Software Project Management

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Risk Management cont …

Topics to be covered

- Monte Carlo Simulation
- Critical Chains

Evaluating Risks to the Schedule

- It can be shown that a job might take 5 days, but that there is a small chance it might need 4 or 6 days, and a smaller chance of 3 or 7 days, and so on.
- If a task in a project takes longer than planned, we might hope that some other task might take less and thus compensate for this delay.
- We have already discussed that PERT takes account of the uncertainties in the durations of activities within a project.
- Now, we will discuss Monte Carlo simulation, which is a more powerful and flexible tool, that also tackles the same problem.

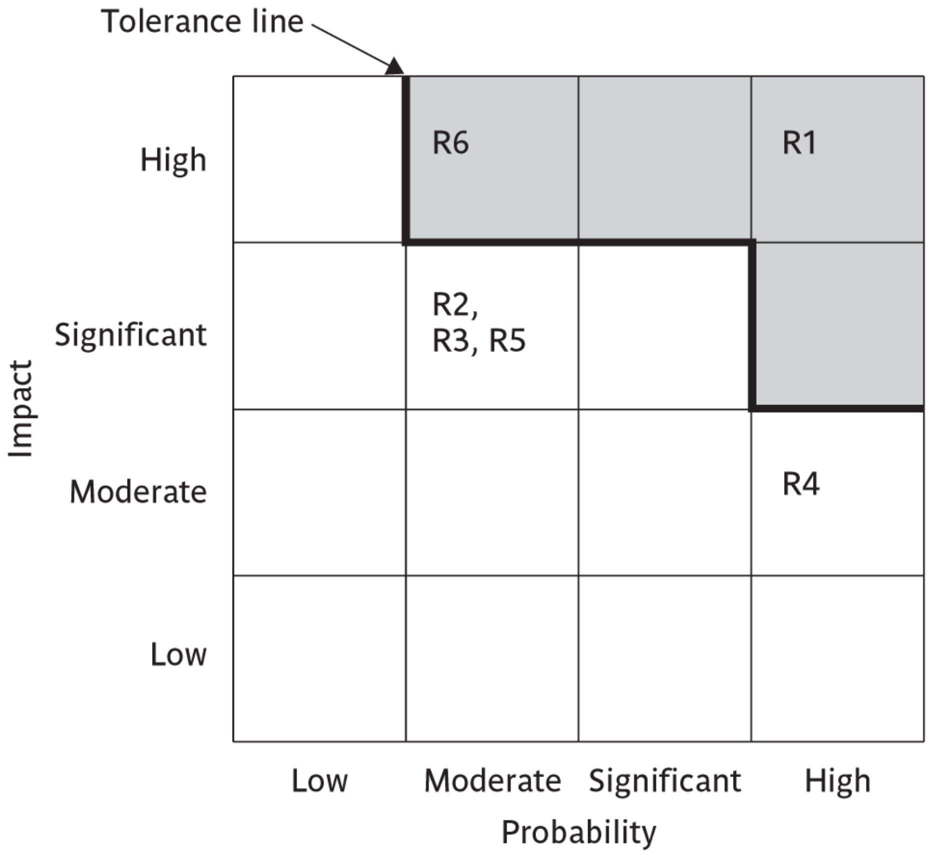
Monte Carlo Simulation

- As an alternative to the PERT technique, we can use Monte Carlo simulation approach.
- Monte Carlo simulation are a class of general analysis techniques that are valuable to solve any problem that is nonlinear, or involves more than just a couple of uncertain parameters. Hence, it can be used to handle risks in projects.
- Monte Carlo simulations involve repeated random sampling to compute the results.
- Since this technique is based on repeated computation on random numbers, it becomes easier to use this technique when available as a computer program.

Monte Carlo Simulation

- When Monte Carlo simulation is used to analyse the risk of not meeting the project deadline, the project completion time is first modelled as a mathematical expression involving the probability distributions of the completion times of various project activities and their precedence relationships.
- Activity durations can be specified in a variety of forms, depending upon the information available.
- For example, if historic data are available about the durations of similar activities as shown in the probability chart in next figure, we might be able to specify durations as pertinent probability distributions.

Probability impact matrix

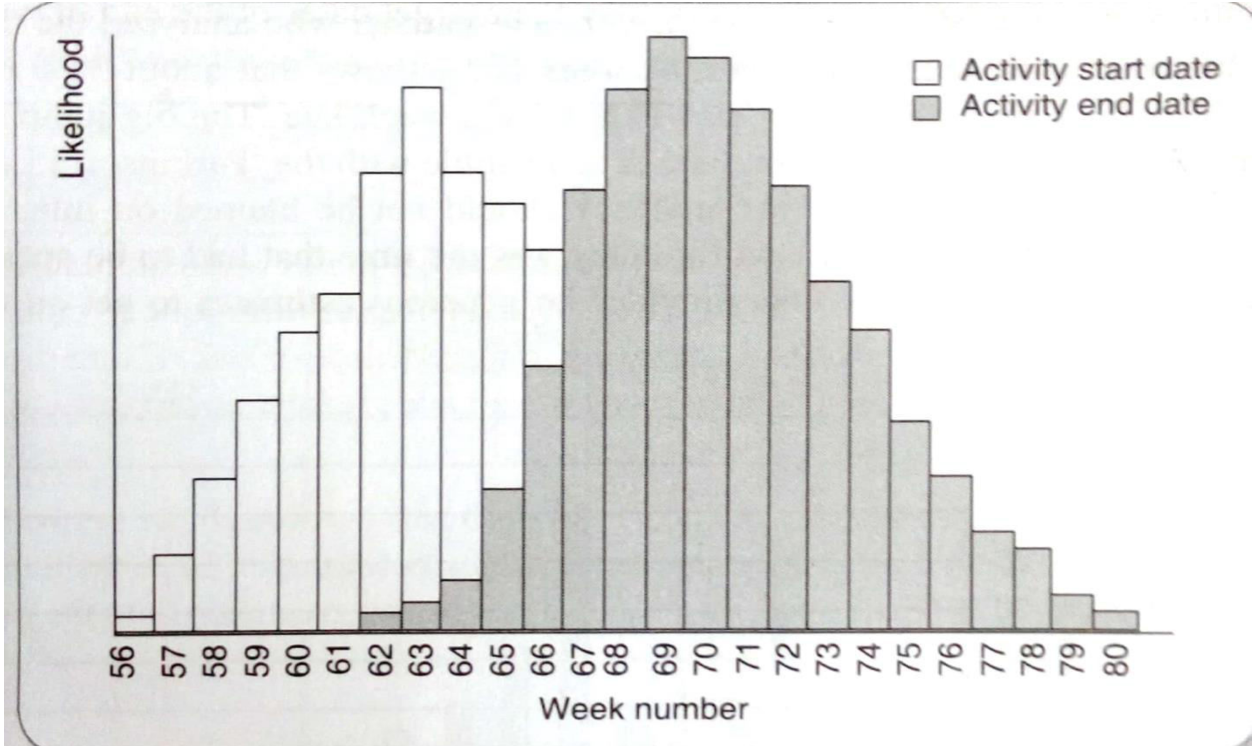


Monte Carlo Simulation

- With less information available, we should, at least, be able to provide three time estimates as used by PERT.
- Monte Carlo simulation essentially evaluates a range of input values generated from the specified probability distributions of the activity durations.
- It then calculates the results repeatedly; each time using a different set of random values generated from the given probability functions.
- Depending upon the number of probabilistic parameters and the ranges specified for them, a Monte Carlo simulation could involve thousands or even millions of calculations to complete.

Monte Carlo Simulation

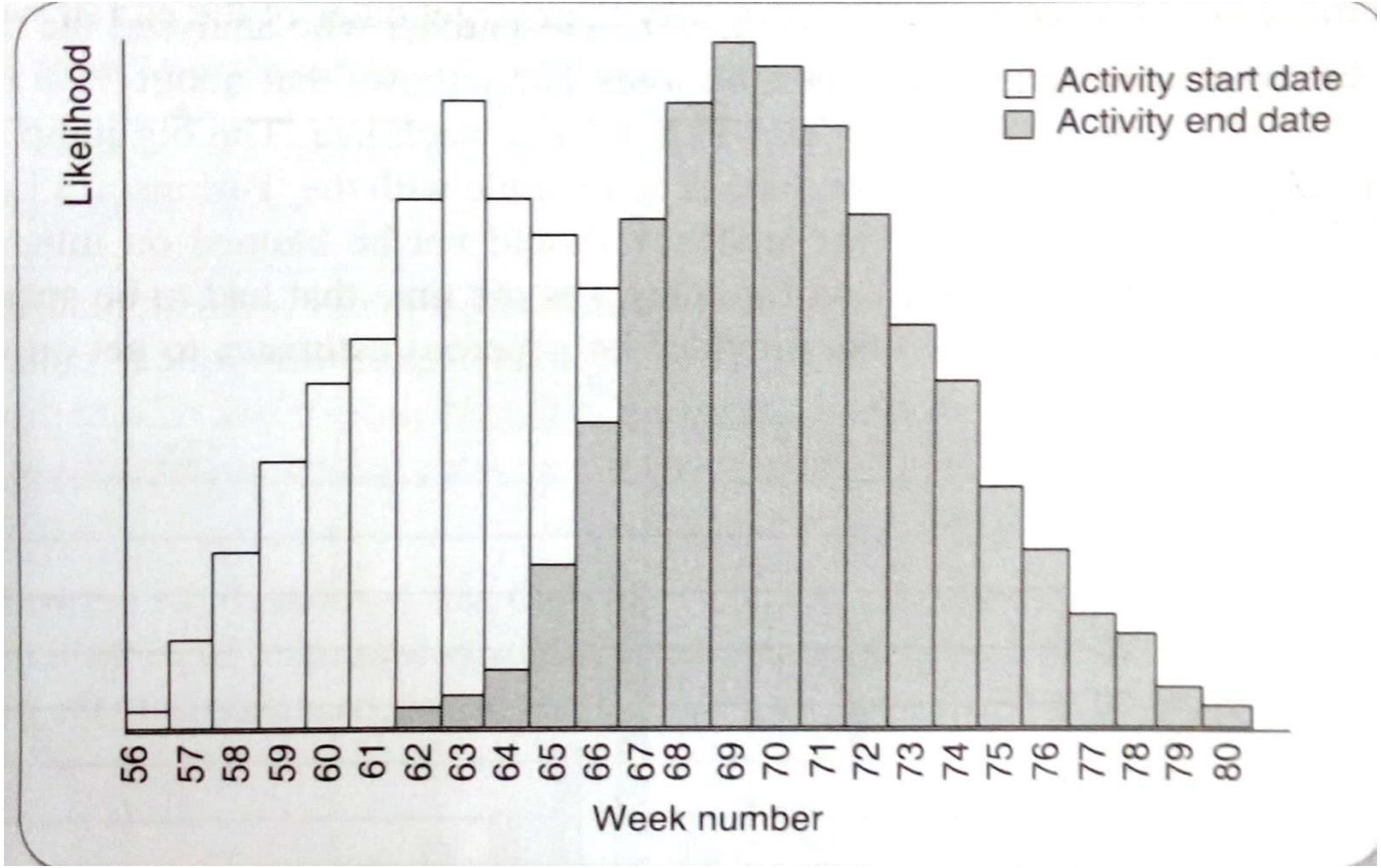
- After the simulation results are available, these are analysed, summarized and represented graphically, possibly using a histogram.



Steps for Monte Carlo simulation

- Step 1: Express the project completion time in terms of the duration of the n activities (x_{i}, $_{i=1,n}$ and their dependences as a precedence graph, $d = f(x_1, x_2, ..., x_n)$).
- Step 2: Generate a set of random inputs, $x_{i1}, x_{i2}, ..., x_{in}$ using the specified probability distributions.
- Step 3: Evaluate the project completion time expression and store the result in d_i
- Step 4: Repeat Steps 2 and 3 for the specified number of times.
- Step 5: Analyse the results $d_{i,\, i=1,n}$; summarize and display using a histogram.

Monte Carlo Simulation



Advantage of Monte Carlo simulations

- In the manual approach, a few combinations of each project duration are chosen (such as best case, worst case, and most likely case), and the results recorded for each selected scenario.
- In contrast, in Monte Carlo simulation, hundreds or thousands of possible random sampling of probability distribution functions of the activity durations are considered as samples for evaluation of the project completion time expression to produce outcomes.
- Monte Carlo simulation is expected to give a more realistic result than manual analysis of a few cases, especially because manual analysis implicitly gives equal weights to all scenarios.

Critical Chain Concepts

- A drawback to the application of methods like PERT is that, in practice there is a tendency for developers to work to the schedule even if a task could be completed more quickly.
- Even if tasks are completed earlier than planned, project managers are not always quick to exploit the opportunities to start subsequent activities earlier than scheduled.
- Critical chain management will be explored as a way of tackling this problem.

Critical Chain Concepts

- The forecast for the duration of an activity cannot in reality be a single number, but must be a range of durations.
- However, we would want to pick one value in that range, which would be the target.
- The duration chosen as the target might be the one that seems to be the most likely.

Example

- Imagine someone who cycles to work each day. It may be that on average it takes them about 45 minutes to complete the journey, but on some days it could be more and on other days it could be less.
- If the cyclist had a very important meeting at work, it is likely that they would give themselves more time – say an extra 15 minutes – than the average 45 minutes to make sure that they arrive in time.

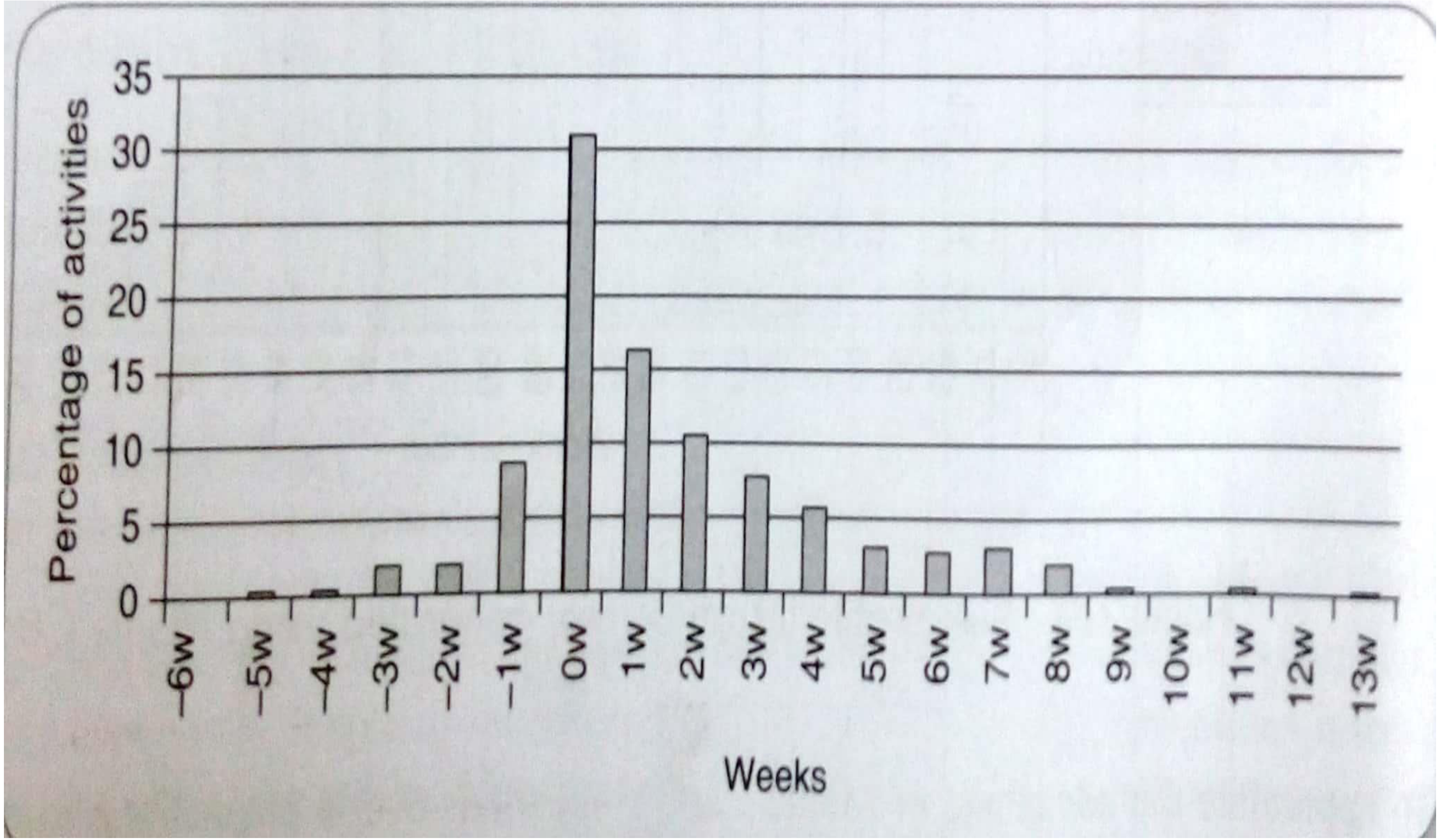
Example

- According to PERT, the most likely duration is the middle value and the pessimistic estimate is the equivalent of 45 + 15 = 60 minutes. Of course, there will be some days when the cyclist will beat the average of 45 minutes.
- When a project is actually being executed, the project manager will be forced to focus on the activities where the actual durations exceed the target.
- Activities which are actually completed before the target date are likely to be overlooked. If these early completions, are properly handled, it can put some time in hand that will allow the project to meet its target completion date, if the later activities are delayed.

Example

- Next figure shows the findings of Michiel van Genuchten, a researcher who analysed the reasons for delays in the completion of software development tasks. This bar chart shows that about 30% of activities were finished on time, while 9% were a week early and 17% were a week late.
- The big jump of 21 percentage points between being a week early and being on time is compatible with the "Parkinson's Law" which says that 'work expands to fill the time available'.
- This tendency should not be blamed on inherent laziness, van Genuchten found that the most common reason for delay was the time that had to be spent on non-project work. The developers used the spare time on some other urgent work.

Percentage of activities early or late

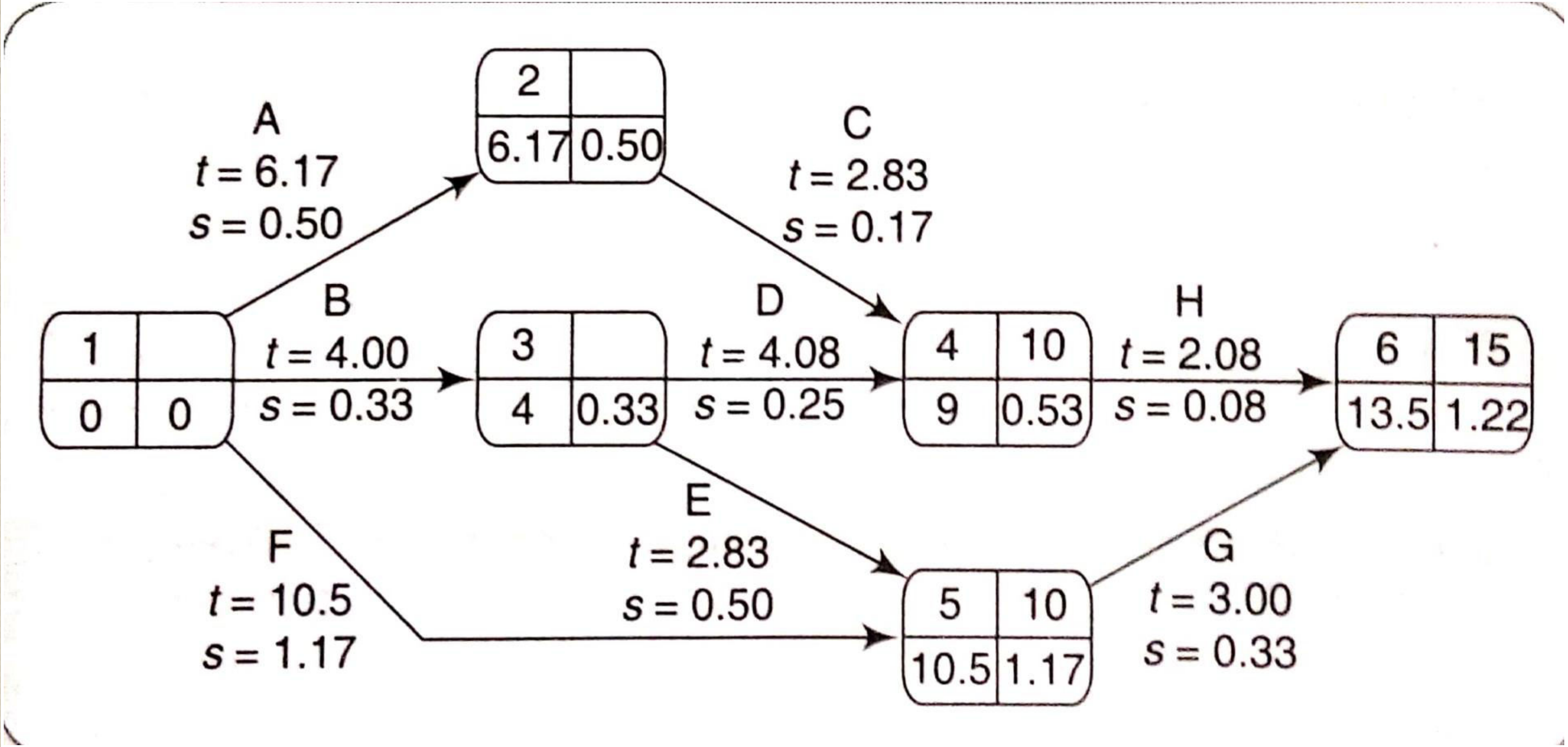


- One approach which attempts to solve some of these problems is the application of the critical chain concept originally developed by Eliyahu Goldratt.
- In order to demonstrate the principles of this approach, the example shown in next figure is redrawn as a Gantt chart.
- The next figure shows what the Gantt chart for this project might look like if a “traditional approach' were adopted, but we have already adopted the most likely durations.
- The general steps in the Critical Chain approach are explained in the next slides.

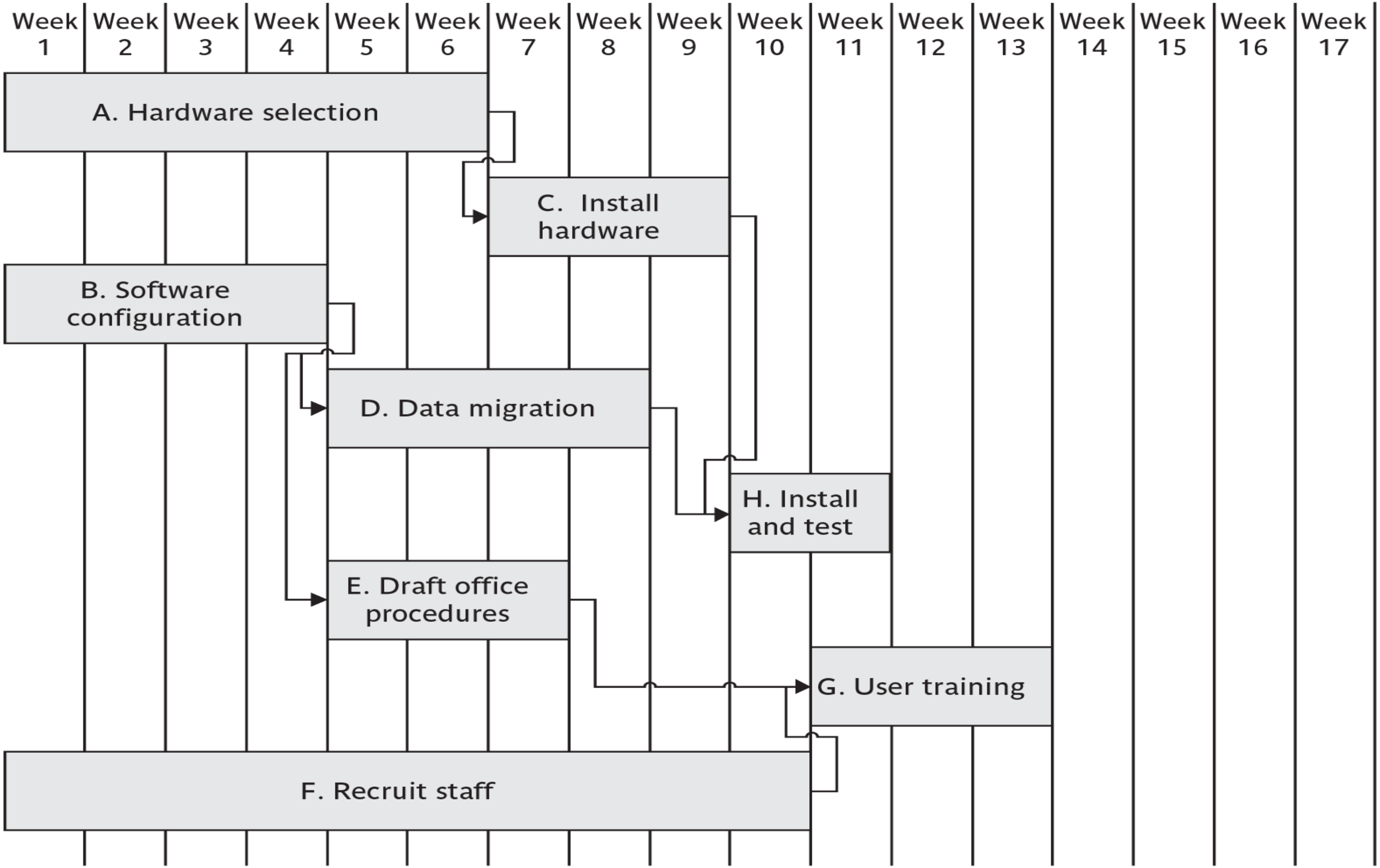
PERT activity time estimates for a project

Activity	Optimistic (a)	Most likely (m)	Pessimistic (b)
A	5	6	8
B	3	4	5
C	2	3	3
D	3.5	4	5
E	1	3	4
F	8	10	15
G	2	3	4
H	2	2	2.5

PERT network



Gantt chart – 'traditional' planning approach



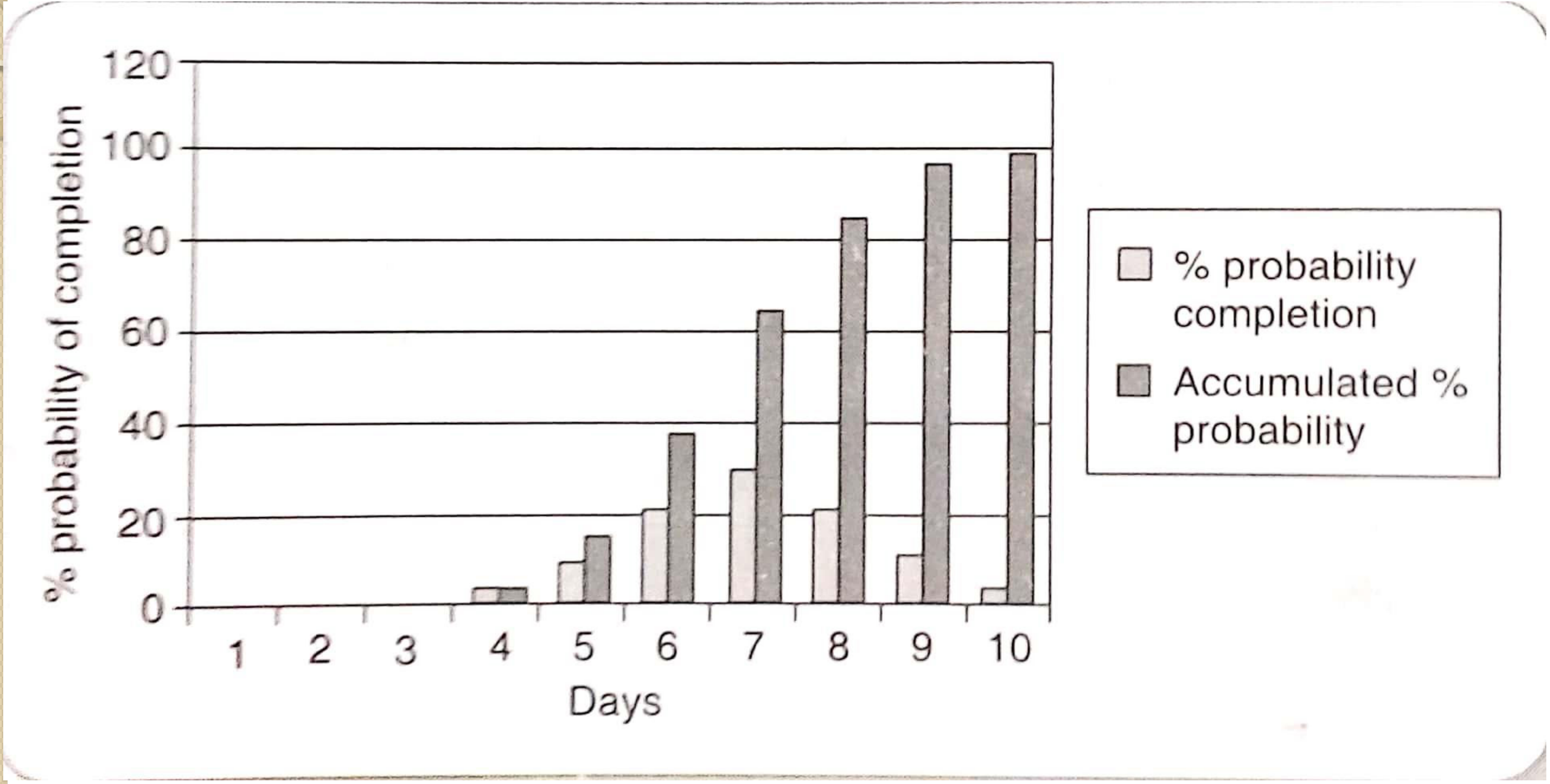
Steps in Critical Chain approach

- Derive the ‘most likely' activity durations
- Use the latest start dates for activities
- Insert project and feeder buffers

Derive ‘most likely' activity durations

- The target date generated by critical chain planning is one where it is estimated that there is a 50% chance of success – this approximates to the expected time identified in the PERT method.
- In critical chain method, the developers are asked to supply two estimates.
  - One of these would be a 'most likely' estimate and
  - the other would include a safety margin or comfort zone.

Probability chart



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F	8	10	15
G	2	3	4
H	2	2	2.5

Most likely and comfort zones estimates

Activity	Most likely	Plus comfort zone	Comfort zone
A	6	8	2
B	4	5	1
C	3	3	0
D	4	5	1
E	3	4	1
F	10	15	5
G	3	4	1
H	2	2.5	0.5

Use latest start dates for activities

- Working backwards from the target completion date, each activity is scheduled to start as late as possible.
- Among other things, this should reduce the chance of staff being pulled off the project on to other work. It is also argued – with some justification according to van Genuchten's research – that most developers would tend to start work on the task at the latest start time anyway. However, it does make every activity ‘critical’, i.e. if one is late, the, the whole project is late.

Insert project and feeder buffers

- To cope with activity overruns, a project butter is inserted at the end of the project before the target completion date.
- One way of calculating this buffer is as the equivalent of 50% of the sum of lengths of the comfort zones that have been removed from the critical chain.
- The critical chain is the longest chain of activities in the project, taking account of both task and resource dependencies.

Insert project and feeder buffers

- This is different from the critical path as the latter only takes account of task dependencies, not resource dependencies.
- A resource dependency is where one activity has to wait for a resource (usually a person in software development) which is being used by another activity to become available.
- If an activity on this critical chain is late, it will push the project completion date further into the project buffer.
- Why the buffer should be 50% of the total comfort zones? Reason: It is based on the grounds that if the estimate for an activity was calculated as having a 50% chance of being correct, the buffer would only need to be called upon by the 50% of cases where the estimate was not correct.

An alternative proposal

- An alternative proposal is to sum the squares of the comfort zones and then take the square root of the total. This is based on the idea that each comfort zone is the equivalent to the standard deviation of the activity.
- This method of calculation still produces a figure which is less than simply summing all the comfort zones.
- This is justified on the grounds that the contingency time needed for a group of activities is less than the sum of the individual contingency allowances as the success of some activities will compensate for the shortfalls in others.

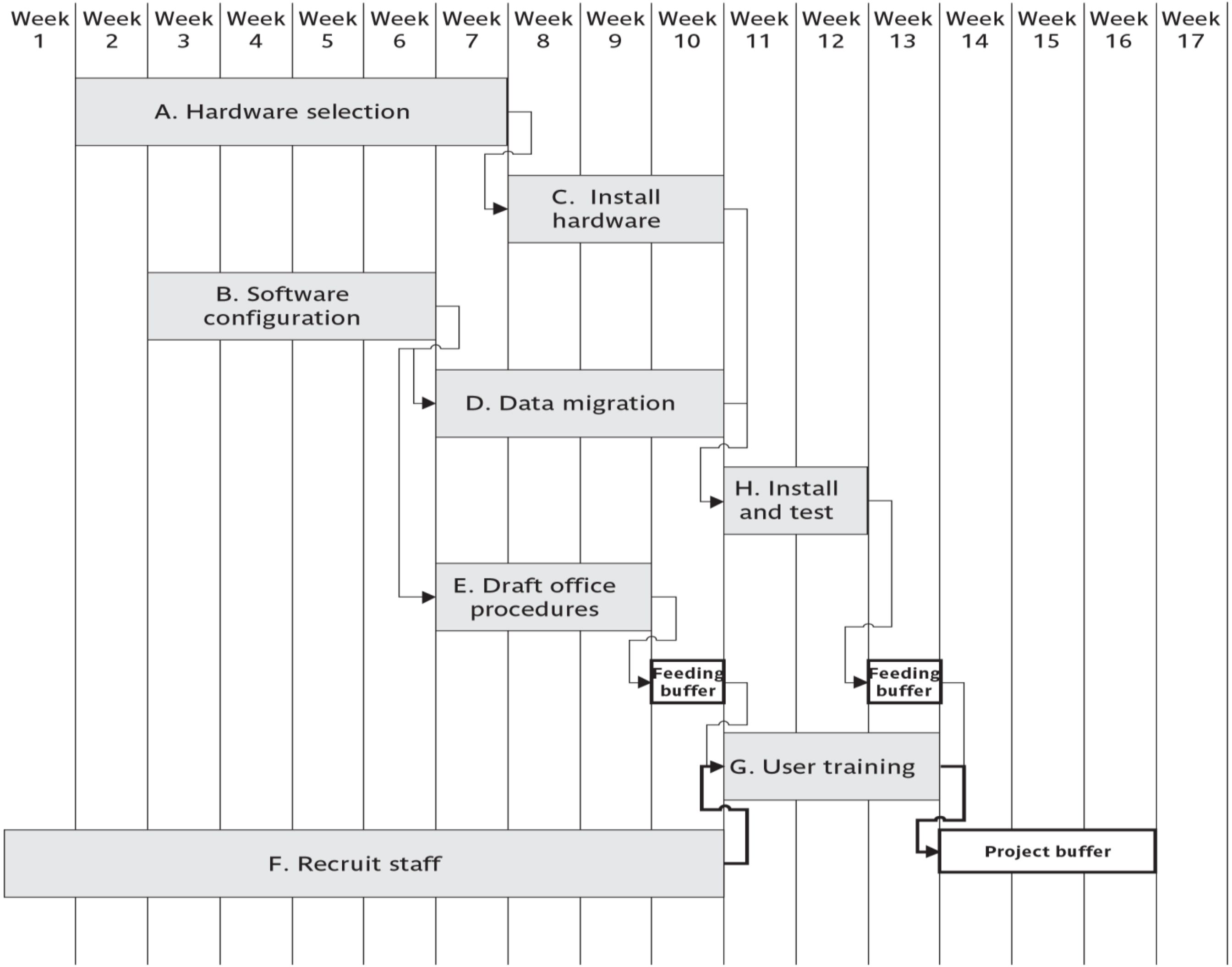
Feeding buffers

- Buffers are also inserted into the project schedule where a subsidiary chain of activities feeds into the critical chain.
- These feeding buffers could once again be set at 50% of the length of the 'comfort zone' removed from the subsidiary or feeding chain.

Worked example

- Next figure shows the results of this process.
- The critical chain in this example happens to be the same as the critical path, that is activities F and G which have comfort zones of 5 weeks and 1 (one) week respectively, making a total of 6 weeks.
- The project buffer is therefore (5+1)/2 = 3 weeks.

Gantt chart – 'critical chain' planning approach



Feeding Buffers

- Subsidiary chains feed into the critical chain where activity H links into the project buffer and where activity E links into G which is part of the critical chain.
- Feeding buffers are inserted at these points. For the first buffer the duration would be 50% of the saved comfort zones of A, C and H, i.e. (2 + 0 + 0.5)/2 = 1.25 weeks.
- It could be argued that B, D & H could form a feeder chain which also has a comfort zone of (1+1+0.5)/2 = 1.25 weeks.
- In situations, where there are parallel alternative paths on a feeder chain, the practice is to base the feeding buffer on whichever comfort zone total is greater. This because if one or both parallel paths are late they could use the same buffer.

- It could be argued that the feeding and the final project buffer could also be merged, but explanations of critical chain planning, make clear that this is not to be done.
- This could be because a delay penetrating the feeding buffer time does not affect the completion date of the project, while penetrating project buffer does.
- In the second place, where a feeder chain of activities joins the critical chain, the feeder buffer would be 50% of the comfort zones of activities B and E, i.e. (1+1) / 2 = 1 week.

Project execution

When the project is executed, the following principles are followed:

- No chain of tasks should be started earlier than scheduled, but once it has been started it should be finished as soon as possible – this invokes the relay race principle,
  - where developers should be ready to start their tasks as soon as the previous, dependent, tasks are completed.
- Buffers are divided into three zones: **green**, **amber** **and** **red**, each of an even (33%) size.

Project execution

- green, where no action is required if the project completion date creeps into this zone;
- amber, where an action plan is formulated if the project completion dates moves into this zone;
- red, where the action plan above is executed if the project penetrates this zone.

Summary

- Discussed Monte Carlo Simulation.
- Discussed Critical Chain method with an example.

References :

1. B. Hughes, M. Cotterell, R. Mall, *Software Project Management*, Sixth Edition, McGraw Hill Education (India) Pvt. Ltd., 2018.

Thank you