**Large Scale Systems Design**

**G52LSS**

**Lecture 9 – Project Re-scheduling**

- Resource Smoothing
- Crashing Activities
- Project Management Software

**Learning outcomes**: apply resource smoothing to re-allocate resources in a project; explain and illustrate how staff utilisation can be improved in a project; apply activity crashing to reduce the overall duration of a project; use resource smoothing, resource levelling and activity crashing to aid project management; understand benefits and limitations of project management software; utilise MS Project to create a project schedule.

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**Resource Smoothing**

Resource smoothing is often used to re-allocate resources and re-schedule activities when resources (e.g. staff) are not available at the required level or when it is desirable to improve resource utilisation.

The **non-critical tasks are re-scheduled** within their time window avoiding as much overlap as possible making sure that task dependencies are maintained. Resource smoothing seeks to re-schedule non-critical activities but without extending the overall project duration.

The process of **resource smoothing is a limited form of resource levelling** which seeks to remove over-allocation of resources.

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**Example 9.1** Consider the following project and suppose that there are 6 people available for working in the project but one of them returns from holidays at time = 2.

**Example 9.1 (cont.)** Then, re-scheduling is needed because tasks A and B cannot be carried out simultaneously until time = 2. Task A is delayed and therefore task C must be delayed as well.
Example 9.1 (cont.) The staff profile changes as shown below but staff utilisation does not change from the value of 85.7%.

Example 9.2 Considering the modified project schedule, suppose that the equipment and materials needed to carry out task E and F are available from time=6 and time=9 respectively.

Example 9.2 (cont.) Then, re-scheduling is needed because tasks E and F cannot start at their ES times so both tasks are delayed but the overall project duration is not affected.

Example 9.2 (cont.) The staff profile changes as shown below and the staff utilisation changes from 85.7% to 74.5%.
Example 9.3 Consider the following project with a staff utilisation of 57.65% and suppose that the requisite is to improve staff utilisation. What are the options available to achieve this?

Example 9.3 (cont.) One option is to shift tasks A and D to reduce the maximum staff requirements at one time in the project from 14 to 11 so the staff utilisation improves to 73.37%. Can this value be further improved?

Crashing Activities

The obvious way to reduce the overall project duration is to reduce the duration of critical activities. The process of crashing critical activities refers to reducing the duration of one critical task at a time (by allocating more resources) until achieving the desired project duration.

The risk of crashing critical activities is that it might actually reduce productivity and surely increase costs.

Sometimes it might be possible to reduce the amount of resources allocated to non-critical activities without increasing the overall project duration.

Process of Crashing Critical Activities

- Determine the cost slope for each activity in the project by dividing the interval cost by the interval time.
- Analyse the options for reducing the overall project duration by the required \( t_{\text{min}} \) time.
- Select the best option according to cost (risks and other criteria might also be considered).
- For the selected option, crash critical activities in the project and re-calculate the critical path, task durations and task slack times for critical and non-critical tasks.
- Note that when crashing critical tasks, non-critical tasks might become critical as a result.
- If a non-critical task is in the same path as the critical task being crashed, then the slack time of the critical task will not normally be affected.
- If the non-critical task is in a different path than the critical task being crashed the slack time of the non-critical task may be reduced by \( t_{\text{min}} \).


**Example 9.4** For the following project, some options for crashing critical activities to reduce the project duration are illustrated.

<table>
<thead>
<tr>
<th>Task</th>
<th>Proc.</th>
<th>Slack</th>
<th>Original Schedule</th>
<th>Normal Duration</th>
<th>Cost</th>
<th>With Crashing</th>
<th>Minimum Duration</th>
<th>Cost</th>
<th>Cost Slacks</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>20</td>
<td>1</td>
<td>40</td>
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<td></td>
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</tr>
<tr>
<td>C</td>
<td>A 3</td>
<td>2</td>
<td>10</td>
<td>10</td>
<td>2</td>
<td>10</td>
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<tr>
<td>D</td>
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<td>10</td>
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<td>10</td>
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<td></td>
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<tr>
<td>E</td>
<td>D 0</td>
<td>3</td>
<td>10</td>
<td>10</td>
<td>1</td>
<td>30</td>
<td>10</td>
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</tbody>
</table>

The maximum reduction of the overall duration in this project is 4 days.

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**Example 9.4 (cont.)** Crashing for 1 day

Option 1: crashing task A
- Critical tasks D,E can start earlier reducing project duration
- Non-critical tasks B,C can start earlier and keep slack time (can also remain unchanged)
- Cost is 20

<table>
<thead>
<tr>
<th>Task</th>
<th>Proc.</th>
<th>TD</th>
<th>Cost</th>
<th>Min TD</th>
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<tr>
<td>A</td>
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<tr>
<td>E</td>
<td>4</td>
<td>0</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>

Option 2: crashing task D
- Critical task D can start earlier reducing project duration
- Non-critical tasks B,C remain unchanged but their slack is reduced
- Cost is 30

<table>
<thead>
<tr>
<th>Task</th>
<th>Proc.</th>
<th>TD</th>
<th>Cost</th>
<th>Min TD</th>
</tr>
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<tbody>
<tr>
<td>A</td>
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<td>0</td>
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<td>C</td>
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<tr>
<td>D</td>
<td>2</td>
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<tr>
<td>E</td>
<td>3</td>
<td>0</td>
<td>10</td>
<td>1</td>
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</tbody>
</table>

Option 3: crashing task E
- Critical task E can finish earlier reducing project duration
- Non-critical tasks B,C remain unchanged but their slack is reduced
- Cost is 10

<table>
<thead>
<tr>
<th>Task</th>
<th>Proc.</th>
<th>TD</th>
<th>Cost</th>
<th>Min TD</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
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<td>NA</td>
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<tr>
<td>D</td>
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<td>0</td>
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<td>1</td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td>0</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>
### Example 9.4 (cont.) Crashing for 1 more day after crashing task E

#### Task 1: Crashing task A
- Critical tasks D, E can start earlier reducing project duration
- Non-critical task B must start earlier
- Non-critical task C can start earlier or remain unchanged
- Cost is 20

#### Task 2: Crashing task D
- Critical task E can finish earlier reducing project duration
- Non-critical task B must also be crashed
- Non-critical task C remains unchanged but its slack reduced
- Cost is 30+10=40

#### Task 3: Crashing task E
- Critical task E can finish earlier reducing project duration
- Non-critical task B must also be crashed
- Non-critical task C remains unchanged but its slack reduced
- Cost is 40+10=50

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### Example 9.4 (cont.) Crashing for 1 more day after crashing task E and A

#### Task 1: Crashing task A
- Critical tasks D, E can start earlier reducing project duration
- Non-critical task B must start earlier
- Non-critical task C can start earlier or remain unchanged
- Cost is 20

#### Task 2: Crashing task D
- Critical task E can finish earlier reducing project duration
- Non-critical task B must also be crashed
- Non-critical task C remains unchanged but its slack reduced
- Cost is 30+10=40

#### Task 3: Crashing task E
- Critical task E can finish earlier reducing project duration
- Non-critical task B must also be crashed
- Non-critical task C remains unchanged but its slack reduced
- Cost is 40+10=50

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### Example 9.4 (cont.) Crashing for 1 more day after crashing task E, A, and B

#### Task 1: Crashing task A
- Critical tasks D, E can start earlier reducing project duration
- Non-critical task B must start earlier
- Non-critical task C can start earlier or remain unchanged
- Cost is 20

#### Task 2: Crashing task D
- Critical task E can finish earlier reducing project duration
- Non-critical task B must also be crashed
- Non-critical task C remains unchanged but its slack reduced
- Cost is 30+10=40

#### Task 3: Crashing task E
- Critical task E can finish earlier reducing project duration
- Non-critical task B must also be crashed
- Non-critical task C remains unchanged but its slack reduced
- Cost is 40+10=50

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### Example 9.4 (cont.) Crashing for 1 more day after crashing task E, A, and B

#### Task 1: Crashing task A
- Critical tasks D, E can start earlier reducing project duration
- Non-critical task B must start earlier
- Non-critical task C can start earlier or remain unchanged
- Cost is 20

#### Task 2: Crashing task D
- Critical task E can finish earlier reducing project duration
- Non-critical task B must also be crashed
- Non-critical task C remains unchanged but its slack reduced
- Cost is 30+10=40

#### Task 3: Crashing task E
- Critical task E can finish earlier reducing project duration
- Non-critical task B must also be crashed
- Non-critical task C remains unchanged but its slack reduced
- Cost is 40+10=50
Example 9.4 (cont.) Suppose that there is additional profit of 25 per day for finishing the project earlier.

Then, the project manager should consider costs, potential profits, potentials risks, resource constraints and schedule flexibility (tasks that become critical) when deciding for how much to reduce the overall project duration.

Ways to Reduce Overall Project Duration

- Crashing activities
  - Adding resources to selected critical tasks
- Network re-evaluation
  - Explore ways to increase parallelisation of tasks
- Fast tracking
  - Overlap two or more major phases of the project
- Re-scoping
  - Reduce or adjust the scope of the project
- Increased procurement
  - Outsource additional parts of the project
- Lean thinking
  - Redesign processes to save time and reduce time waste
- (Renegotiate target dates
  - Get more time without reducing overall project duration)
Project Management Software

There exist a number of project management software tools to help in the planning and control of large software development projects. Most tools include functions to plan, schedule and control, but most decision-making still has to be done by the project manager.

Project management software can be very useful when analysing the options for crashing critical activities because the new critical paths and slack times can be calculated very quickly for the changes proposed.

MS Project is an example of this type of software.

Exercise 9.1 Explore using MS Project to create a project schedule (Gantt chart and Network diagram) for the project in Example 8.2

About Project Management Software

Areas of Benefit include:
- Calculate project schedule
- Identify critical path
- Resource smoothing and levelling
- Cost tracking
- Comparison between planned and actual data
- Automatic generation of reports and charts
- History tracking
- Identify trouble spots
- Simulate hypothetical situations

Areas of Limitation include:
- Tasks definition and breakdown structure
- Analysis of tasks dependencies
- Allocation of resources to tasks
- Estimation of staff requirements
- Estimation of tasks durations
- Monitoring project progress
- Evaluate compromises
- Make decisions

Additional Reading

Chapter 5 of (Maylor, 2003)

Chapter 3 of (Kendall and Kendall, 2005)