Backward pass by traversing the network from finishing node to starting node.*
8. *Mark risky activities and simultaneously update their counter variable by incrementing that with 1 if an activity is found to be risky and add that risky activity to crtPathList[i] (list of critical paths).*
9. *Calculate risk indices.*
10. *Print and store the results for further analysis.*

3. Network Model

In this paper, a website development project is considered for the risk analysis and estimation of schedule. Here, PERT (Project Evaluation and Review Technique) network representation is used for representing the website development project as a network which consists of 31 activities and 24 nodes/events as shown in Figure 1.

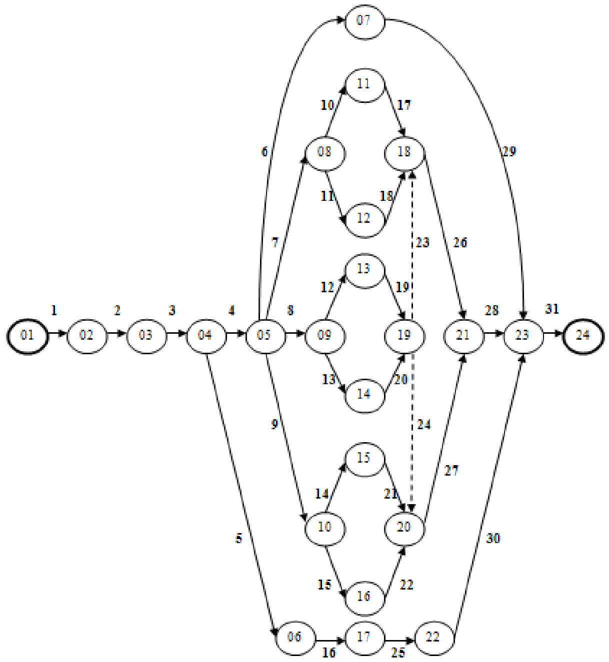


Figure 1: Network representation of website development project

For each project activity three parameters, viz. optimistic estimate, most likely estimate, and pessimistic estimate are considered. On the basis of these three parameters, the mue (mean) and sigma (standard deviation) values are calculated for each activity using the following formulas:

$$\text{Mean} = \mu_n = (OE\,[I] + 4ME\,[I] + PE\,[I])/6 \quad \text{----(1)}$$

$$\text{Standard deviation} = \sigma_n = (PE\,[I] - OE\,[I])/6 \quad \text{--- (2)}$$

Where, OE [I] = Optimistic Estimate of I^{th} activity
ME [I] = Most likely Estimate of I^{th} activity.
PE [I] = Pessimistic Estimate of time of I^{th} activity

The calculated values of mue and sigma along with the starting nodes (snode) and finishing nodes (fnode) of project activities are listed in Table 1.

Table 1 Time estimates of all activities.

Activity no.	snode	fnode	Mue	Sigma
1	1	2	1450	216.67
2	2	3	1200	133.33
3	3	4	1500	166.67
4	4	5	1500	166.67
5	4	6	600	66.67
6	5	7	2000	333.33
7	5	8	1666.67	133.33
8	5	9	1500	166.67
9	5	10	1500	166.67
10	8	11	2466.67	200
11	8	12	2000	166.67
12	9	13	2000	166.67
13	9	14	2000	166.67
14	10	15	2000	166.67
15	10	16	2000	166.67
16	6	17	700	66.67
17	11	18	2050	116.67
18	12	18	1500	166.67
19	13	19	2000	166.67
20	14	19	1583.33	250
21	15	20	2000	166.67
22	16	20	1500	166.67
23	19	18	0	0
24	19	20	0	0
25	17	22	400	66.67
26	18	21	2083.33	250
27	20	21	2083.33	250
28	21	23	3000	333.33
29	7	23	0	0
30	22	23	1916.67	250
31	23	24	4000	1000

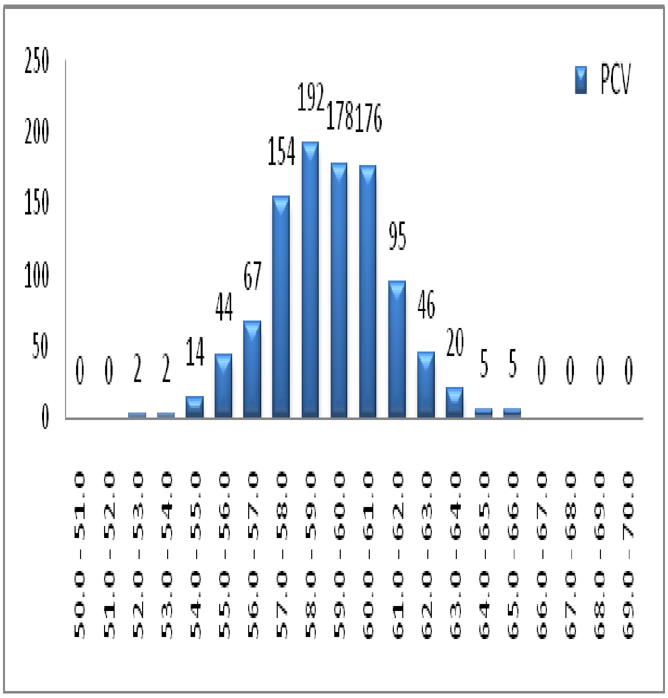
The mue and sigma values represent the measure of uncertainty associated with each activity [5]. Using the values of mue and sigma random samples of duration can be generated using box-muller transformation method [6]:

$x = (-2 \log_e r1)^{1/2} \cos (2 \pi r2)$
rdv[i] = x*sigma[i] + mue[i]

Here, r1 and r2 are two random numbers in the range of (0,1), x is a sample from standardized normal distribution, rdv[i] is the generated random duration value of the i^{th} activity.

4. Results and Discussion

After 1000 simulation runs, the results generated by the simulator are presented here with the help of tables and graph. For achieving successful on-time completion, correct estimates are very crucial. For this, Project completion value (PCV) is calculated at the end of each run to estimate the value of total time to complete a project. And, by using the PCV values, the frequency of PCV values can be calculated which represents the number of times a PCV value repeats itself in different runs. Graph 1, shows the frequency distribution of PCV's in 1000 runs in different intervals.



Graph 1: Frequency distribution of PCVs.

Here the duration of 58.0-59.0 days occurred for the maximum times i.e. 192 times and it means chances are higher for the completion of the website development project in this time interval.

After this, risk index of every activity is calculated. The risk index of an activity specifies how many times an activity becomes risky out of the total number of simulation runs [6]. Table 2 shows the risk indices of all activities. The risky activities collectively form a critical path. The critical path is the longest path in the network and it may cause delay to a project due to the risk of schedule slippage [7]. An activity with risk index lying in the range of 0.8 to 1.0 is considered to be riskier than others. Hence, as shown in table 4, activities 1, 2, 3, 4, 7, 10, 17, 26, 28 and 31 are riskier than other activities and the critical path made by these activities that is 1-2-3-4-7-10-26-28-31 is the most critical path. Therefore these activities are required to be handled more carefully than others.

Table 2: Risk index

Activity	Risk Index	Activity	Risk Index
1	**1**	**17**	**0.855**
2	**1**	18	0.045
3	**1**	19	0.044
4	**1**	20	0.005
5	0	21	0.046
6	0	22	0.005
7	**0.9**	23	0.02
8	0.049	24	0.029
9	0.051	25	0
10	**0.855**	**26**	**0.92**
11	0.045	27	0.08
12	0.044	**28**	**1**
13	0.005	29	0
14	0.046	30	0
15	0.005	**31**	**1**
16	0		

For delivering a project on time we need correct duration estimates of all activities and if we can have them then the chances of on-time project completion increase. It can be done by analyzing the results of the SIM_RACE which shows that PCV of run number 218 is repeated most of the times in the highest frequency interval of 58.0-59.0 days. Various values calculated in run number 218, as shown in Table 3, during the schedule risk analysis are RDV (Random Duration Values), EBT (Earliest Beginning Time), ECT (Earliest Completing Time), LBT (Latest Beginning Time), LCT (Latest Completing Time) and Risk. Using these values, one can plan the schedule of the project efficiently.

Table 3: Duration and other values in run 218

Run = 218	PCV= 58.964 (in days)					
Activity	RDV	EBT	ECT	LBT	LCT	RISK
1	4.29	0	4.297	0	4.297	1
2	5.05	4.297	9.353	4.297	9.353	1
3	5.80	9.353	15.16	9.353	15.16	1
4	4.55	15.16	19.72	15.16	19.72	1
5	4.85	15.16	20.02	34.69	39.55	0
6	2.26	19.72	21.99	52.39	54.66	0
7	6.32	19.72	26.04	19.72	26.04	1
8	4.66	19.72	24.38	22.85	27.51	0
⋮	⋮	⋮	⋮	⋮	⋮	⋮
29	2.15	21.99	24.14	54.66	56.81	0
30	6.69	30.58	37.28	50.11	56.81	0
31	2.15	56.81	58.96	56.81	58.96	1

5. Conclusion

Attaining the goal of successful on-time project completion is extremely important in this highly competitive era. Due to which, the designed simulator SARES uncovered the critical paths and risky activities and also provided the risk indices of those risky activities. It is observed that the higher is the risk index, the higher is the risk associated with that activity and the higher should be the attention paid to that activity. The simulator also predicted the project completion value as well as the duration values of all coordinating activities.

The results of the simulator are highly reliable due to the inclusion of the uncertainty factor in terms of random durations. Also, the designed simulator calculated approximately the same results in less than 1 minute, which could have taken months to be calculated analytically. Therefore, it is concluded that accurate risk analysis and reliable estimates of schedule can be obtained in time and cost-effective manner by using the Monte Carlo Simulation technique.

References

[1] Miler, J. & Górski, J. 2001. "*Implementing risk management in software projects*", 3rd national conference on software engineering, Otwack, Poland

[2] Xing-xia, W. and Jian-wen, H. 2009. "*Risk Analysis of Construction Schedule Based on Monte Carlo Simulation*".Computer Network and Multimedia Technology,IEEE, Wuhan,1 – 4

[3] Sharma, S.D. 2009. *Operations Research*, 15th Ed. Reprint, Kedar Nath and Ram Nath, Meerut.

[4] Hira, D. S. 2001. *System Simulation*, S. Chand & Company Pvt. Ltd, New Delhi.

[5] Sharma, I. et al. 2011. "*Schedule Risk Analysis Simulator using Beta Distribution*". International Journal of Computer Science and Engineering (IJCSE), Vol. 3, No. 6, 2408-2414.

[6] Deo, N. 2003. *System Simulation with Digital Computer*, Prentice-Hall of India, New Delhi.

[7] Pressman, R. S. 2006. *Software Engineering - A Practitioner's Approach*, fifth edition, McGraw-Hill.

Author Profile

Er. Heena Kashyap
Received B.Tech in Computer Science and Engineering in 2014 and currently pursuing her M.Tech in Computer Science and Engineering from Ganpati Institute of Technology and Management, Bilaspur, Haryana.

Er. Nitika Bansal
Received the B.Tech. and M.Tech. degrees in Computer Science and Engineering in 2011 and 2014, respectively. Presently, she is working as an Assistant Professor in Computer Science and Engineering Department in Ganpati Institute of Technology and Management, Bilaspur, Haryana.

Mrs. Meenu Gupta
Received MCA From kurukshetra University Kurukshetra and M.Phil. From Choudhry Devi Lal University Sirsa. She has been Sharing her

knowledge for more than 10 Year as a Lecturer in Seth Jai Parkash Polytechnic Damala Haryana.Her Research interest cover Simulation risk Management embedded systems and software testing .