Introduction of Project Scheduling

Part :1

Soe Naing Win

Email: snw1975@gmail.com

What are we going to study:

1
- Identification a real need & Selection of the best approach
- Structuring the project: WBS, OBS, LRC

2
- Determine the “cost” and “duration” of the tasks and the whole project

3
- Project Scheduling: Gantt chart, Network model
- Project budgeting and resource planning

Objectives

- Understand the importance of project scheduling.
- Understand and complete the project scheduling using Early and late start of **Gantt** chart.
- Apply network technique to complete project scheduling using forward and backward path of **AON** method.

Contents

- Introduction
- Precedence Relationship
- Gantt Chart
- Activity on Node (Critical Path Method)

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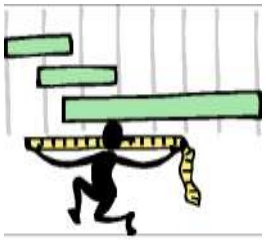
Introduction

- Scheduling can be developed after **WBS** is established and the time estimation for each activity is done.
- Scheduling is the most important step in planning because it is the basis for
  - ✓ allocating resources,
  - ✓ estimating revenue and spending
  - ✓ controlling the cash flow
  - ✓ monitoring project performance



Introduction

The scheduling process will integrate:

- ✓ The estimated duration of activities.
- ✓ The technological precedence relations among activities.
- ✓ Constraints imposed by the availability of resources and budget.
- ✓ Due-date requirements

Definition – Activity (task)

- **Activity** – any task, any job or any operation which **must be completed to finish the project.**
- It requires time (for people to work or to wait) and may require resources.
- Have to consider logical relationships between activities.

Definition – Calendar

- **Calendar/ Workpattern** » the days on which the works are scheduled.
- Like what days of the week will be working or How many days a week (e.g. 5 days per week, 8 hours per day).
- The work pattern allows the activity durations to be related to calendar dates.

Definition – Milestone

- **Milestones** are any significant events in a project.
  - **They should represent major segments of work** - should be a natural, important control point.
  - Milestone chart is the skeleton for the project schedule which senior managers should know.
  - Examples:
    - completion of critical or difficult tasks v' availability of crucial resources
    - Completion of major tests

How to start a schedule

- **How to start a schedule?**
  - **Top down -** define major task (milestones or phases) and then decompose each milestone/phase into more detailed activities.
  - **Bottom up** - list all the activities in a project in any order. Group the list into phases/milestones based on the required sequence, constraints, and assumptions.

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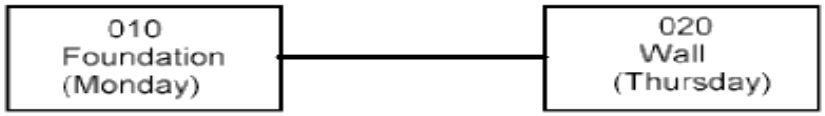
Precedence relations among the activities

- Precedence relations – technological constraints of the project that limit the availability of resources to perform activities.
- How to arrange “the order of activities”.
  - Finish-to-start relationship
  - Start-to-start relationship
  - Finish-to-finish relationship
  - Start-to-finish relationship.

Finish-to-Start relationship

- **Finish-to-start relationship:** typical, generic relationship mostly used in scheduling. Requires that an activity can start only after its predecessor has been completed.
  - Activity 020 can not start until activity 010 is finished.



  - Space shuttle can be launched after all payloads are in place.
  - Shipment can begin after the quality inspection is done.

Start-to-Start relationship

- **Start to start relationship** - exists when an activity can start only after a specified activity has already begun.
- Sequential activities can be worked in parallel and concurrently.
  - activity 060 can start after activity 050 has started.

  - In the construction of a house, the foundation work can be started even though the final design is not finished. Usually, only the initial design plan is required for the foundation work.

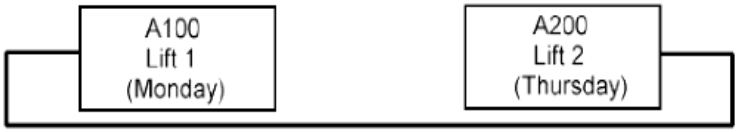
Finish-to-Finish relationship

- **Finish-to-finish relationship** – The finish of one activity depends on the finish of another activity.
  - Activity 2000 can finish, after activity 1000 is completed.

  - For example, if you have two tasks, "Add wiring" and "Inspect electrical," the "Inspect electrical" task cannot be completed until the "Add wiring" task is completed

Start-to-finish relationship

- **<u>Start-to-finish relationship</u>** – an activity cannot finish until another activity has begun (Overlap).
  - After activity A100 starts, A200 can finish



  - For example, the roof trusses for your construction project are built off-site. Two of the tasks in your project are "Truss delivery" and "Assemble roof." The "Assemble roof" task cannot be completed until the "Truss delivery" task begins.

  - A security guard's shift cannot end until the next guard has commenced his/her shift.

Schedule Presentation

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- Schedules can be presented in several different **ways to match the needs of the user.**
  - Chart
    - ✓ Milestone chart
    - ✓ Gantt chart
- **Networks either AOA (Activity on arrow) or** AON (activity-on-node) method.
  - ✓ Critical Path Method (CPM) .
  - ✓ Program Evaluation and Review Technique (PERT).

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Gantt Chart

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- The most widely used management tool for project scheduling and control.
- Particularly useful to manage "***critical***" and "***scarce***" resources.
- Possible to schedule activities by either early-start or late-start logic. Then a range of schedules can be generated using a combination of these two.
- Disadvantage: does not show inter-relationships among activities - network techniques are often used in parallel to compensate it.

Gantt Chart

Horizontal bars denote the length of **time** for each activity.

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	A	A												
B				BBB										
C			C	C	C	C	C	C						
D						D	D	D	D					
E									E	E	E			
F										F	F	F	F	F

Vertical Axis: Always **Activities** or Jobs

Horizontal Axis: Always Time

Gantt Chart – two approaches

- Early start or late start approach.
  - **The early start approach** - each activity is initiated as early as possible without violating the precedence relations.
  - **The late start approach** - each activity is delayed as much as possible as long as the finish time of the project is not compromised.

Gantt Chart : how to read table

Activity	Immediate Predecessors	Duration (weeks)
A	--	5
B	--	3
C	A	8
D	A,B	7
E	--	7
F	C, D, E	4
G	F	5

- Activities, A, B and E do not have any predecessors and thus can start at any time.
- Activity C can start only after A finishes, while D can start after the completion of A and B.
- F can start only after C, D and E are finished, and G must follow F.

Gantt Chart : procedures

1. Generate the *early start schedule* using activity list given and its precedence relationships - the duration of the whole project will be obtained,
2. Using the *duration* of the *whole project obtained*, the late start schedule can be generated by shifting each activity to the right as much as possible without violation of precedence relationships.
   - When the late start is completed, make sure that the starting date of the whole project is day (week) 1.
3. With applying a *combination* of early and late start approaches, a range of schedules can be generated on *Gantt chart* - Slack management!

1. Early Start

Activity	Immediate Predecessors	Duration (weeks)
A	--	5
B	--	3
C	A	8
D	A,B	7
E	--	7
F	C, D, E	4
G	F	5

- For early start:
  Count from the beginning!
- Activities, A, B and E do not have any predecessors and thus can start at Week 1.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	**A**	**A**	**A**	**A**	**A**																	
B	**B**	**B**	**B**																			
C																						
D																						
E	**E**	**E**	**E**	**E**	**E**	**E**	**E**															
F																						
G																						

2. Early Start

Activity	Immediate Predecessors	Duration (weeks)
A	--	5
B	--	3
C	A	8
D	A,B	7
E	--	7
F	C, D, E	4
G	F	5

- Activity C can start only after A finishes, While D can start after the completion of both A and B.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	A	A	A	A	A																	
B	B	B	B																			
C						C	C	C	C	C	C	C	C									
D						D	D	D	D	D	D											
E	E	E	E	E	E	E	E															
F																						
G																						

3. Early Start

Activity	Immediate Predecessors	Duration (weeks)
A	--	5
B	--	3
C	A	8
D	A,B	7
E	--	7
F	C, D, E	4
G	F	5

- F can start only after C, D and E are finished, and G must follow F - early start Gantt chart finished. Duration is 22 weeks.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	**A**	**A**	**A**	**A**	**A**																	
B	**B**	**B**	**B**																			
C						**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**									
D						**D**	**D**	**D**	**D**	**D**	**D**	**D**										
E	**E**	**E**	**E**	**E**	**E**	**E**	**E**															
F														**F**	**F**	**F**	**F**					
G																		**G**	**G**	**G**	**G**	**G**

1. Late Start

Activity	Immediate Predecessors	Duration (weeks)
A	--	5
B	--	3
C	A	8
D	A,B	7
E	--	7
F	C, D, E	4
G	F	5

- For Late start
  Count form the End!
- Compare activity list and predecessor column -find any missing activity
  - start of LS (in here G)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A																						
B																						
C																						
D																						
E																						
F																						
G																		G	G	G	G	G

2. Late Start

- Activity F is required by only G.

Activity	Immediate Predecessors	Duration (weeks)
A	--	5
B	--	3
C	A	8
D	A,B	7
E	--	7
F	C, D, E	4
G	F	5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A																						
B																						
C																						
D																						
E																						
F														F	F	F	F					
G																		G	G	G	G	G

3. Late Start

Activity C, D, & E are required by only F.

Activity	Immediate Predecessors	Duration (weeks)
A	--	5
B	--	3
C	A	8
D	A,B	7
E	--	7
F	C, D, E	4
G	F	5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A																						
B																						
C						**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**									
D							**D**	**D**	**D**	**D**	**D**	**D**	**D**									
E							**E**	**E**	**E**	**E**	**E**	**E**	**E**									
F														**F**	**F**	**F**	**F**					
G																		**G**	**G**	**G**	**G**	**G**

4. Late Start

Activity B is required by only D.

Activity	Immediate Predecessors	Duration (weeks)
A	--	5
B	--	3
C	A	8
D	A,B	7
E	--	7
F	C, D, E	4
G	F	5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A																						
B				**B**	**B**	**B**																
C						**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**									
D							**D**	**D**	**D**	**D**	**D**	**D**	**D**									
E							**E**	**E**	**E**	**E**	**E**	**E**	**E**									
F														**F**	**F**	**F**	**F**					
G																		**G**	**G**	**G**	**G**	**G**

5. Late Start

Activity A is required by both C & D.
You have to follow the earlier one!

Activity	Immediate Predecessors	Duration (weeks)
A	--	5
B	--	3
C	A	8
D	A,B	7
E	--	7
F	C, D, E	4
G	F	5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	**A**	**A**	**A**	**A**	**A**																	
B				**B**	**B**	**B**																
C						**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**									
D							**D**	**D**	**D**	**D**	**D**	**D**	**D**									
E							**E**	**E**	**E**	**E**	**E**	**E**	**E**									
F														**F**	**F**	**F**	**F**					
G																		**G**	**G**	**G**	**G**	**G**

6. Late Start

Remember!! The starting date of the starting date of the schedule should be “week 1”.

Activity	Immediate Predecessors	Duration (weeks)
A	--	5
B	--	3
C	A	8
D	A,B	7
E	--	7
F	C, D, E	4
G	F	5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	**A**	**A**	**A**	**A**	**A**																	
B				**B**	**B**	**B**																
C						**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**									
D							**D**	**D**	**D**	**D**	**D**	**D**	**D**									
E							**E**	**E**	**E**	**E**	**E**	**E**	**E**									
F														**F**	**F**	**F**	**F**					
G																		**G**	**G**	**G**	**G**	**G**

ES and LS- Differences

ES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	**A**	**A**	**A**	**A**	**A**																	
B	**B**	**B**	**B**																			
C						**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**									
D						**D**	**D**	**D**	**D**	**D**	**D**	**D**										
E	**E**	**E**	**E**	**E**	**E**	**E**	**E**															
F														**F**	**F**	**F**	**F**					
G																		**G**	**G**	**G**	**G**	**G**

LS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	**A**	**A**	**A**	**A**	**A**																	
B				**B**	**B**	**B**																
C						**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**									
D							**D**	**D**	**D**	**D**	**D**	**D**	**D**									
E							**E**	**E**	**E**	**E**	**E**	**E**	**E**									
F														**F**	**F**	**F**	**F**					
G																		**G**	**G**	**G**	**G**	**G**

Total Slacks: Differences between two Gantt charts

• Total Slack (float) of activity - the difference between the start (or the end) times of an activity on the two schedules.

ES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	**A**	**A**	**A**	**A**	**A**																	
B	**B**	**B**	**B**																			
C						**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**									
D						**D**	**D**	**D**	**D**	**D**	**D**	**D**										
E	**E**	**E**	**E**	**E**	**E**	**E**	**E**															
F														**F**	**F**	**F**	**F**					
G																		**G**	**G**	**G**	**G**	**G**

A(0), B(3), C(0), D(1), E(6), F(0), G(0)

LS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	**A**	**A**	**A**	**A**	**A**																	
B				**B**	**B**	**B**																
C						**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**									
D							**D**	**D**	**D**	**D**	**D**	**D**	**D**									
E							**E**	**E**	**E**	**E**	**E**	**E**	**E**									
F														**F**	**F**	**F**	**F**					
G																		**G**	**G**	**G**	**G**	**G**

Critical path

- Critical activities: *activities not having any total slacks*
- Critical Path: the sequence of critical activities connecting the start and the end points of the project. The duration of the whole project.

➡

- A delay in any activity along the critical path delays the entire project, *so special attention should be made for the delay of critical activities: Control actions*.

Critical path ?

ES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	**A**	**A**	**A**	**A**	**A**																	
B	**B**	**B**	**B**																			
C						**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**									
D						**D**	**D**	**D**	**D**	**D**	**D**	**D**										
E	**E**	**E**	**E**	**E**	**E**	**E**	**E**															
F														**F**	**F**	**F**	**F**					
G																		**G**	**G**	**G**	**G**	**G**

Critical Path: A>C>F>G

LS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A	**A**	**A**	**A**	**A**	**A**																	
B				**B**	**B**	**B**																
C						**C**	**C**	**C**	**C**	**C**	**C**	**C**	**C**									
D							**D**	**D**	**D**	**D**	**D**	**D**	**D**									
E							**E**	**E**	**E**	**E**	**E**	**E**	**E**									
F														**F**	**F**	**F**	**F**					
G																		**G**	**G**	**G**	**G**	**G**

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PERT/ CPM Method

- PERT (Program Evaluation and Review Technique)
  - Views the time to complete an activity as a random variable that can be characterised by an optimistic, a pessimistic, and a most likely estimate of its duration.
  - Statistical method is used to estimate time.
- CPM (Critical Path Method)
  - Assumes that activity times are deterministic.
  - Critical path is determined and used to analyse time of a project.
- Usually CPM is good enough for most projects.
- Network models are to be developed for it.

Project Network Model

- Project network model is a graphical flow chart of the project job plan.
- Shows the inter-relationships of all activities : communication channels defined.
- Identify the critical paths.
- Calculate the expected project completion dates.
- Usually used together with Gantt chart

Project Network Model

- **Activity-on-Arrow (AOA) Analysis**
  - The arrows represent the activities, while the nodes represent events.
  - Closely associated with PERT analysis, but it can also be used for CPM analysis.
  - Often requires the dummy event nodes that correct the network function > complication also introduced.
- **Activity-on-Node (AON) Analysis**
  - The nodes represent the activities and the arrows identify the precedence relationships between activities.
  - Closely associated with CPM analysis.
  - More popular than AOA.

- **TO BE CONTINUED!!**

Questions & Answers