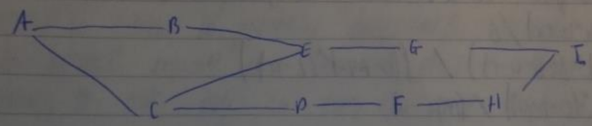
21/04/16 DECISION

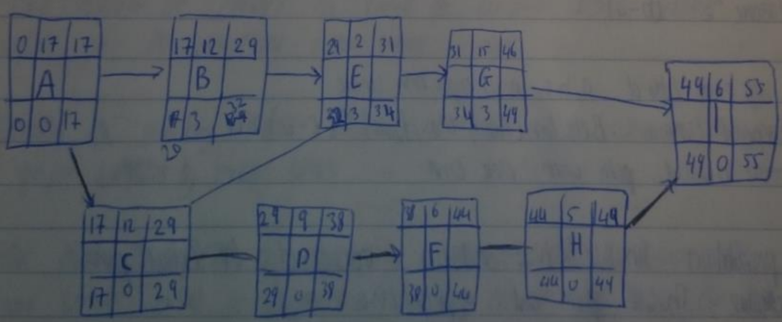
CPM

- Given deterministic activity times, it is possible to describe a project as a network, and find a critical path through the network

- Set up network with dummy nodes so that activities do not finish at the same place
- Do a forward and backward pass

- Should be clear, in practice that activities do not take fixed time known a priori. CPM is appropriate for deterministic situation





A ⇒ C ⇒ D ⇒ F ⇒ H ⇒ I

Start time | duration | finish time

node

Start time | Slack | latest finish time

Pick path with the 0's

22/04/16

~~ADBP~~ PERT

- Programme Evaluation and Review Technique
- Key output is time to completion of project
- Times can be uncertain
- Used to summarise times for parts of projects
- It is a distribution taking, min, most likely, and max
- It is "smoother" than a triangle
- In fact, it is a Beta Distribution
- PERT(a,b,c) = Be(alpha, beta) * (c-a) + a

Parameterisation

- The alpha and beta are given (where the PERT is not symmetric) by:

  mu = (a + 4*b + c) / 6

  alpha = ((mu - a) * (2b - a - c)) / ((b - mu) * (c - a))

  beta = (alpha * (c - mu)) / (mu - a)

  Variance = $(b-a)^2$

Set up excel table of a, b, c, mu, alpha, beta, variance

Expected time = Beta.Inv(Rand, alpha, beta) * (c - a) + a

Create critical path with these times

For probabilities: Simulate 1000 or 10000 versions of the critical path

- calculate shortest path and expected time
- Use proportions to calculate expected times

- In reality each of these completion times are random variables that each have some probability distribution of.
- First step in project scheduling is to establish the tasks that need to be completed and the order in which they can be done. We must know which tasks are pre requisite of others beginning others. A network diagram of the tasks should be drawn and the critical path for tasks must be identified.

22/04/16 DECISIONS

Pert...

- The critical path through a project network is one, where, should the duration of any activity ~~[illegible]~~ on the path increase; the total time taken to complete the project would increase. This is based off estimated completion times for each task. Activities that are not on the critical path can be said to have slack. This is the time that the activity can be delayed without affecting the overall completion time of the project. Activities on the critical path have 0 slack.

Up to this point, no deviation from estimated task times has been considered. In reality, however, tasks will not take exactly as long as they have been predicted to.

Because of this uncertainty must be modelled. As such the next step in the PERT method is to establish the probability distributions for the tasks in the project. Each of these "variables" requires three estimated pieces of information to form their individual distribution; the most likely time taken, the minimum time taken, and max time taken. These distributions are combined to create the complete PERT distribution which can consider all the uncertainty contained within a project.

Ultimately the resulting PERT distribution can be used to estimate the probabilities of project completion by certain times.

Another name for PERT is dependency diagrams. This is because they easily show which tasks are dependent on one another. It shows the tasks in a logical order and indicates which tasks cannot be started or completed without the start or completion of other tasks.

There are four types of dependencies.

1. Finish Start - Task B cannot be started until task A is complete - e.g. foundations dug before concrete. - Standard prerequisite we deal with mostly
2. Finish-Finish: Task B cannot be completed until task A is e.g. roof tiled - house finished
3. Start Start: B can't start before A does (sorting materials can't be before unloading)
4. Start Finish: B can't finish until A starts (previous shift can't leave until new shift arrives)

The arrows between activities indicate the dependencies between those activities in a PERT network chart

Spreadsheet
- PERT dist used exclusively for modelling expert estimates.
- Have estimates for min, likely, and max time
- Smoother version of the triangular distribution

- Three derived parameters needed: mu (heavily weighted average of our range of estimates) Alpha, beta

By creating a table of all the activities and their respective 3 estimates, we can apply the above formulae to find mu, alpha and beta
- Once this is done we have all the information we need to simulate a run of each activity, generating a random selection from the Beta distribution of the activity
- The BETAINV(probability, alpha, beta, min, max) function in excel can do this.
- By passing RAND() to the probability argument, we can obtain our random selection from the distribution

- Do this in a row for each task; we then have our simulated time for each task.
- Can use the max function to determine which is the critical path from the simulated times

- Can allow us to select the latest finish time for dependent activities.
- Adding our simulated activity time to the latest completion time gives us the completion time of the activity with dependencies.
- Sequentially summing models of dependencies is simplest and most effective way of incorporating them into spreadsheet models
- PERT assumes a distribution of values for the time taken to perform a task instead of a single time
- CPM activity oriented, PERT is node oriented

DECISIONS CPM, PERT

- Given deterministic activity times, it is possible to describe a project as a network and find a critical path through the network.

earliest start time	Duration	earliest finish time
latest start time	Slack	latest finish time

Standard CPM of analysing project assume that the estimated time of a task completion will be the actual time of task completion.
PERT - Programmable Evaluation and Review technique attempt to consider uncertainties in our estimates of how long tasks will take. In reality, each of these completion times are random variables that each have some probability distribution.

The first step in project scheduling is to establish the tasks that need to be completed and the order in which they can be done. We must know which tasks are prerequisites for beginning others. A network diagram of the tasks should be drawn and the critical path for tasks must be identified.

The critical path through a project network is one where, should the duration of any activity on the path increase; the total time taken to complete the project would increase. This is based off estimated completion times for each task. Activities that are not on the critical path can be said to have "Slack": this is the time that the activity can be delayed without affecting the overall completion time of the project. Activities on the critical path have 0 slack.

Up to this point no deviation from estimated task times has been considered. In reality however, tasks will not take exactly as long as they have been predicted.

Because of this uncertainty must be modelled. Next step in PERT method is to establish the probability distributions for the tasks in the project. Each of these 'variables' requires three estimated pieces of info to form the individual distribution: the most likely time taken, the minimum time taken and the max time taken. These dist are combined to create the complete PERT dist, which can consider all the uncertainties contained within a project

Ultimately the resulting PERT dist can be used to estimate the probability of project completion by certain time

4 types of dependencies:
1. Finish Start - task B cannot be started until task A is completed (foundation dug - pour concrete)
2. Finish Finish - task B cannot be completed until task A is (roof tiled - have finished)
3. Start Start - B can start before A starts - sourcing materials - material delivered
4. Start Finish - B can't finish before A starts - previous shift can end until new shift arrives

PERT dist used exclusively for modelling expert estimates. We have estimates for min, max and most likely expressed as PERT(a, b, c). It is a smoother version of the triangular distribution, which also takes these 3 parameters

There are 3 derived parameters that are also included:
1. The mean $\mu = (a + 4b + c)/6$ Heavily weighted average of our range of estimates

2. Alpha $\alpha = \dfrac{(\mu - a)(2b - a - c)}{(b - \mu)(c - a)}$

3. Beta $=$ alpha $* \left((c - \mu)/(\mu - a) \right)$
4. Variance $= (b - a)^2$

By creating a table of all the activities and their 3 respective estimates, we can apply the above formulae to find μ, α, β

/05/2016

DECISIONS: PERT

Once this is done, we have all the info needed to simulate a run for each activity, generating a random selection from the Beta distribution of the activity. The BetaINV (probability, alpha, beta, min, max) function in excel can do this. By putting RAND() into the probability argument, we can obtain our random selection from the distribution

Doing this for each row we have our simulation time for each task. The Max() function can help us determine which dependent activities take the longest and therefore actually lie on the critical path. If D depends on B, C, being finished, we must find the time at which the last of these is finished, this is the max and should be summed to the max dependent time for A.

Adding our simulated activity time of the activity to this latest completion time gives us the completion time of the activity with dependants
- Sequentially summing maxes of dependencies is the simplest and most effective way of incorporating them into spreadsheet model

CPM and PERT are both concerned with project scheduling and management. The primary difference between the two is that CPM does not model uncertainty
- PERT allows a distribution of values for the time taken to perform a task instead of single value estimates
- CPM is activity oriented, PERT is node oriented (time taken to reach node gives the start time of the next dependent activity).