Chapter 5
Monte Carlo Project Risk Analysis

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ABSTRACT

Monte Carlo simulations of project schedules have become one of the foundations of quantitative project risk analysis. Monte Carlo method helps to determine the chance that project will be completed on time and on budget, expected project cost and finish time given risks and uncertainties, as well as identify critical risks and crucial tasks. There are a number of ways how Monte Carlo schedule risk analysis can be conducted. "Traditional" Monte Carlo schedule analysis is performed based on statistical distributions of task duration, cost and other input parameters. Event-based quantitative risk analysis incorporates risk events, which can affect project schedules. The chapter discusses a number of important concepts related to Monte Carlo simulations: statistical distribution, sampling process, convergence monitoring, sensitivity analysis, probabilistic and conditional branching and others.

INTRODUCTION TO MONTE CARLO SCHEDULE RISK ANALYSIS

Monte Carlo simulations of project schedules have become one of the foundations of quantitative project risk analysis (Salkeld, 2016, Vanhoucke, 2016, Wanner, 2013). Monte Carlo method is used to approximate the distribution of potential results based on probabilistic inputs. Each simulation is generated by randomly pulling a sample value for each input variable, such as task duration or cost from its probability distribution. These input sample values are then used to calculate the results:

- Project duration,
- Start and finish times,
- Success rate,
- Work,
- Cost, and others.

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This 'traditional' Monte Carlo method for schedule risk analysis is based on statistical distributions of task durations, cost and other parameters, and has a number of short comings. Particularly defining distributions is not a trivial process. It is difficult to elicit distribution parameters from subject matter experts. Also project managers perform certain recovery actions when a project slips. These actions in most cases are not taken into account by Monte Carlo (Williams, 2004).

The one of the solutions is to combine risk events with statistical distributions. Project risk analysis with events has been used since the early 2000s (Virine & Trumper, 2007, Virine & Trumper, 2013). This approach is sometimes referred to as "Risk Drivers" (Hulett, 2009, 2011). From the computational perspective, using statistical distributions and risk events are very similar.

Event chain methodology is an extension of "traditional" and event-based quantitative risk analysis. Event chain methodology is an uncertainty modelling and schedule network analysis technique that is focused on identifying and managing events and event chains that affect project schedules.

Statistical Distributions

When we calculate project schedule we may not know exactly, how long certain activity would take and how much it would cost. For example, activity "Paint a wall" may take something between 5 hours and 8 hours and cost between $30 and $50. Since any activity in the schedule may have such uncertainties it is hard to estimate how long would it take to perform the project and how much would it cost. It theory it is possible to perform project calculation of project schedule for all combinations of task durations and costs. However, it will be impractical and inefficient. The solution would be to use Monte Carlo simulations. Monte Carlo offers a universal method to perform project risk analysis.

One of the main concepts used in Monte Carlo method is a statistical distribution. Statistical or probability distribution is a relationship between data samples or outcome of a statistical experiment and its probability of occurrence. Figure 1 shows an example of statistical distribution of task duration. In this example most likely duration will be 6.3 hours. Horizontal axis on this chart represents task duration, while vertical axis represents frequency or probability.

Figure 1. An example of statistical distribution