Scheduling Projects

BY
Dr. Rohit Titiyal

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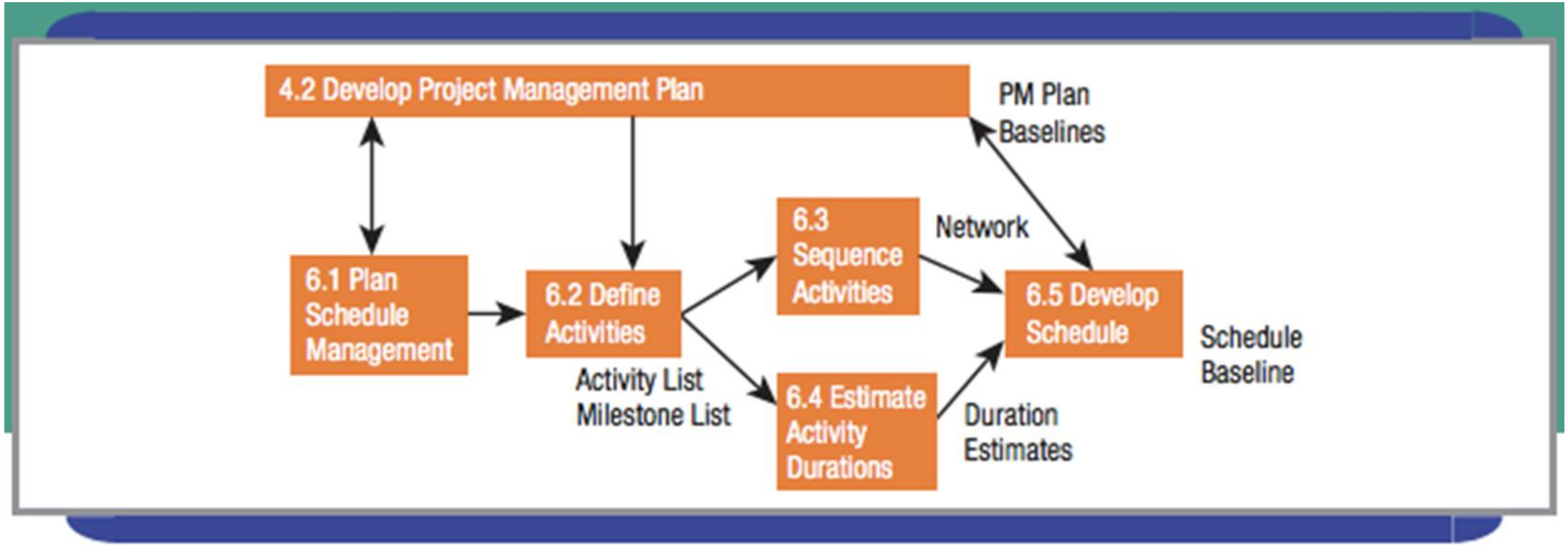
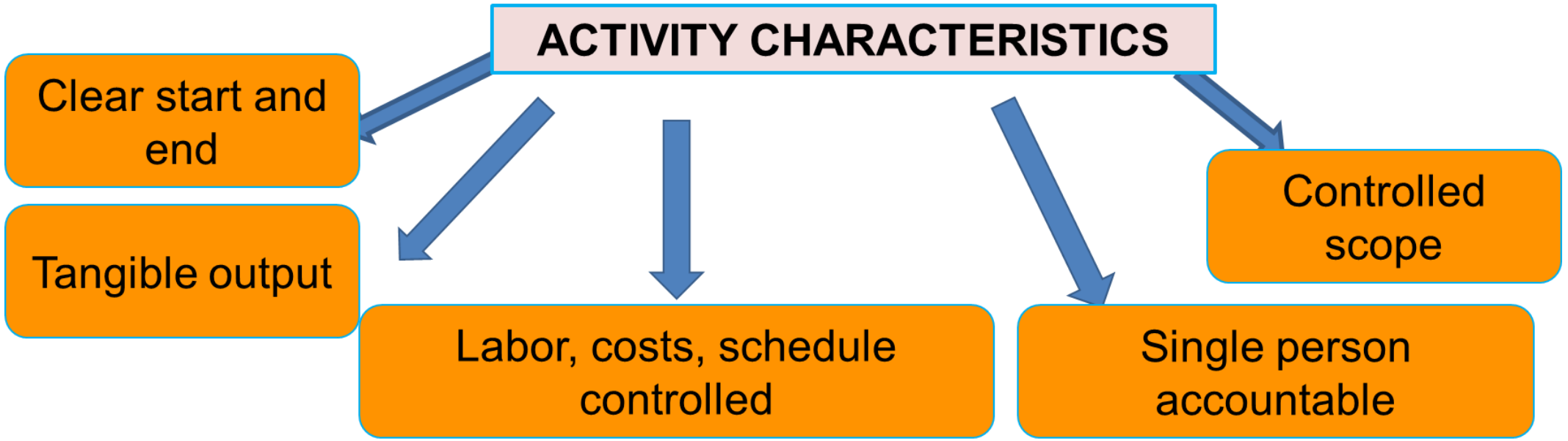


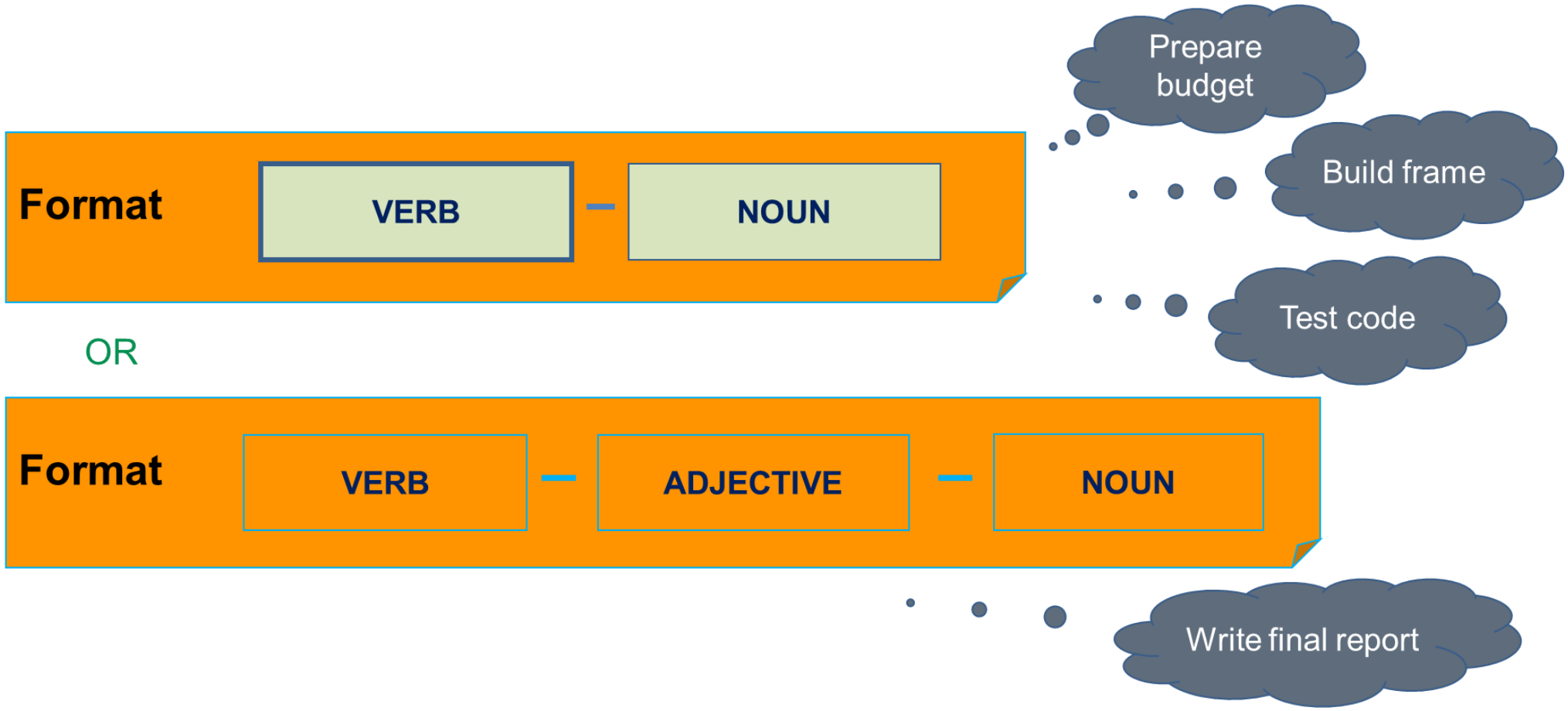
Plan Schedule Management

Building blocks of a project schedule are activities

Activity – “a component of project scope work performed during the course of a project.” – **PMI**



Plan Schedule Management



Project time management processes*

1. Plan schedule management
2. Define activities
3. Sequence activities
4. Estimate activity resources
5. Estimate activity durations
6. Develop schedule
7. Control schedule

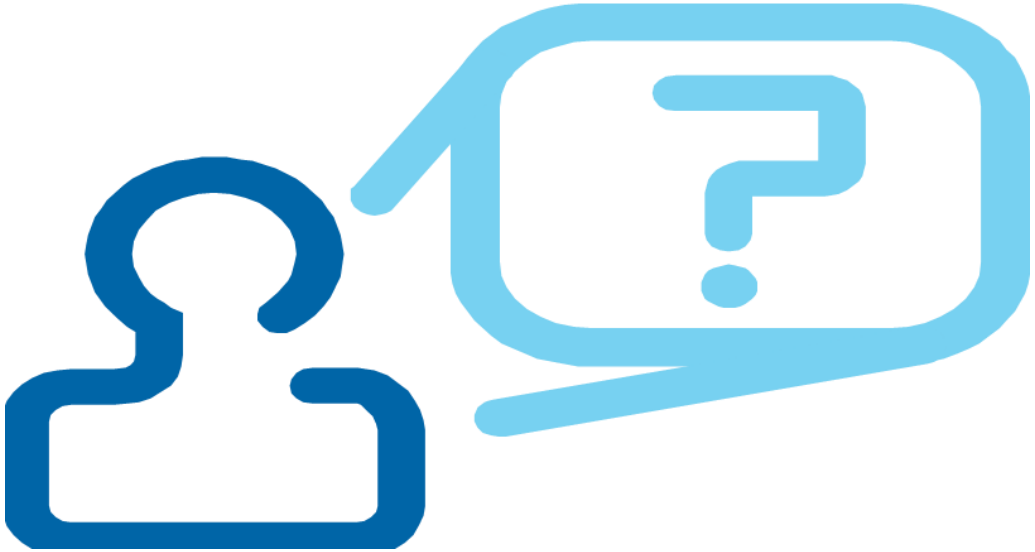
* Adapted from *PMBOK® Guide*

Purposes of a Project Schedule

What is the earliest a particular activity can start, and when will it end?

What would happen if a delivery of material was one week late?

What activity must begin before which other activities can take place?



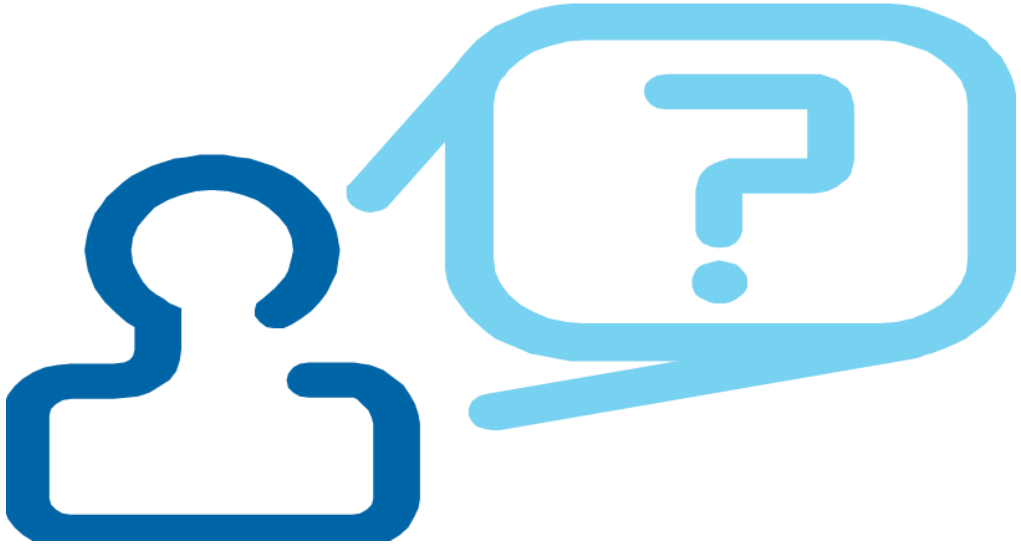
If one worker is assigned to do two activities, which one must go first?

When will the project be complete?

Purposes of a Project Schedule

Which worker or other resource is a bottleneck, limiting the speed of our project?

Can a key worker take a week vacation the first week of March?



What will the impact be if the client wants to add another module?

If I am willing to spend an extra $10,000, how much faster can the project be completed?

How many hours do we need from each worker next week or month?

Are all of the activities completed that should be by now?

Historical Development of Project Schedules

- Scheduling as a result of competition
- Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) – 1950s
  - Identify activities
  - Determine their logical order
  - Estimate the duration of each activity
- Network scheduling technique

PERT

- Estimate most likely time needed to complete a project
- Estimate level of confidence in completing a project in a particular time
- Useful in (R&D) projects

DEPARTMENT OF THE NAVY POLARIS WEAPONS SYSTEM

CPM

- Used to plan very large projects
- Single time estimates for each activity
- Focus on longest sequence of activities
- Used to determine how to complete a project early
- Useful in construction industry

DUPONT ENGINEERING SERVICES DIVISION

Terminology

Activity - A specific task or set of tasks that are required by the project, use up resources, and take time to complete

Event - The result of completing one or more activities

Network - The combination of all activities and events that define a project

- Drawn left-to-right
- Connections represent predecessors

Terminology

Path - A series of connected activities

Critical - An activity, event, or path which, if delayed, will delay the completion of the project

Critical Path - The path through the project where, if any activity is delayed, the project is delayed

- There is always a critical path
- There can be more than one critical path

Terminology

Sequential Activities - One activity must be completed before the next one can begin

Parallel Activities - The activities can take place at the same time

Immediate Predecessor - That activity that must be completed just before a particular activity can begin

Sequential Activities

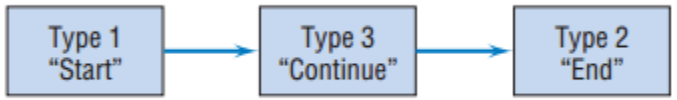


Figure 8-1 Three sequential activities, AON format.

AON and AOA Format

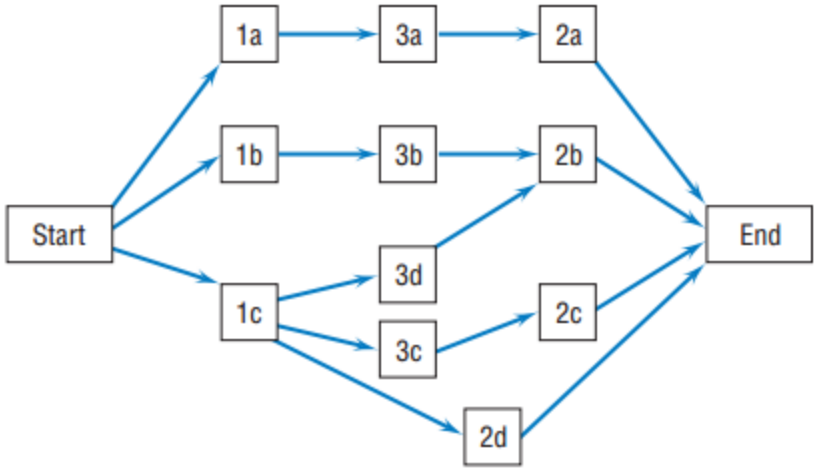


Figure 8-2 Activity network, AON format.

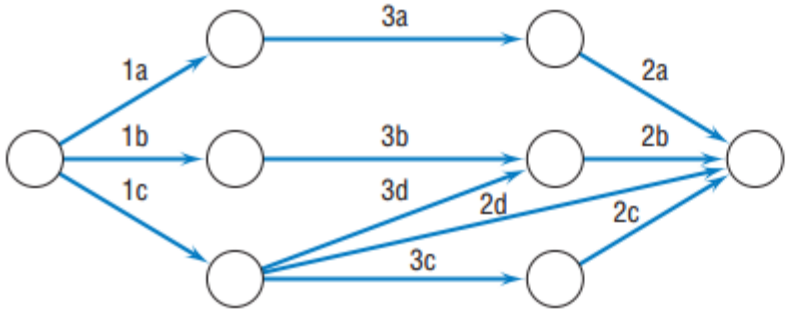


Figure 8-3 Activity network, AOA format.

Constructing the Network

Begin with START activity

Add activities without precedences as nodes

- There will always be one
- May be more

Add activities that have those activities as precedences

Continue

WBS

Task	Precedence	Time	Cost	Who does
a	-	5 Days	-	-
b	-	4 Days	-	-
c	a	6 Days	-	-
d	b	2 Days	-	-
E	b	5 Days	-	-
f	c,d	8 Days	-	-

Sample of Network Construction

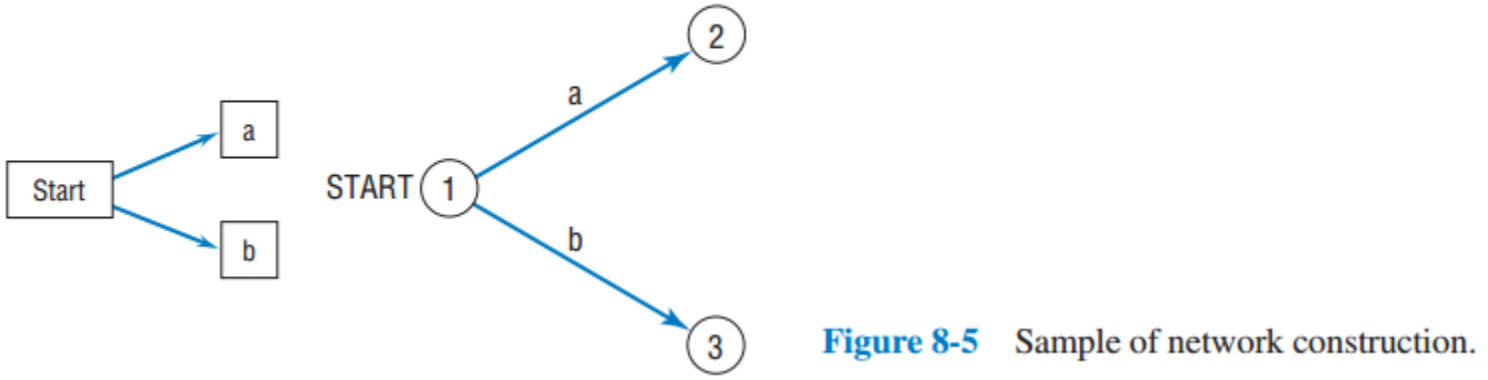


Figure 8-5 Sample of network construction.

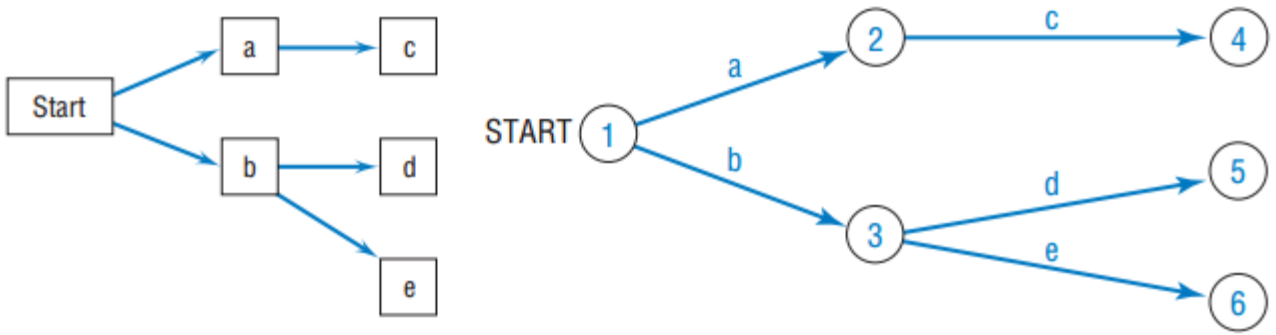
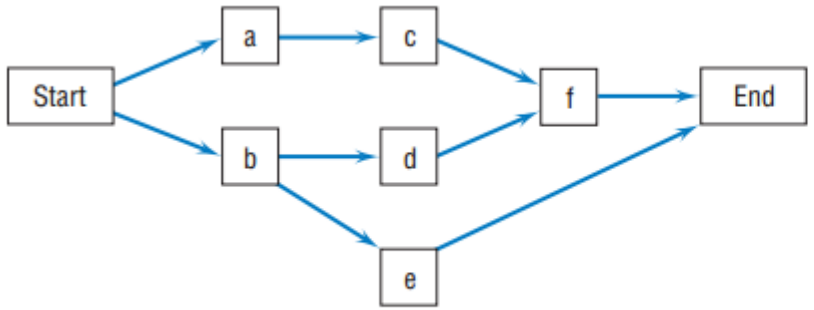


Figure 8-6 Sample of network construction.

Sample of Network Construction



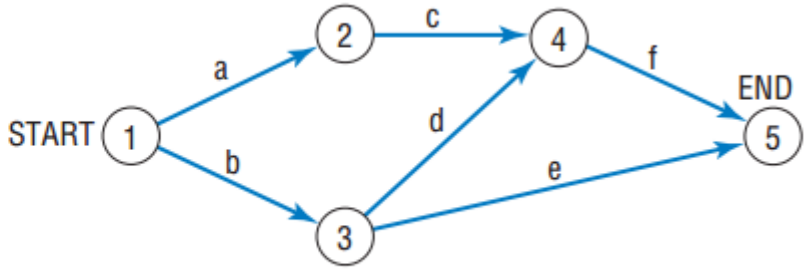
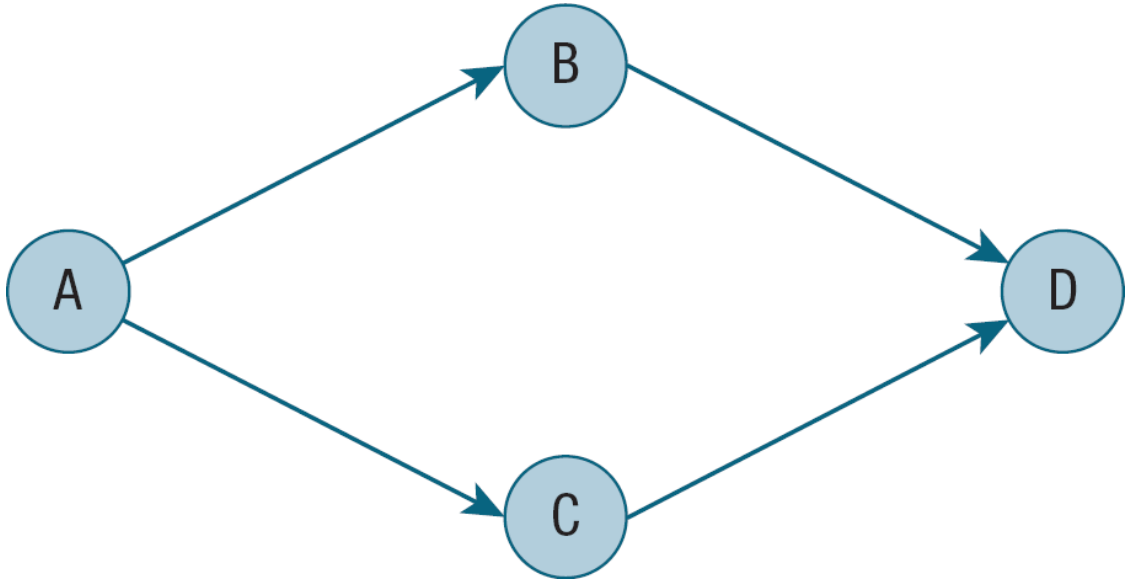


Figure 8-7 Sample of network construction.

Activity on Node (AON) or Precedence Diagramming Method (PDM)

Most widely used

AON FORMAT SCHEDULE EXAMPLE



node = activity

arrow = sequence

Precedence Diagramming Method (PDM) – scheduled activities are represented by “nodes,” and arrows are used to show the logical sequence

5 Factors Limit Project Completion

1. Logical order in which activities need to be completed
2. How long each activity will take
3. How many key resources are available at specific points in the project
4. Imposed dates
5. Cash flow

Creation of Project Schedules

- Identify all activities
- Determine logical order
- Estimate time required for that activity
- Assign resources to each activity
- Compare schedule with imposed dates
- Consider project budget and cash flow, quality demands, and risk factors

The Project Manager's Responsibility

- Resist pressure to dictate a schedule
- Determine a schedule that is possible
- Persuade stakeholders that the schedule makes sense
- Deliver project according to the agreed-upon schedule

- Within each iteration, team considers level of uncertainty & complexity with desired outcomes
- Number of team members as resources is often primary limitation

Define Activities (1 of 2)

Use WBS with deliverables only

WORK BREAKDOWN STRUCTURE WITH DELIVERABLES ONLY

COLLEGE FUNDRAISER PROJECT

1. Project Management
2. Location
3. Information
4. Entertainment
5. Safety
6. Parking
7. Food
8. Sanitation
9. Volunteers

"What work activities must be completed to create each of the project deliverables?"

Define Activities

- Don’t omit activities
- Activity sequencing may uncover missing activities
- Schedule will not be approved until all related planning is in place
- Avoid adding activities after final schedule is approved
- Use previous projects, templates, or checklists as a starting point

List Project Milestones

- Completion of a major deliverable or critical activity
- Prior to a large financial commitment
- Merging point in project schedule

WBS with Milestone List

Milestone

WORK BREAKDOWN STRUCTURE WITH MILESTONE LIST

COLLEGE FUNDRAISER PROJECT

1. **Project Management**
2. **Location**
   - 2.4 LOCATION CONFIRMED
3. **Information**
   - 3.1 PROVIDE TEAM INFORMATION
   - 3.2 PRODUCE PRE-EVENT ADVERTISEMENTS
   - 3.3 DISPLAY WELCOME SIGNS AT ALL ENTRANCES
   - 3.4 SET UP SIGN-IN TABLE
   - 3.5 DISPLAY SIGNS WITH RULES
   - 3.6 INFORMATION NEEDS FINALIZED
4. **Entertainment**
   - 4.4 BAND CONTRACT SIGNED
   - 4.5 ENTERTAINMENT ARRANGED
5. **Safety**
   - 5.6 SAFETY REQUIREMENTS COMPLETED
6. **Parking**
   - 6.4 ALL PARKING NEEDS ARRANGED
7. **Food**
   - 7.4 FOOD AND BEVERAGES READIED
8. **Sanitation**
   - 8.5 ALL SANITATION NEEDS IN PLACE
9. **Volunteers**
   - 9.4 VOLUNTEERS PREPARED

Sequence Activities

What activity or activities can be started right away and do not depend on any others?

Successor activity – an activity that logically follows another activity or activities

Predecessor activity – activity that logically precedes another activity or activities

What activity or activities can we start next?

Sequence Activities

- Place a successor activity after its predecessor
- Draw arrow to show the relationship
- Continue until all activities have been placed on the work surface
- Dependencies can be mandatory or discretionary

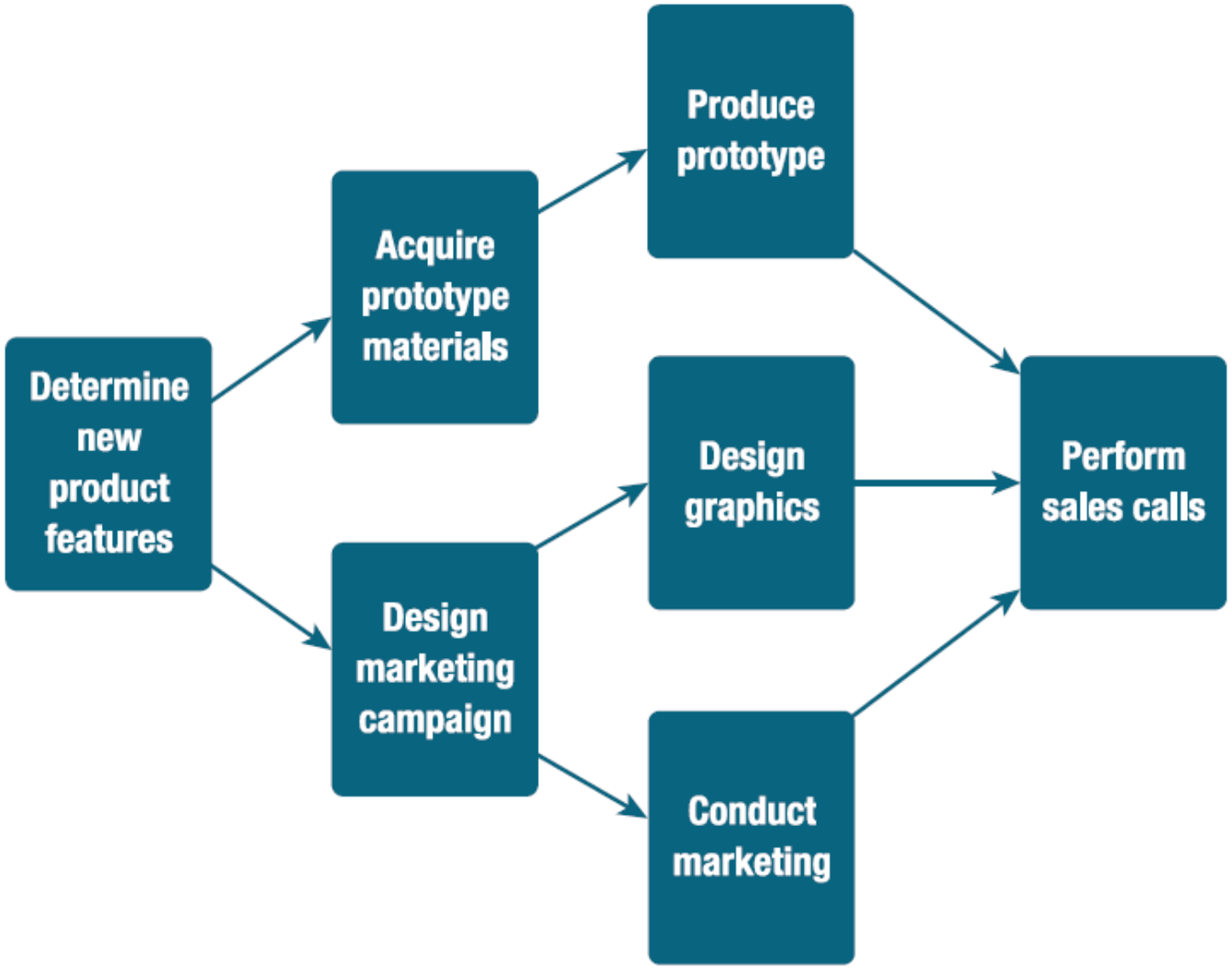
Mandatory dependency – logical relationship that *must* be followed (generally due to physical or contractual demands)

Discretionary dependency – a preferred logical relationship, based on best practices and judgment

Example: Activity List for Product Upgrade Project

- Determine product features
- Acquire prototype materials
- Produce prototype
- Design marketing campaign
- Design graphics
- Conduct marketing
- Perform sales calls

Example: Network for Product Upgrade Project



Leads and Lags

Lead – “a modification of a logical relationship that allows an acceleration of the successor activity.” **Practice Standard for Scheduling (PMI)**

Lag – “a modification of a logical relationship that directs a delay in the successor activity.” **Practice Standard for Scheduling (PMI)**

Leads are helpful if a project needs to be completed quickly

Finish-to-start – “a logical relationship where initiation of work of the successor activity depends upon the completion of work of the predecessor activity.” **Practice Standard for Scheduling (PMI)**

Finish-to-start (FS) dependency -most common type

Estimate Activity Duration

- Evaluate each activity independently
- Document all assumptions & constraints
- Changing assumptions & constraints could change estimates

Duration – “the total number of work periods (not including holidays or other non-work periods) required to complete a schedule activity… usually expressed as workdays or workweeks.”

-Practice Standard for Scheduling (PMI)

Activity Duration Estimate Example

TIME ESTIMATE IN WORKDAYS	ACTIVITY NAME
5	Determine new product features
20	Acquire prototype materials
10	Produce prototype
10	Design marketing campaign
10	Design graphics
30	Conduct marketing
25	Perform sales calls

Suggestions for Creating Realistic Time Estimates

1. Verify time estimations with the people doing the work
2. Estimate times without initial reference to a calendar
3. Make sure all time units are identical: working days, work week, months (consider time off for company holidays)
4. Consider time constraints (see following slide!)
5. Acknowledge tendency toward optimistic or pessimistic estimations
6. Be realistic
7. Adjust estimates based on size, familiarity, & complexity differences

Suggestions for Creating Realistic Time Estimates

Possibly time constraints…

Learning curves

Unexpected meetings

Inaccuracy in work instructions

Vacation

Emergencies/illness

Resources or information not available on time

Interruptions

Re-work

Develop Project Schedules

Identify the ***critical path***

- Determines project's earliest possible end date
- Most critical in terms of time
- Methods for determining critical path:

Two-pass method

Enumeration method

Critical path – "the sequence of schedule activities determining the duration of the project. Generally it is the longest path through the project." **-Practice Standard for Scheduling (PMI)**

Two-Pass Method

- Used to determine amount of slack each activity has
- Make two logical passes through the constructed network
  - The **forward pass**
  - The **backward pass**

Times Important to Each Activity

Early start date (ES) – “the earliest possible point in time on which uncompleted portions of a schedule activity can start, based upon the schedule network logic, the data date, and any schedule constraints.”

-**Practice Standard for Scheduling (PMI)**

Early finish date (EF) – “the earliest possible point in time on which uncompleted portions of a schedule activity can finish, based upon the schedule network logic, the data date, and any schedule constraints.”

-**Practice Standard for Scheduling (PMI)**

Times Important to Each Activity

Late start date (LS) – “the latest possible point in time that a schedule activity can start, based upon the schedule network logic, the project completion date, and any schedule constraints.”

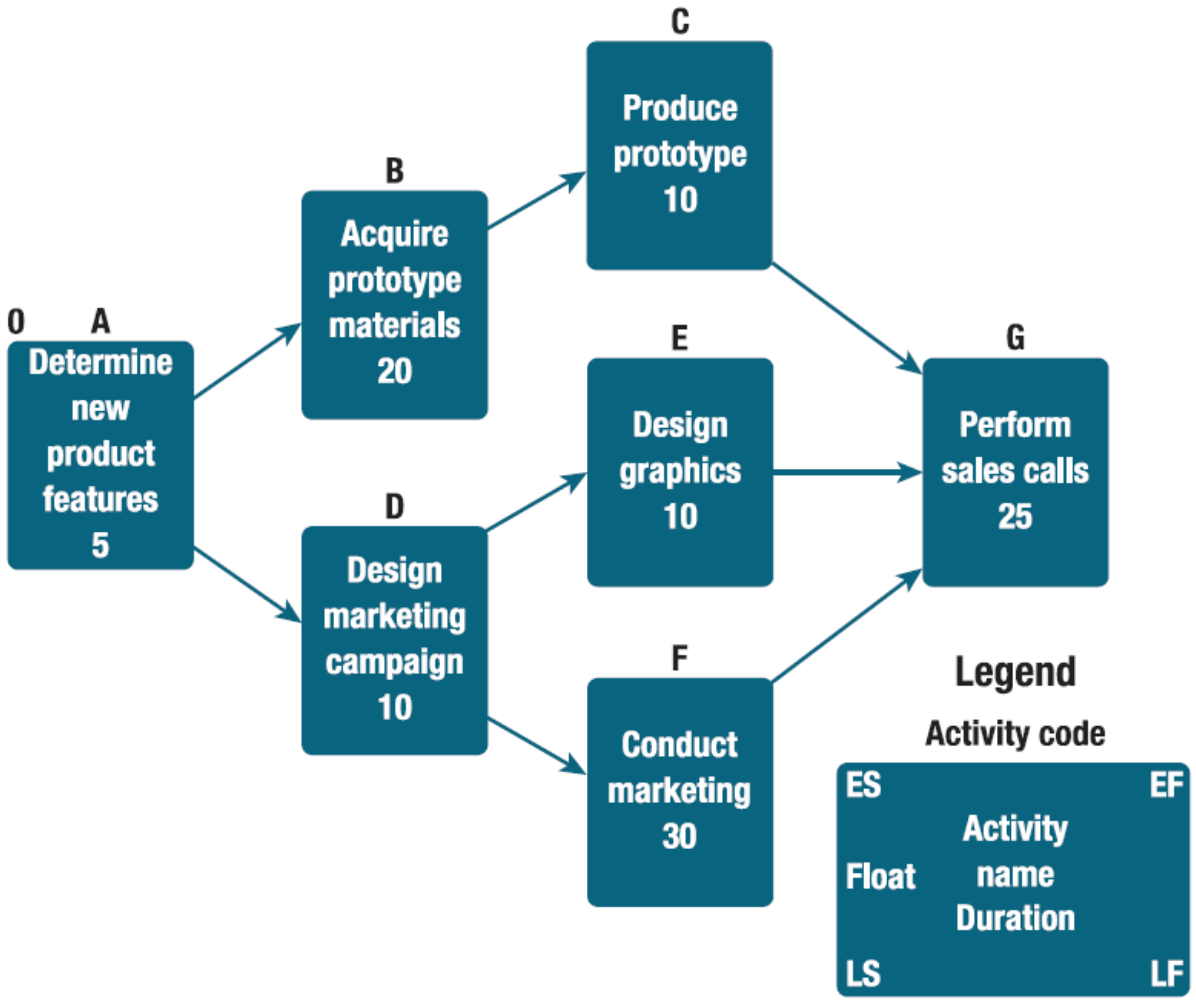
-Practice Standard for Scheduling (PMI)

Late finish date (LF) – “the latest possible point in time when a schedule activity can finish based upon the network logic, the project completion dates, and any schedule constraints.”

-Practice Standard for Scheduling (PMI)

Two-Pass Example Schedule Set Up

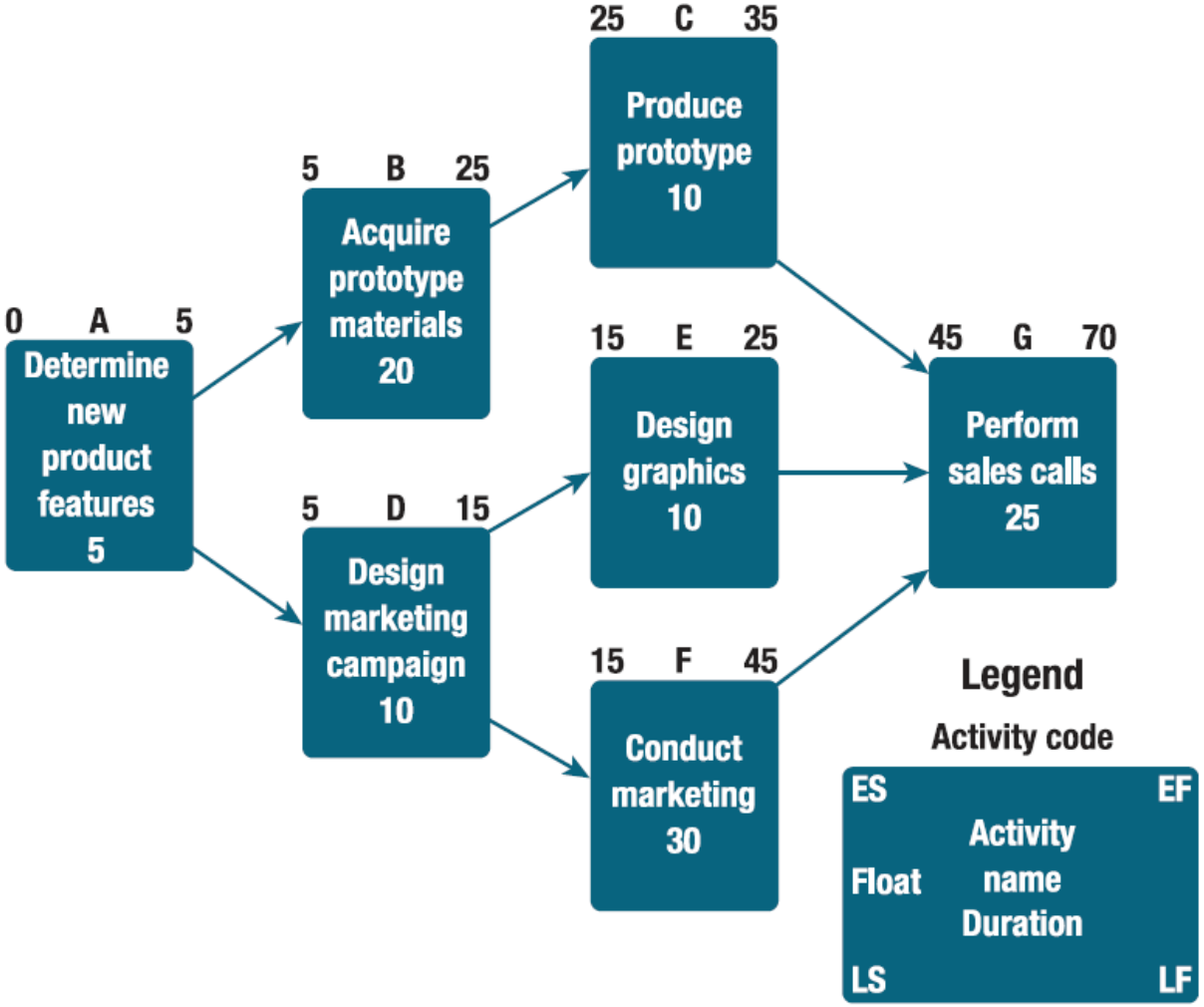
Start at the beginning of the project and ask how soon each activity can begin and end



Schedule Example First Pass Complete

Forward pass—calculate Early Finish for each activity

EF = ES + Duration



Second or Backward Pass

How late can each activity be finished and started?

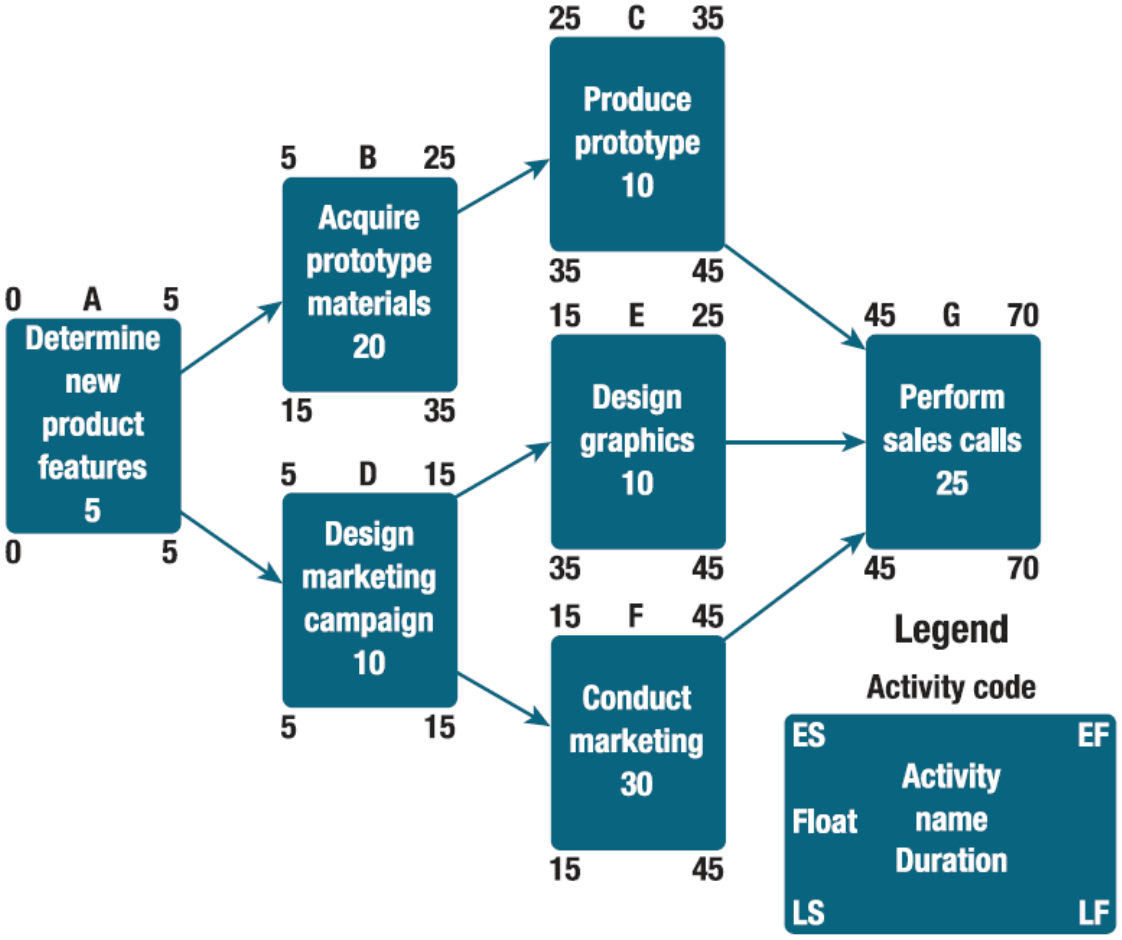
Backward pass – “the calculation of late finish date and late start dates for the uncompleted portions of all schedule activities. Determined by working backward through the schedule network logic from the project’s end date. **Practice Standard for Scheduling (PMI)**

Schedule Example Second Pass Complete

Backward Pass—calculate Late finish & late start dates

Late finish date for last activity is same as early finish date

LF − duration = LS



Float and the Critical Path

Total float – “the amount of time a schedule activity may be delayed from its early start date without delaying the project end date.” **-Practice Standard for Scheduling (PMI)**

Free float – “the amount of time a schedule activity can be delayed without delaying the early start of immediately following schedule activities.” **-Practice Standard for Scheduling (PMI)**

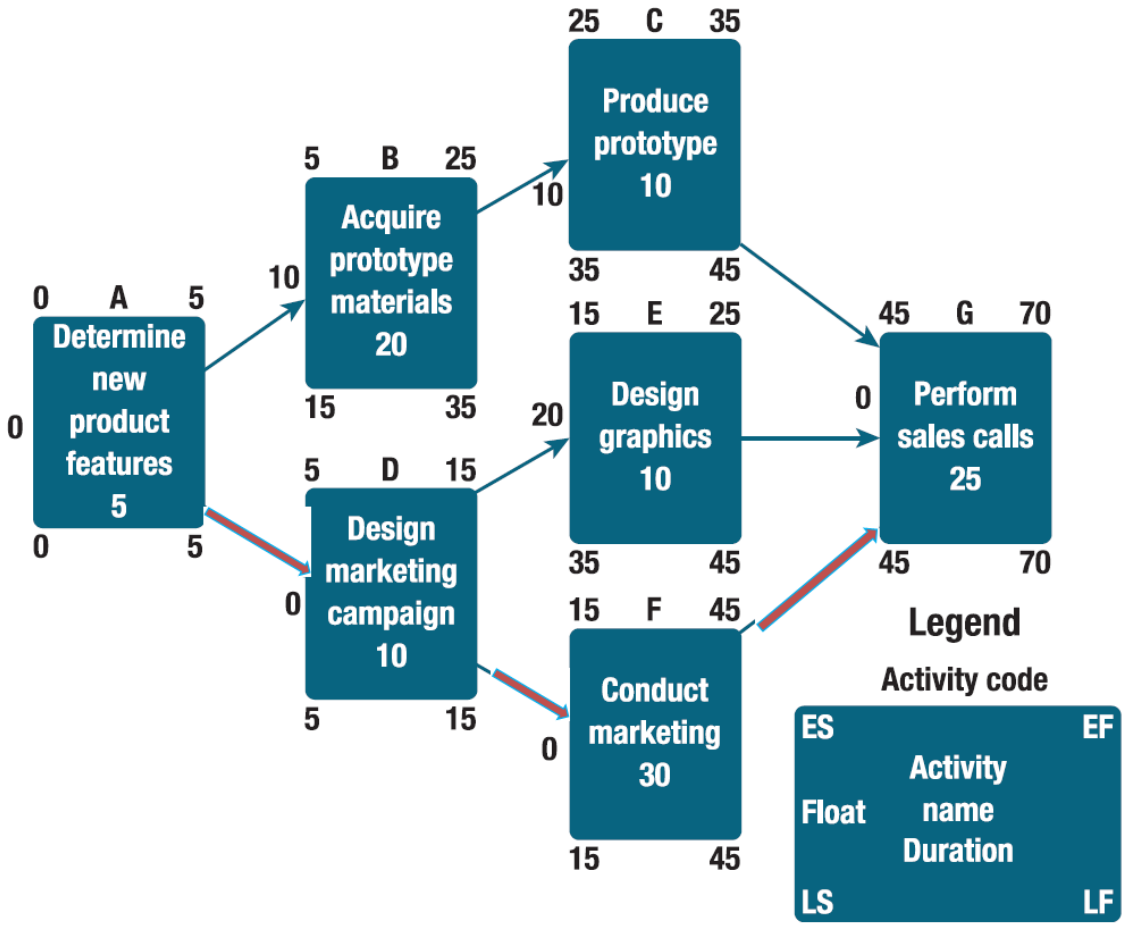
- Compute the critical path based on **float (slack)**
- Activities with no/very little float need to be scheduled very carefully

Float and the Critical Path

- Float = Late Start − Early Start (Float = LS − ES)
- Critical path is the sequence of activities that has no float

A – D – F – G

TWO-PASS COMPLETE SCHEDULE EXAMPLE

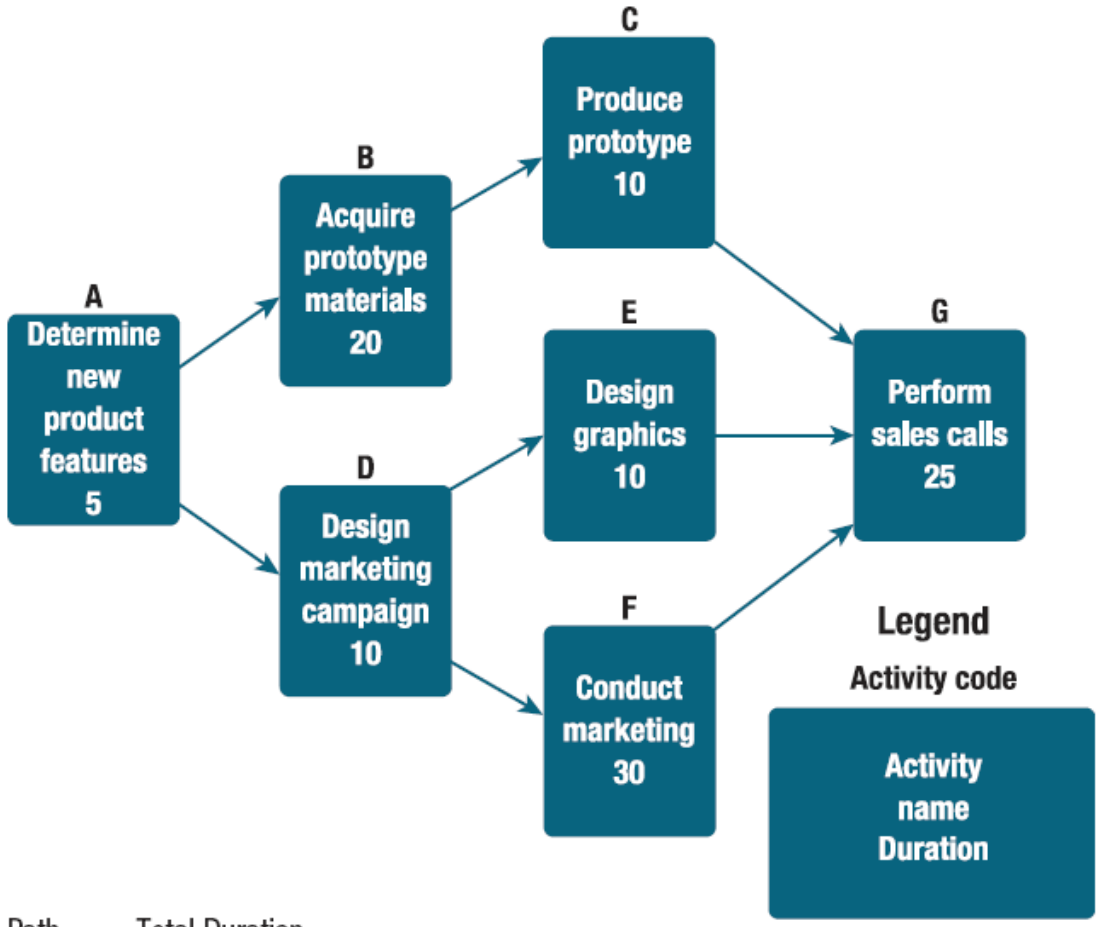


Enumeration Method

- List all paths through the network
- All paths are identified & timed if the team needs to compress the schedule

Enumeration Method

EXHIBIT 8.15: ENUMERATION METHOD EXAMPLE SCHEDULE



Path	Total Duration
ABCG	60
ADEG	50
ADFG	**70**

Uncertainty in Project Schedules

- Construct the best possible schedule
- Manage the project very closely

OR

- Estimate a range of possible times each individual activity may take
- Examine the impact of each activity on the entire schedule

Program Evaluation and Review Technique

- How does variability in duration of individual activities impact the entire project schedule?
- Sequence activities into a network
- Create 3 estimates of time to complete each activity

$$\text{Estimated time} = \frac{\text{Optimistic} + 4(\text{Most likely}) + \text{Pessimistic}}{6}$$

Program Evaluation and Review Technique

PERT TIME ESTIMATE EXAMPLE

ACTIVITY	OPTIMISTIC	MOST LIKELY	PESSIMISTIC	EXPECTED
Determine new product features	4	5	12	6
Acquire prototype materials	16	20	30	21
Produce prototype	8	10	12	10
Design marketing campaign	9	10	14	10.5
Design graphics	6	10	20	11
Conduct marketing	28	30	50	33
Perform sales calls	20	25	30	25

PERT Considerations

- Advantages
  - Reinforces uncertainty that exists in project schedules
  - Calculations often indicate expected time is actually *longer* than “most likely” time
- Difficulties
  - Takes more effort to create 3 estimates
  - No guarantee how good the estimates are
  - May underestimate the risk of a schedule running long

Project Managers and PERT

- Infrequently used by project managers
- PMs may informally use 3 time estimates for key activities
- PMs may use Monte Carlo simulation instead

Monte Carlo Simulation

- An entire range of possible time estimates can be used for any activity
- Project schedule is calculated many times (1,000+)
- Estimates for a particular activity based on likelihood of various times as determined by PM

Monte Carlo Analysis – “a computerized mathematical technique that allows people to account for risk in quantitative analysis and decision making that furnishes the decision maker with a range of possible outcomes and the probabilities with which they will occur.”

-**Practice Standard for Scheduling (PMI)**

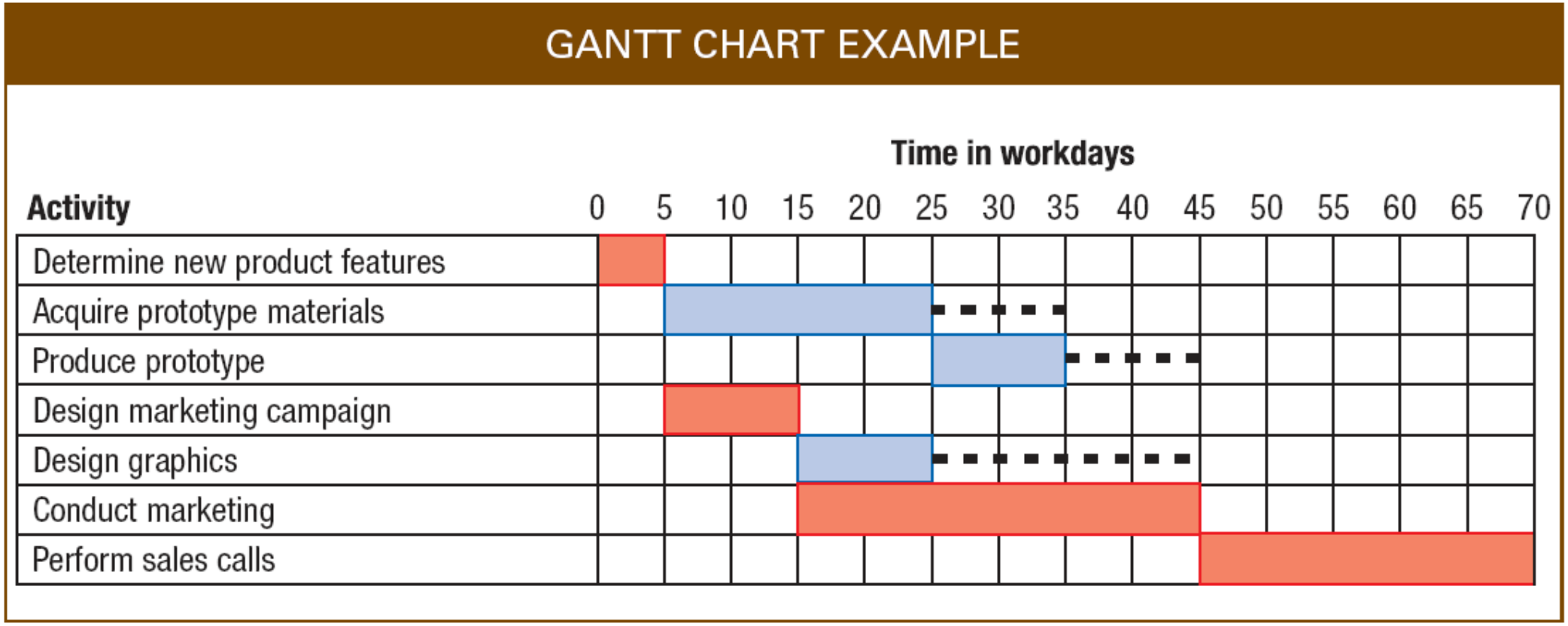
Monte Carlo Simulation

- Computer output: how often project would be expected to take each possible length of time
- Advantages
  - Flexibility allows more realistic estimates
  - Extent of information provided
- Disadvantages
  - Time requirement
  - Software and skill required
- PMs decide when this specialized technique is worth the extra effort to the project

Show the Project Schedule on a Gantt Chart

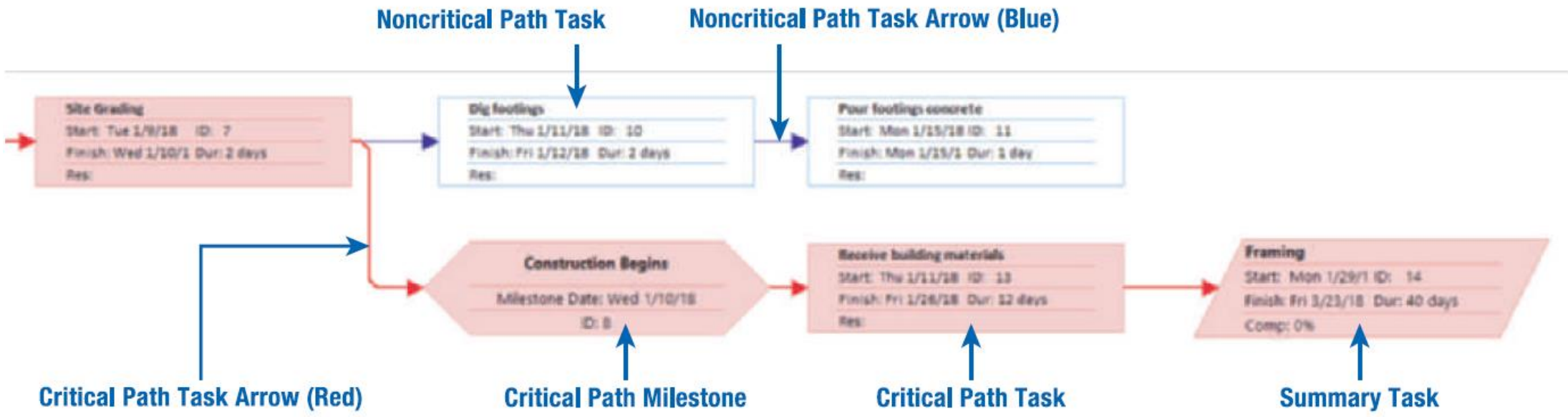
- Easy-to-understand tool
- Horizontal bar chart
- A bar for each activity stretched over a time line
- Units of time are units used to create schedule
- Chart does not show critical path, predecessor-successor relationship, or late start & finish dates
- Use scheduling software

Show the Project Schedule on a Gantt Chart



Understand the network diagram view

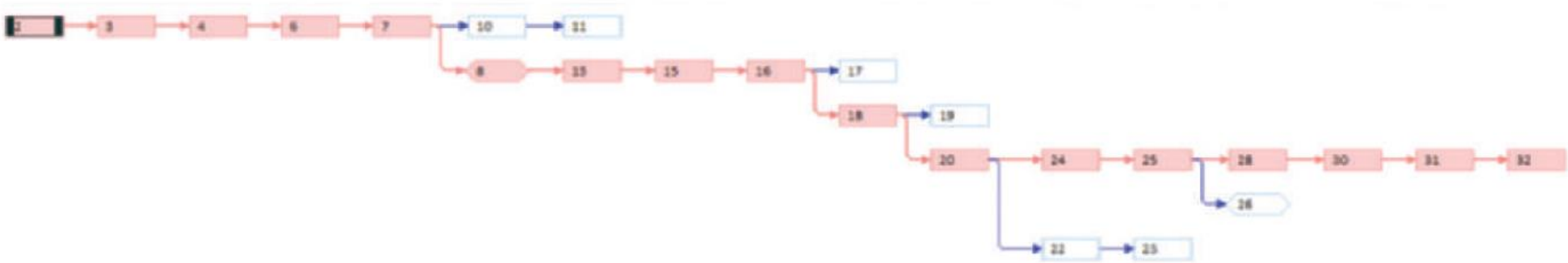
BANK PROJECT WITH STARTUP AND INITIATION DETAILS



Source: Microsoft product screen shots reprinted with permission from Microsoft Corporation.

6. Understand the network diagram view (2 of 2)

EXHIBIT 8.25: BANK PROJECT WITH EXECUTING AND CLOSING ACTIVITIES



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Task tab – Task Views group – Network Diagram

Detailed instructions p.275 in textbook

Display and Print Schedules with MS Project

- Project scheduling software may not be available to all members of the project team, so emailing won't work
- Create an output that can be printed and easily read (pdf file format)
- *File – Print – appropriate settings (see p.275) – Print*

1. *Set up the project schedule*
2. *Build the Logical Network Diagram & Identify critical path*
3. ***Display and print schedules***

Summary

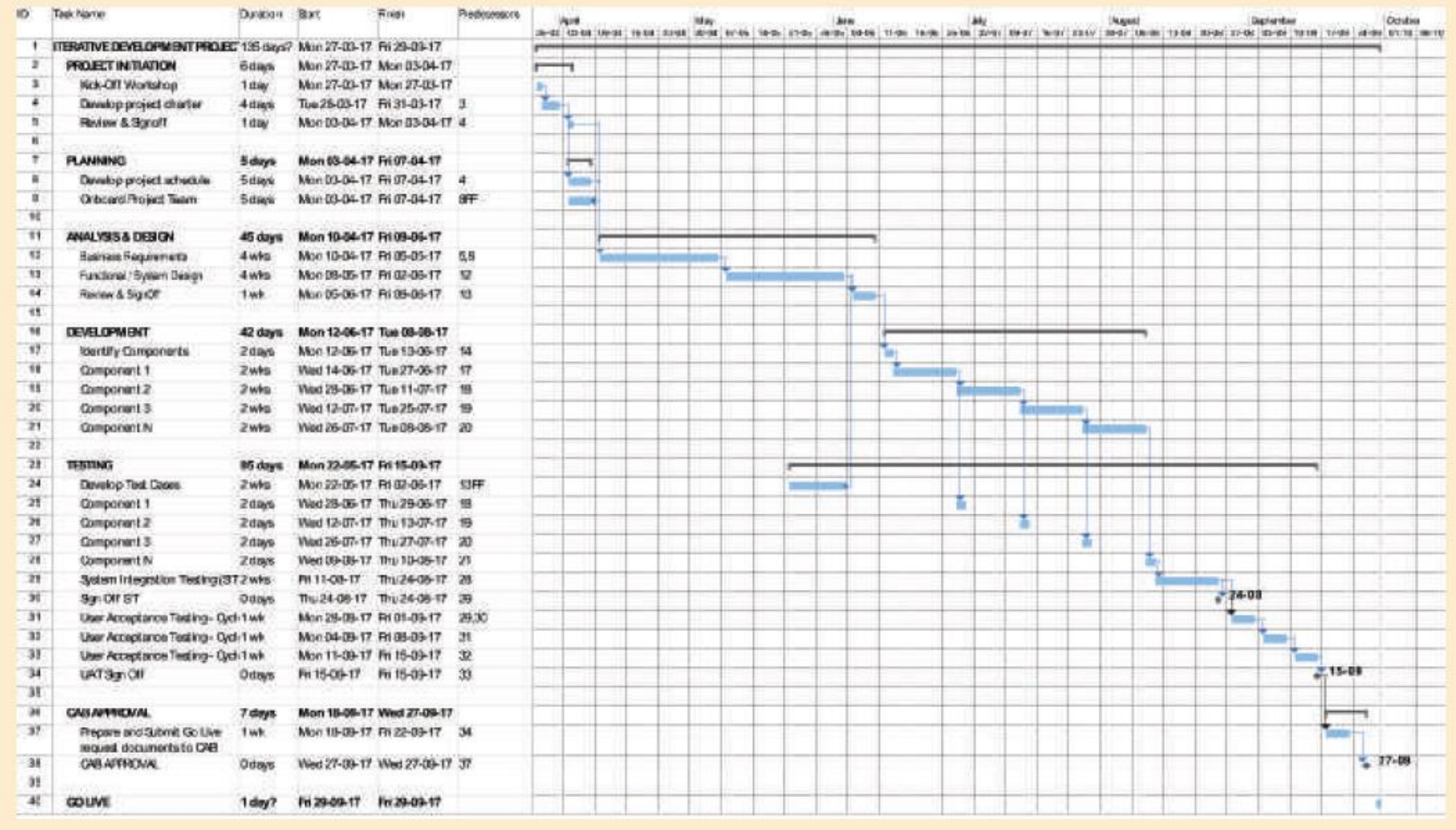
- Project schedules are created by listing all activities that will need to be performed (**define activities**)

How? By whom? How long? How much?

- Determine predecessors and successors to sequence activities (**sequence activities**)
- Estimate how long each activity will take (**estimate activity durations**)
- **Develop schedule** is an iterative process

Incremental/Iterative Software Development Project Sample Project Schedule (1 of 2)

PM *IN ACTION*



ID	Task Name	Duration	Start	Finish	Predecessors
1	**ITERATIVE DEVELOPMENT PROJECT**	135 days?	Mon 27-03-17	Fri 29-09-17	
2	**PROJECT INITIATION**	6 days	Mon 27-03-17	Mon 03-04-17	
3	Kick-Off Workshop	1 day	Mon 27-03-17	Mon 27-03-17	
4	Develop project charter	4 days	Tue 28-03-17	Fri 31-03-17	3
5	Review & Signoff	1 day	Mon 03-04-17	Mon 03-04-17	4
6					
7	**PLANNING**	**5 days**	**Mon 03-04-17**	**Fri 07-04-17**	
8	Develop project schedule	5 days	Mon 03-04-17	Fri 07-04-17	4
9	Onboard Project Team	5 days	Mon 03-04-17	Fri 07-04-17	8FF
10					
11	**ANALYSIS & DESIGN**	**45 days**	**Mon 10-04-17**	**Fri 09-06-17**	
12	Business Requirements	4 wks	Mon 10-04-17	Fri 05-05-17	5,8
13	Functional / System Design	4 wks	Mon 08-05-17	Fri 02-06-17	12
14	Review & Sign Off	1 wk	Mon 05-06-17	Fri 09-06-17	13
15					
16	**DEVELOPMENT**	**42 days**	**Mon 12-06-17**	**Tue 08-08-17**	
17	Identify Components	2 days	Mon 12-06-17	Tue 13-06-17	14
18	Component 1	2 wks	Wed 14-06-17	Tue 27-06-17	17
19	Component 2	2 wks	Wed 28-06-17	Tue 11-07-17	18
20	Component 3	2 wks	Wed 12-07-17	Tue 25-07-17	19
21	Component N	2 wks	Wed 26-07-17	Tue 08-08-17	20
22					
23	**TESTING**	**85 days**	**Mon 22-05-17**	**Fri 15-09-17**	
24	Develop Test Cases	2 wks	Mon 22-05-17	Fri 02-06-17	13FF
25	Component 1	2 days	Wed 28-06-17	Thu 29-06-17	18
26	Component 2	2 days	Wed 12-07-17	Thu 13-07-17	19
27	Component 3	2 days	Wed 26-07-17	Thu 27-07-17	20
28	Component N	2 days	Wed 09-08-17	Thu 10-08-17	21
29	System Integration Testing (ST	2 wks	Fri 11-08-17	Thu 24-08-17	28
30	Sign Off ST	0 days	Thu 24-08-17	Thu 24-08-17	29
31	User Acceptance Testing - Cycl	1 wk	Mon 28-08-17	Fri 01-09-17	29,30
32	User Acceptance Testing - Cycl	1 wk	Mon 04-09-17	Fri 08-09-17	31
33	User Acceptance Testing - Cycl	1 wk	Mon 11-09-17	Fri 15-09-17	32
34	UAT Sign Off	0 days	Fri 15-09-17	Fri 15-09-17	33
35					
36	**CAB APPROVAL**	**7 days**	**Mon 18-09-17**	**Wed 27-09-17**	
37	Prepare and Submit Go Live request documents to CAB	1 wk	Mon 18-09-17	Fri 22-09-17	34
38	CAB APPROVAL	0 days	Wed 27-09-17	Wed 27-09-17	37
39					
40	**GO LIVE**	**1 day?**	**Fri 29-09-17**	**Fri 29-09-17**	

Incremental/Iterative Software Development Project Sample Project Schedule (2 of 2)

PM *IN ACTION*

- Can be easily modified depending on project complexity
- At end of each of 3 project stages, PM may reassess development & testing estimates
- Change approval board (CAB)
  - Meets regularly to assess, approve, or reject proposed systems changes
  - Must be notified ASAP of any delays
- Development stage broken into several components
  - Time set aside to test each component after development
  - New component development begins as soon as previous one is completed