Math 251/Buad427 **ACTIVITY 7:** Project Networks – Activities with uncertain durations

Why

One important use of the project networks model is in planning projects in which the time required for activities is not known – this occurs particularly with research and development projects. In this case, the network model provides a *probability distribution* for the completion time. The probabilities for (ranges of) completion times are important information for planning, and different alternatives can be compared in terms of the *expected value* of the results.

LEARNING OBJECTIVES

1. Work as a team, using the team roles
2. Understand the design of a project network and be able to construct a PERT chart network and a chart of Early and Late times..
3. Understand the use of the optimistic, most likely, and pessimistic times in estimating completion time for activities.
4. Understand the use of the mean and variance for durations of activities to estimate mean and variance for completion time of a project.
5. Be able to find and interpret probabilities for different (ranges of) completion times and cutoffs (times) for different levels of confidence.
6. Be able to use the expected value of cost or profit to compare difference plans for a project.

CITERIA

1. Success in working as a team and in fulfilling the team roles.
2. Understanding of the material by all team members
3. Success in completing the exercises.

RESOURCES

1. The handout on projects with uncertain durations (10/12)
2. Your text – sections 5.8 – 5.9
3. Microsoft Excel on the campus network
4. the PERT template (one page of the PERT-CPMtemplates.xls workbook)
5. 50 minutes

PLAN

1. Select roles, if you have not already done so, and decide how you will carry out steps 2 and 3
2. Work through the exercises given below you will submit one (team) copy of the work, with the usual reports [see the syllabus]
3. Assess the team's work and roles performances and prepare the Reflector's and Recorder's reports including team grade.
4. Be prepared to discuss your results

MODEL

(This assumes you have read, and have available, the notes in the handout)
The handout from Wednesday summarizes the calculations also described in the text section 5.8 (pp278 – 285). This is the development project for a new handheld scheduling/ communication device. With the three estimates of (the distribution of) times for each activity, we obtain a mean and standard deviation for the duration of our critical path. We find that the mean predicted time is 194 days, with a standard deviation (square root of the variance –"typical" deviation from the mean) 9.3 days, with our assumptions which lead to a "normal" distribution of times, we can say (for example) that the probability of completion in 180 days

is about .065, that if we want 99% certainty of completion we must allow 216 days, etc. (we can change the values - find probabilities for various times, set our "confidence" level differently, etc.)

This is useful already for making plans, but we can go further (see text section 5.9) and ask questions about the effect on completion time of changing the expected times for activities (by spending more resources). This comes up particularly if there is some greater profit (or reduced cost) to be gained by acceleration of the project – early completion bonuses, marketing advantages (as in the test example), late completion penalties, etc. Since the time for completing the project remains uncertain, we deal with the *expected value* to be obtained from the change, and compare that to the cost of the change:

The new information is that if the project can be completed in 180 days, Klone would gain a competitive advantage leading to an increase of $1 million in profit, and if the project can be completed in 180 to 200 days Klone's profit would be increased by $400,000.
With the present plan, there is a .065 probability of getting the $1 million increase. since the probability of finishing within 200 days is .742, there is a probability $.742 - .065 = .677$ of getting the $400,000 increase in profit (but not the $1 million). The "Expected value" of the extra profit is $.065 \times \$1\text{Million} + .677 \times \$400,000 = \$335,800$. [Out of many such projects, in such situations, the average extra profit from early completion would be this much]. Note that the expected value of the added profit is a sum—each term is a payoff value times the probability of obtaining that value.

Now, Klone has the option of spending $200,000 to accelerate sales training (Activity H)– the duration is still uncertain., but the estimates would change to optimistic – 19 days, most likely – 21 days., pessimistic – 23 days. Would this change the expected value of extra profit by enough to be worthwhile? (Notice that for *this project* it either helps or doesn't. We are looking at a *policy* type question - in the long run, should we do such things?). In this case, the decision is easy. Activity H is not critical, so speeding it up won't change the mean or standard deviation of completion time. Money spent here would produce no return and It shouldn't be done. [You can check, by changing the estimates for activity H on the spreadsheet, that the critical path, mean time, standard deviation of times are not changed by accelerating H in this way]
Klone also has the option of spending $250,000 on Staff training (F) which would change the times to: optimistic–12, most likely–14, pessimistic–16. Since F is critical, changing its time would change the expected duration – putting in the changed times (in the spreadsheet) gives mean completion time 189 days with standard deviation 9.02 days. For this revised plan, the probability of completion within 180 days is .159 and the probability of completion between 180 and 200 days is $.889 - .159 = .730$ so the expected extra profit is $.159 \times \$1\text{Million} + .730 \times \$400,000 = \$451,000$. Making the change will increase the expected extra profit by $201,000. The price on this increase of $201,000 is $250,000; once again, the change should not be made, based on these figures. [If there are other factors such as prestige, market position, this position might be overridden—but based on *this* consideration the change should not be made.]

EXERCISES

Carry out exercise #20 on p. 316 in the text, using the PERT template provided in the "PERT-CPMtemplates.xls" workbook. You will need to enter the activities and times, and will need to use the network to build the precedence relations into the ES and LF columns.
For part c, you need to find the change in expected value of cost (of lease) and compare that to the $3500 out-of-pocket cost.

READING ASSIGNMENT (in preparation for next class meeting)

Sections 5.10

SKILL EXERCISES:(hand in - individually - at next class meeting)

P.312 #28, 29. Ex 28 will involve setting up four networks models with the same network structure but different time estimates—use the "move or copy sheet" command to make a page for each without re-entering the precedence data, and then change the relevant times (label the sheets so you can remember which is which). Ex 29 involves finding the expected cost (rather than profit) for each choice—remember to include the money paid to the contractor in each case–but no new network setup (if you saved the sheets from Ex 28). The "99% sure" date can be found from the appropriate sheet.