Computers & Project Management CMI

Week 9: Topics: Large Networks, Risk Analysis and Standard Networks & Templates
Overview:

- Large Networks
  - Rolling Wave Planning
  - Coding of activities – filtering & sorting
  - Hierarchical network breakdown
- Risk Analysis Techniques
  - PERT
  - Monte Carlo Analysis
- Standard Networks & Templates

Objectives:

- Gain an understanding of the difficulties associated with large networks and how to effectively deal with these.
- Review two risk analysis methods: PERT & Monte Carlo Analysis.
- Understand the use of standard networks & templates

Introduction

This week, some of the "less frequently" used tools and techniques available to project managers are introduced. Quantitative Risk Analysis has become an important component of project management and we will review two risk analysis methods. We will also look at ways to deal with the problems encountered when planning large projects. Finally we will look at the use of standard networks and templates to help bring about efficiencies and process improvements in the management of projects.

Large Projects

Difficulties large projects pose to a PM

A large network may have thousands or even tens of thousands of activities that need to be identified, scheduled and managed. In the past this would have resulted in project plans that covered the walls of a large room. Very large network diagrams, Gantt charts and output reports can be unmanageable especially when displayed on computer screens or even in printed format.

Some of the difficulties a PM will encounter when working with large networks are:

- Difficult to display large networks – even the largest of computer screens will have difficulty displaying a readable network diagram or Gantt chart for a large network. To understand and manage the project plan effectively it really needs to be viewed in its entirety at least at a summary or milestone level. The same is true of output reports, the audience will soon grow tired of reviewing a large several page report unless there is a summary presented.

- Difficult to print – printouts of large networks can span many pages in both length and width, these pages then need to be assembled into the correct sequence for display. The result can be difficult to follow. Large plotters can be used to print the network but these are not always readily available.

- Prone to errors – there is a greater risk of data entry errors when there are large numbers of activities to be added and the task of comparing and reviewing the data to catch errors becomes very time consuming. Of course when it comes to updating the schedule with the latest status information there is also a greater risk that at least some records will contain errors and skew the progress and\or delivery dates.

- Difficult to keep up-to-date – the sheer number of records in a large network may make the task of updating the plan with the latest status information a time consuming undertaking. This can result in the plan becoming out-of-date quickly and dissuade or even prevent the project from adding changes during the post-planning phases.

- Different levels of detail required by different people in the project organisation – for example senior managers may need just a summary level plan, whereas those at middle management level would need an intermediate level of detail and may need information that is department or team specific. Supervisors require more day-to-day detail.

- Some information not known or understood in large networks that span a long timeframe – projects that are expected to span several years may have adequate detail for the early stages but beyond a certain time period information may be vague or non-existent.

Now we will look at three techniques to address these difficulties: Rolling Wave Analysis, Filtering & Sorting of data and Hierarchical Network Breakdown.

Rolling Wave Planning
Although Lock refers to "Rolling Wave" planning as one of the "less frequently" used techniques, versions of rolling wave planning appear in most project management methodologies and in PRINCE2 in particular.

The rolling wave approach acknowledges that project planners do not know everything relating to the project and how it will progress at the start of the project, particularly when a project may be very large and span several years. To get around this, the project is broken into stages with details added to each stage plan as the project progresses.

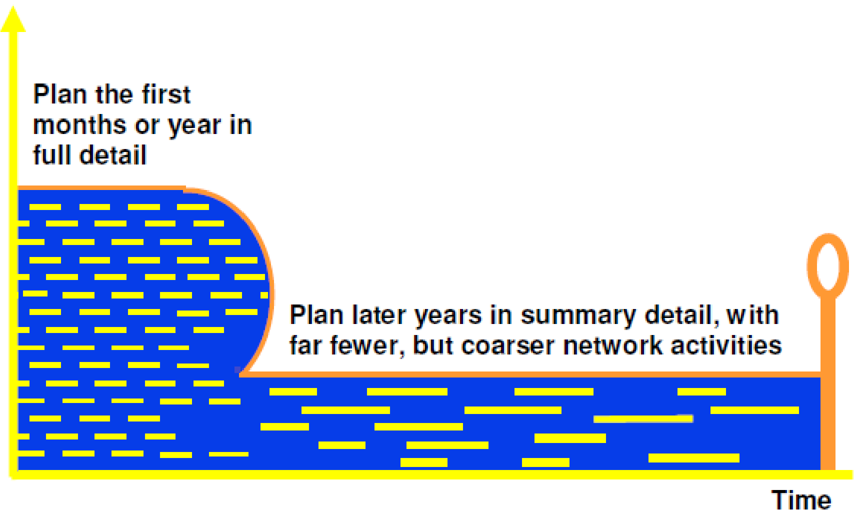

Figure 1 – Rolling Wave Planning (Lock) – Outset

The diagram shows many small activities and detailed logic near the project start, with the later stages showing relatively fewer but larger activities as the final completion activity is approached. These larger activities may correspond to large items of work that have not yet been broken down.

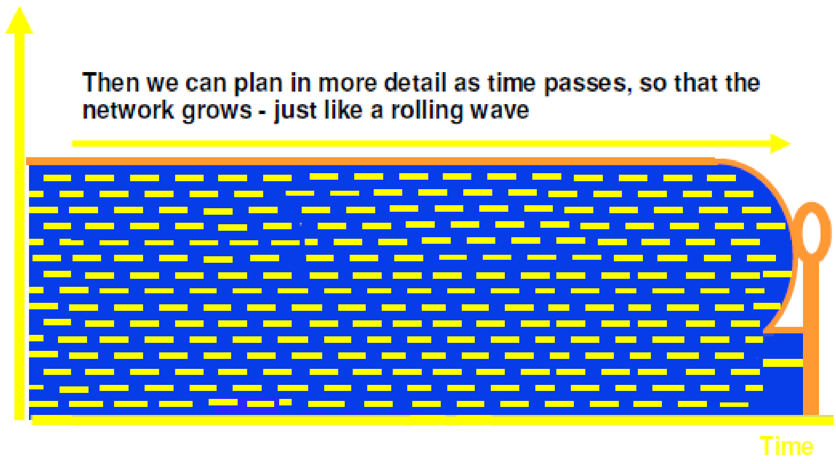

Figure 2 – Rolling Wave Planning (Lock) – Towards Conclusion

The upshot of rolling wave planning for the project manager is the need to update the plan or schedule as the project progresses. Once the stages are determined (or estimated) at the outset of the project these updates can be anticipated in advance.

Usually rolling wave planning needs to stay as least two to three months ahead of the actual work being done, but this can vary by industry.

Filtering and Sorting large projects

As we discussed in Week 6 coding of activities in a way that makes sense to the organisation, allows the PM to sensibly filter and sort the plan to meet the needs of its audience.

It is possible to create one large network for the project and then use the coding of activities and resources to allow effective filtering and sorting of data.

Department codes can be assigned to activities allowing the filtering of data to show only activities for which a particular manager is responsible.

Milestone activities can be created that mark an event, a stage or an achievement in a project. The PM software can then be used to produce schedules and reports that only contain milestones, which should meet the needs of management.

The allocation of resource codes is particularly useful for large projects, to identify resource types. This data can then be used to produce schedules and outputs that only pertain to a specified resource type. Thus the software can filter and sort by both department and resource skills (e.g. skilled, labourer).

There are many other codes that can be used to meet a particular organisations needs for filtering and sorting and these should be considered including – security level codes and OBS level codes. As well as the option to filter on a text string within a field such as the activity description.

Hierarchical network breakdown
It is possible to create networks with sufficient level of detail that do not have many thousands of activities, by creating a hierarchy of subnetworks.
This approach to the breakdown of large project networks recommends the creation of a main or summary network that is then broken down into several more detailed subnetworks.

One way to attempt this is to use the WBS, work packages can be planned separately and have their own smaller network diagram.

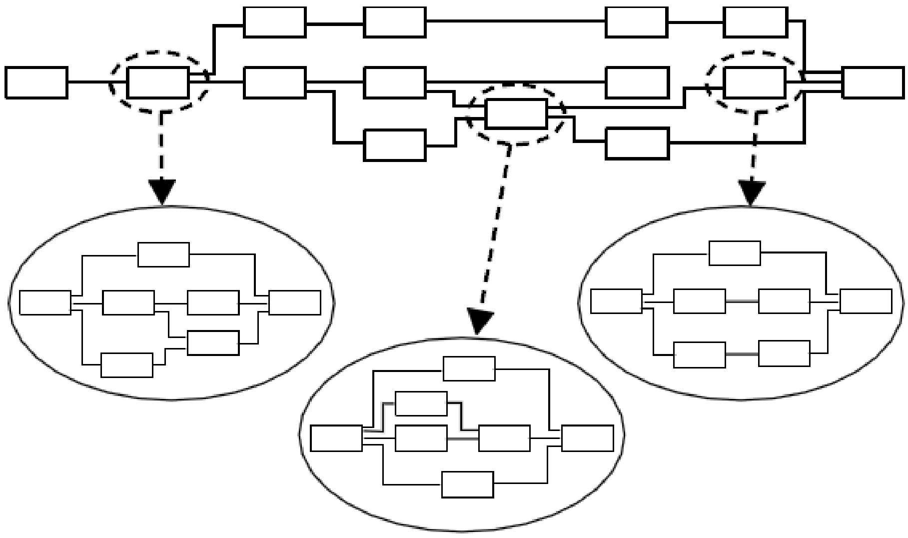

Figure 3 - Example of a large network broken down into subnetworks (Lock).

PERT (Program (or Project) Evaluation and Review Technique)

Most project plans are deterministic. This means that the project manager believes that every task duration estimate is achievable and is determined to see that the project is finished on time. PERT allows for some uncertainty in these determinations. The PERT model was developed in 1950s to address uncertainty in the estimation of project parameters.

PERT allows three different duration estimates for each activity. It calculates the expected time for each activity from the expression:

$$te = \frac{to + 4tm + tp}{6}$$

Where:

t_o = the most optimistic time estimate

t_m = the most likely time estimate

t_p = the most pessimistic time estimate

t_e = the expected time

Or put more simply:

$$\frac{\textbf{shortest time + 4 x likely time + longest time}}{\textbf{6}} \textbf{ = expected time}$$

PERT estimates are usually represented using the following notation:

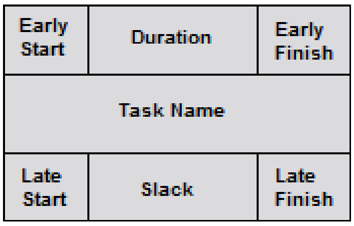

Figure 4 – PERT Notation

Some PM software will allow you to enter PERT estimates, calculate the expected durations and view the results in the Gantt chart and output reports so that analysis can be performed. PERT software add-ons are also available.

PERT has some limitations, mainly associated with how accurately the estimations are for the optimistic, most likely and pessimistic task durations. PERT is recommended for quantitative risk analysis if you have accurate estimates based on reliable historical data.
To overcome the challenges associated with the PERT method, Monte Carlo simulations can be used as an alternative.

Monte Carlo Analysis

Monte Carlo simulation was named for Monte Carlo, Monaco, where the primary attractions are casinos containing games of chance. Games of chance such as roulette wheels, dice, and slot machines, exhibit random behaviour. We have the creators of the atomic bomb to thanks for inventing Monte Carlo analysis and it is now applied in scientific calculations, financial analysis (particularly pricing models) and in the calculation of risk for projects.

The random behaviour in games of chance is similar to how Monte Carlo simulation selects variable values at random to simulate a model. When you roll a die, you know that a 1, 2, 3, 4, 5, or 6 will come up, but you don't know which for any particular roll. It's the same with the variables that have a known range of values but an uncertain value for any particular time or event (e.g. interest rates, staffing needs, stock prices, inventory, and phone calls per minute).

The Monte Carlo process begins, like PERT, by making three estimates for every parameter that has any uncertainty. Thus, as with PERT, tasks in the network are each assigned three durations (optimistic, most likely and pessimistic). After that, the similarities end. Monte Carlo analysis uses thousands of randomly generated iterations of the estimates provided based upon pre-set probabilities.

To run Monte Carlo analysis an application is required. Some of those available include *Crystal Ball* from Oracle (uses MS Excel) and *@Risk* (available for both MS Project and MS Excel)

"Monte Carlo Simulation"

The basic concept of the technique is best described through illustration. We all know that a normal six sided die with the numbers one through six on each of the faces has an equal chance of showing any of the six numbers on any one roll. Statisticians would say that the results of a roll are "uniformly distributed" between one and six, and that the results of any one roll of the die represented a "random number" sampled from that uniform distribution. This is very fancy language for a very simple concept, but the language becomes more useful as we get deeper into the Monte Carlo method.

Now, suppose that you wanted to know what the chances were that the numbers on a normal pair of dice would total seven when rolled. While there are many ways to solve this question mathematically, one simple method would be to roll the dice many times and count the proportion of times that the total is actually seven. If for instance, you rolled them 36 times and they totalled seven on six occasions, you might deduce that the chances of getting a seven were one in six, or 16.7%. As it happens, you would be exactly right in this instance. However, the dice could have shown seven on ten occasions. In this case, the results of your "simulation" would have been misleading, unless you had the judgment to take the results with a grain of salt. The results of rolling a pair of dice are random after all, and the chances of rolling a seven the precise six times required here are rather small.

If, however, we were interested in the **average** number shown on the dice in the same 36 rolls, you typically would find that the total of the numbers on the dice divided by the 36 rolls was close to seven. In other words, your simulation was a rather good predictor of the average result, while not necessarily giving you accurate information about the probability of any individual result occurring.

To continue the illustration, suppose that you were interested in describing the "spread" of your simulation results. One common method of doing this is to show the results in what is known as a "bar graph" or "histogram". Suppose that the results of your 36 rolls were:

Outcomes:
- 1 two
- 3 threes
- 3 fours
- 3 fives
- 6 sixes
- 6 sevens
- 5 eights
- 3 nines
- 1 ten
- 3 elevens
- 2 twelves

The bar graph of these results is shown to the left of the table. Each bar is proportionally as high as the number of times that the result occurred, so that the bar for the result of three is three times as high as the bar for the result of two. Such a graph is a useful tool to describe the results of your simulation, although you would not believe that it accurately represented the chances of rolling a particular total, since the results are random. One thing you might do, however, is draw a smooth line over the results, as has been done here, and think that such a line might come close to the tops of a bar graph of a "perfect" simulation". In this case, you would be right, since the triangle shape is the actual underlying "probability distribution" of the sum of two die.

While the bar graph is a good picture of the results of the simulation, statisticians typically use two particular numbers to describe the same thing in summarized form. The first statistic is the "mean" or average result. This is determined by adding all the results, and dividing the total by the number of trials. In this case, the average result is 290/36 or 8.06. The second statistic is called the "standard deviation". It is a measure of the "spread" of the distribution, and is, mathematically, the square root of the sum of the squares of the deviations from the mean divided by the number of trials. While that is a confusing definition, the use of the statistic in the context of Risk Analysis is quite simple. Since the standard deviation measures the spread of the results, <u>it is a good measure of the amount of risk in the simulation results</u>.

Although the dice illustration is quite simple, a statistician would say that we have just conducted a Monte Carlo Simulation for 36 trials in order to describe the probability distribution of the total

shown on a pair of dice. In order to do so, we have sampled two random numbers from a uniform probability distribution between one and six, and performed a mathematical operation (adding the two numbers together) on the pair of random numbers.
The Risk Analysis used in Project Management is performed in exactly this fashion.
However, there are a few differences due to the nature of the real-life situation we are simulating.

Standard Networks & Templates

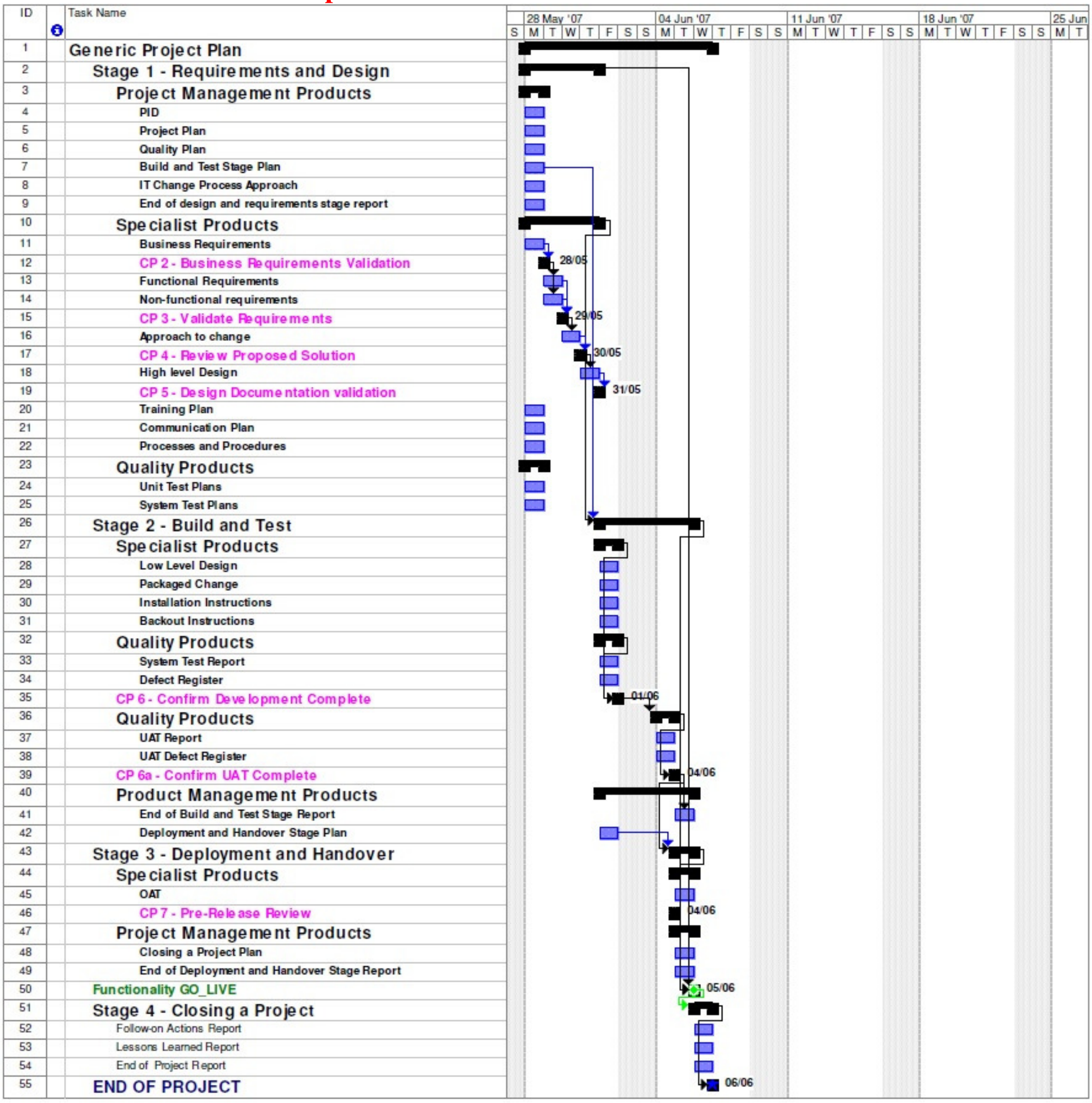

Figure 5 – Generic Development Project Plan Template

It is true that no two projects are identical. It is also true that there are common characteristics between projects within most organisations. Most organisations can therefore use and re-use standard project plans (or networks) and amend accordingly. For example, a standard plan for a construction firm a house and a garage so if a house without a garage is required, simply remove those activities related to the garage from the project plan.

Lock refers to these as “Standard Networks” and the saved versions as “Templates”. (Some templates for various project documents were introduced in Week 3.)

Standard networks or plans (such as the *MS Project* example in Figure 5) should be saved together in “libraries” and a record of the content and type of project each plan applies to should be stored also - a simple spreadsheet will suffice for this piece.

Care should be taken not to overwrite templates when one is in use and the “Task” or “Activity” identifier will need to reflect the name of the project.

Bibliography and Further Reading

- Project Management, 9th Edition – Denis Lock (Gower)
- Guide to the Project Management Body of Knowledge (PMBOK), 4th edition, PMI.
- Managing Successful Project with PRINCE2, OGC 2005
- Brilliant Project Management – Barker & Cole (Prentice-Hall)

Websites

- www.prince-officialsite.com – PRINCE2 website
- www.pmi.org – Project Management Institute
- www.ipma.ch – International Project Management Association
- http://www.esi-intl.co.uk/PM9/ – support materials for Lock
- http://www.oracle.com/crystalball/index.html - Crystal Ball from Oracle
- http://www.palisade.com/products.asp - @Risk from Palisade
- MS Excel sample Monte Carlo simulation:
  Link: https://support.office.com/en-ca/article/Introduction-to-Monte-Carlo-simulation-64c0ba99-752a-4fa8-bbd3-4450d8db16f1

Student preparation (informal):

To prepare yourself for the class, try having a look on the Internet for some of the sample files (links) above. These are easily located using Google searches such as "Monte Carlo Analysis"; "PERT risk assessment"; "Project Schedule Risk"; "Project Cost Risk" etc.