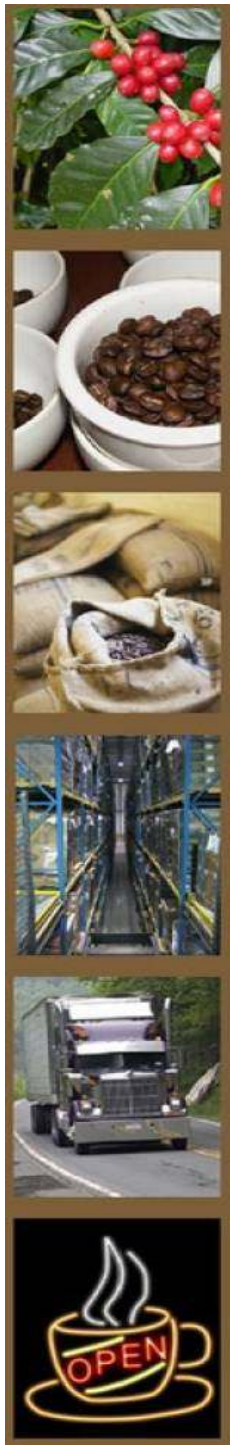
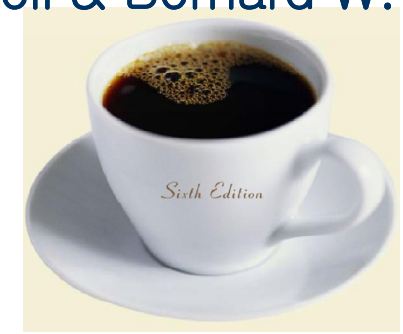


Chapter 9

Project Management

Operations Management - 6th Edition

Roberta Russell & Bernard W. Taylor, III



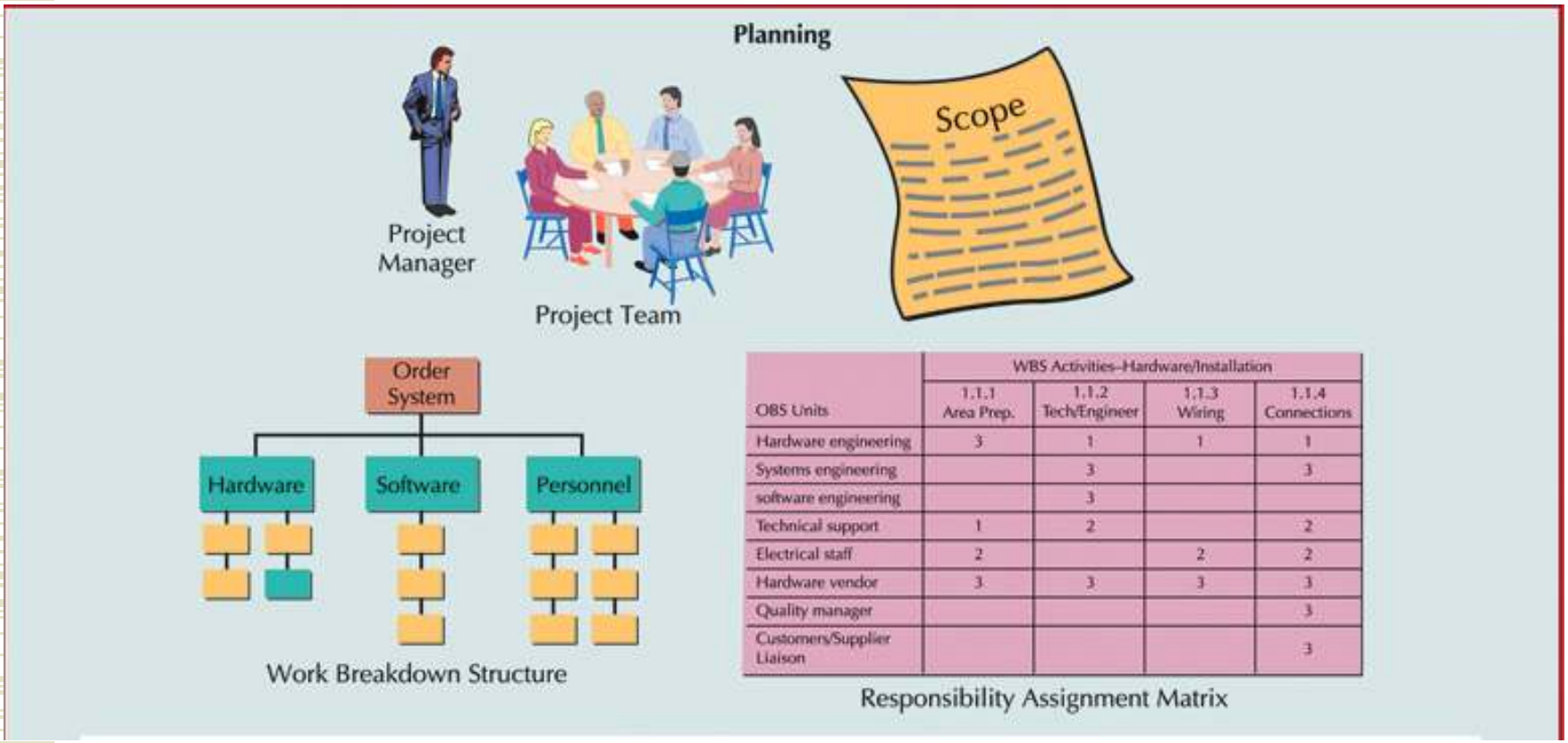
Beni Asllani
University of Tennessee at Chattanooga

Lecture Outline

- Project Planning
- Project Scheduling
- Project Control
- CPM/PERT
- Probabilistic Activity Times
- Microsoft Project
- Project Crashing and Time-Cost Trade-off

Project Management Process

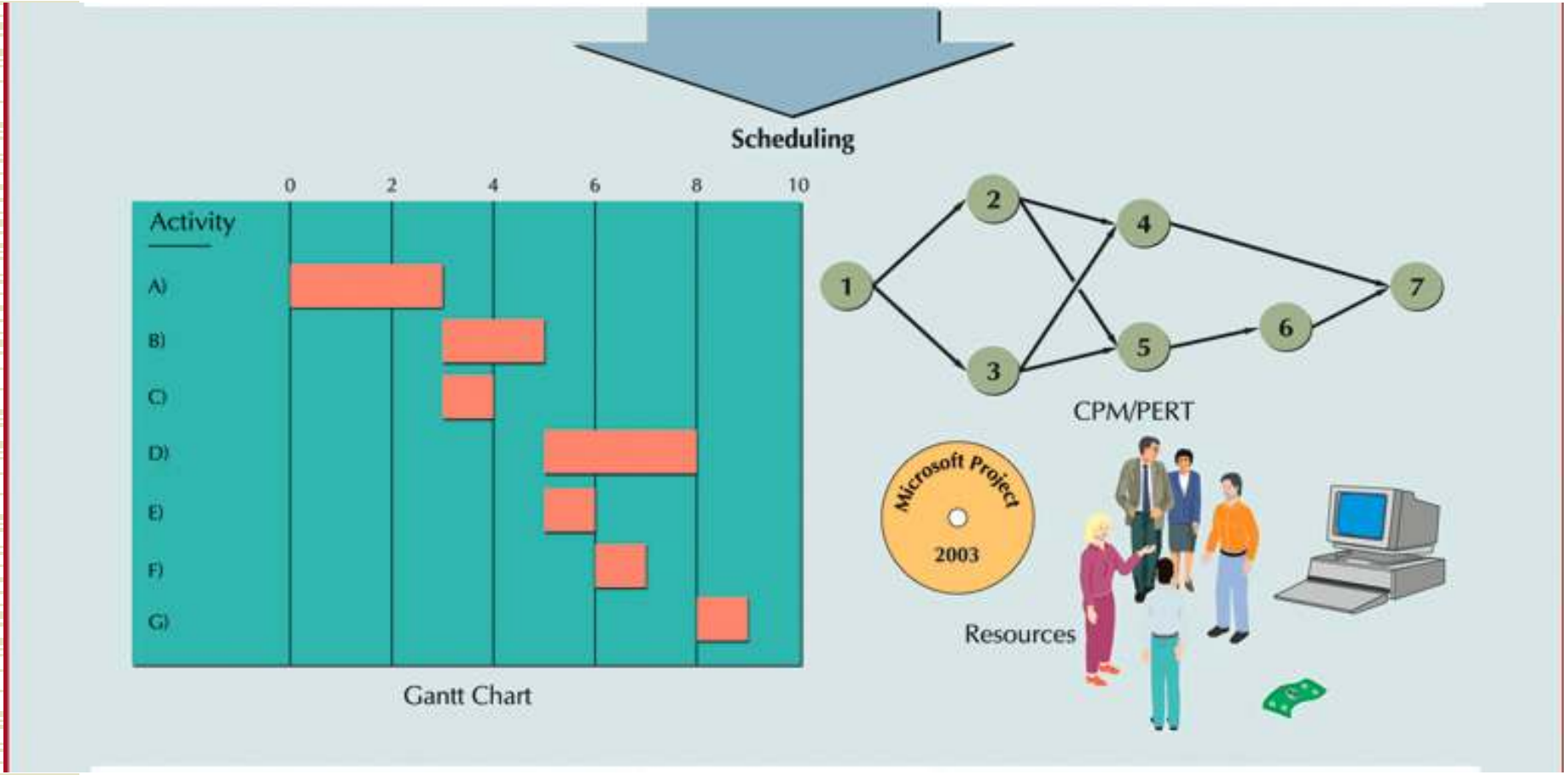
- Project
  - unique, one-time operational activity or effort



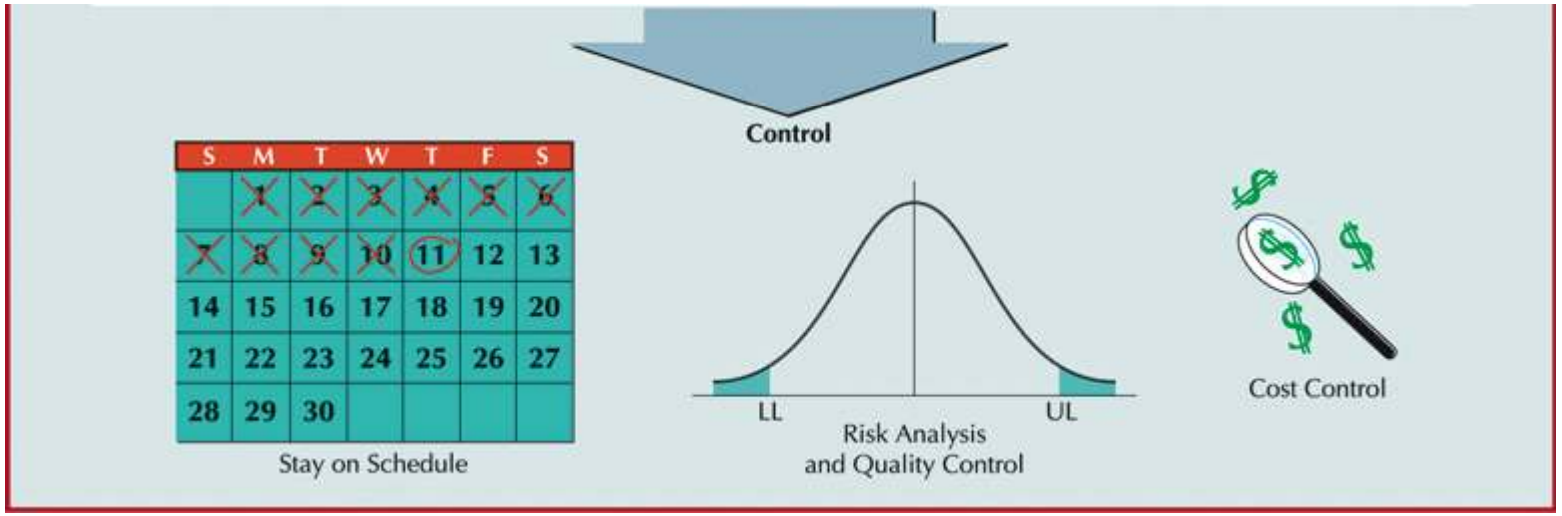
OBS Units	WBS Activities–Hardware/Installation			
	1.1.1 Area Prep.	1.1.2 Tech/Engineer	1.1.3 Wiring	1.1.4 Connections
Hardware engineering	3	1	1	1
Systems engineering		3		3
software engineering		3		
Technical support	1	2		2
Electrical staff	2		2	2
Hardware vendor	3	3	3	3
Quality manager				3
Customers/Supplier Liaison				3

Responsibility Assignment Matrix

Project Management Process (cont.)



Project Management Process (cont.)



Project Elements

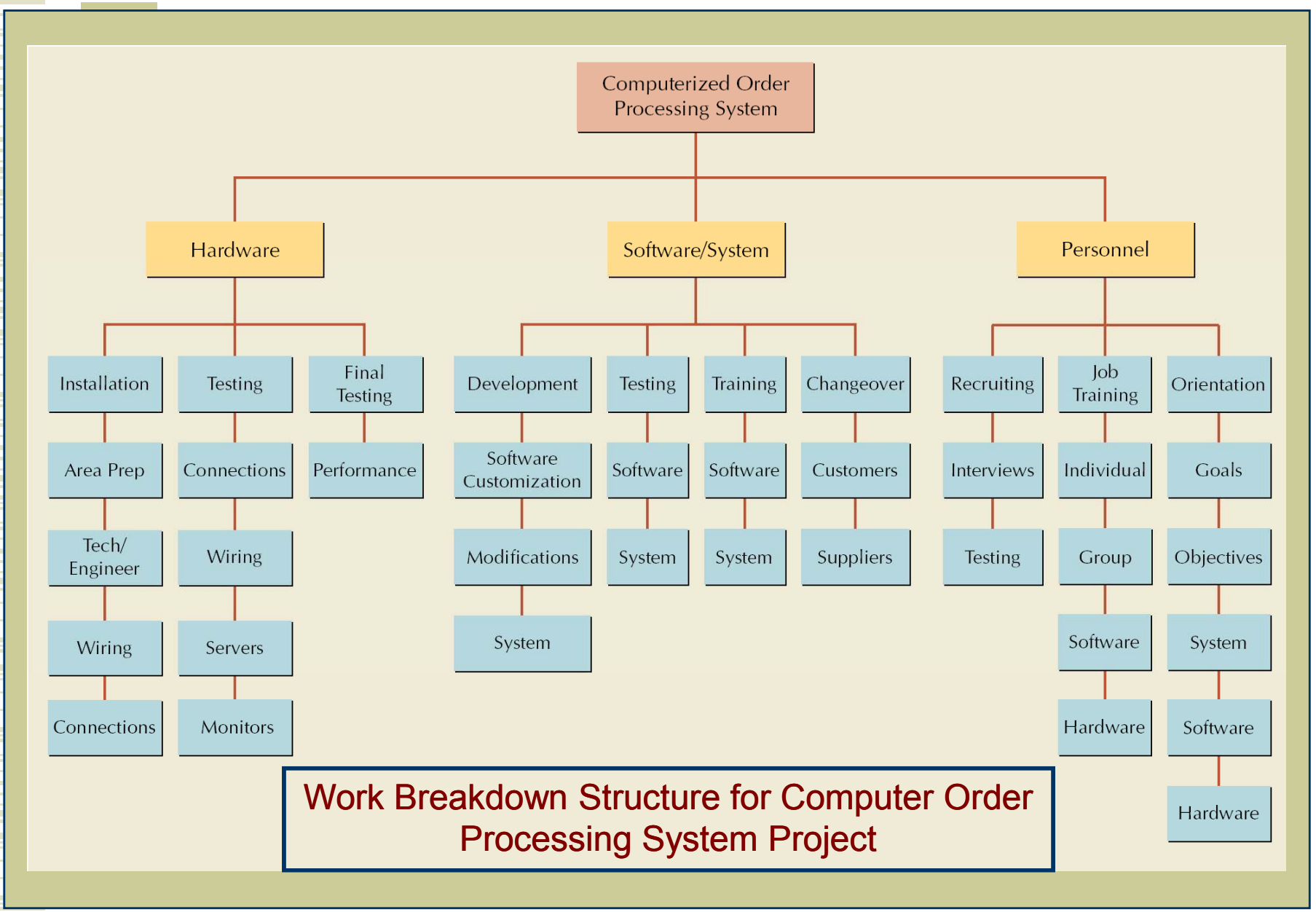
- Objective
- Scope
- Contract requirements
- Schedules
- Resources
- Personnel
- Control
- Risk and problem analysis

Project Team and Project Manager

- Project team
  - made up of individuals from various areas and departments within a company
- Matrix organization
  - a team structure with members from functional areas, depending on skills required
- Project manager
  - most important member of project team

Scope Statement and Work Breakdown Structure

- Scope statement
  - a document that provides an understanding, justification, and expected result of a project
- Statement of work
  - written description of objectives of a project
- Work breakdown structure (WBS)
  - breaks down a project into components, subcomponents, activities, and tasks



Work Breakdown Structure for Computer Order Processing System Project

Responsibility Assignment Matrix

OBS Units	WBS Activities–Hardware/Installation			
	1.1.1 Area Prep	1.1.2 Tech/Engineer	1.1.3 Wiring	1.1.4 Connections
Hardware engineering	3	1	1	1
Systems engineering		3		3
Software engineering		3		
Technical support	1	2		2
Electrical staff	2		2	2
Hardware vendor	3	3	3	3
Quality manager				3
Customer/supplier liaison				3

Level of responsibility: 1 = overall responsibility
2 = performance responsibility
3 = support

- Organizational Breakdown Structure (OBS)
  - a chart that shows which organizational units are responsible for work items
- Responsibility Assignment Matrix (RAM)
  - shows who is responsible for work in a project

Global and Diversity Issues in Project Management

- In existing global business environment, project teams are formed from different genders, cultures, ethnicities, etc.
- In global projects diversity among team members can add an extra dimension to project planning
- Cultural research and communication are important elements in planning process

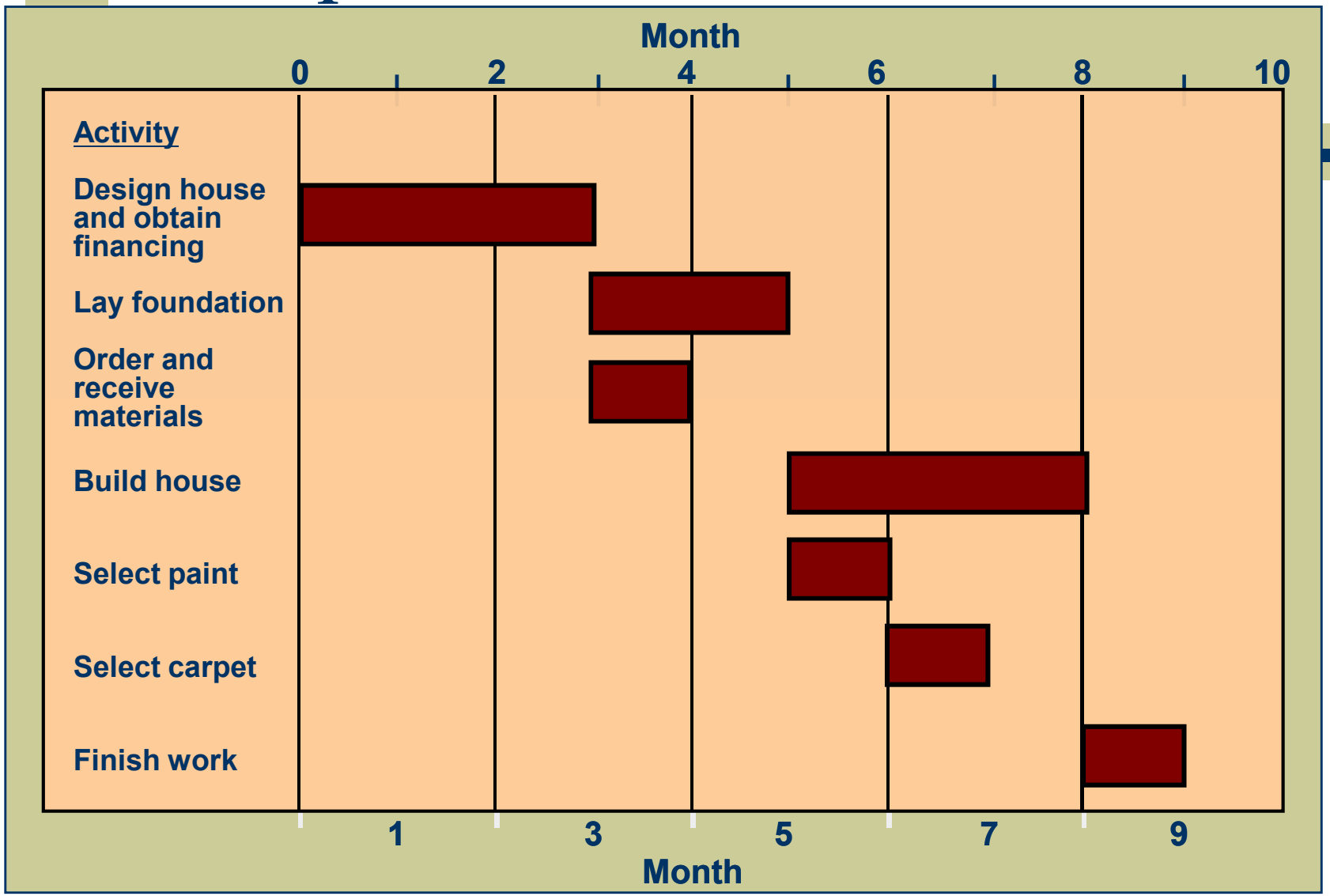
Project Scheduling

- Steps
  - Define activities
  - Sequence activities
  - Estimate time
  - Develop schedule
- Techniques
  - Gantt chart
  - CPM/PERT
  - Microsoft Project

Gantt Chart

- Graph or bar chart with a bar for each project activity that shows passage of time
- Provides visual display of project schedule
- Slack
  - amount of time an activity can be delayed without delaying the project

Example of Gantt Chart



Project Control

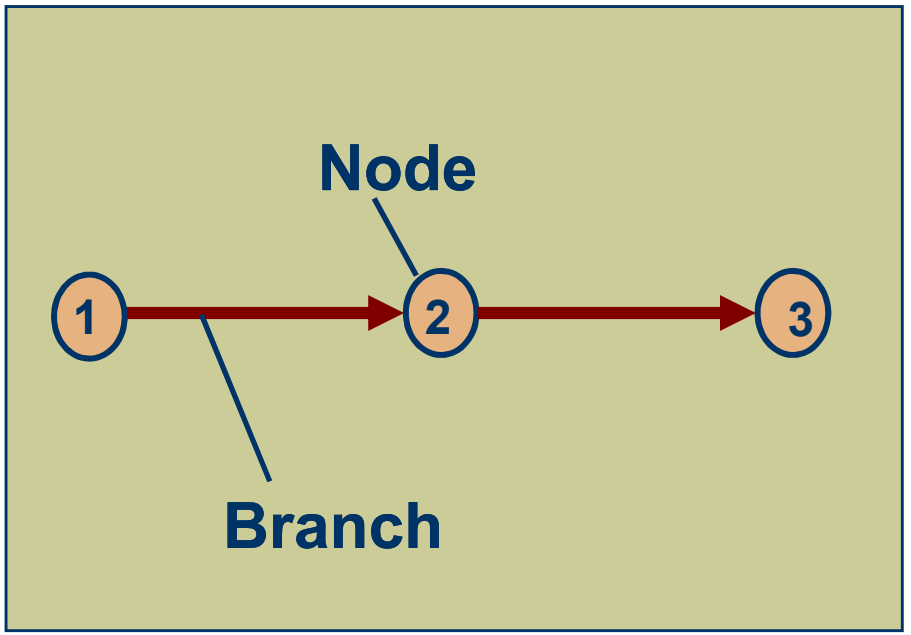
- Time management
- Cost management
- Quality management
- Performance management
  - Earned Value Analysis
    - a standard procedure for numerically measuring a project's progress, forecasting its completion date and cost and measuring schedule and budget variation
- Communication
- Enterprise project management

CPM/PERT

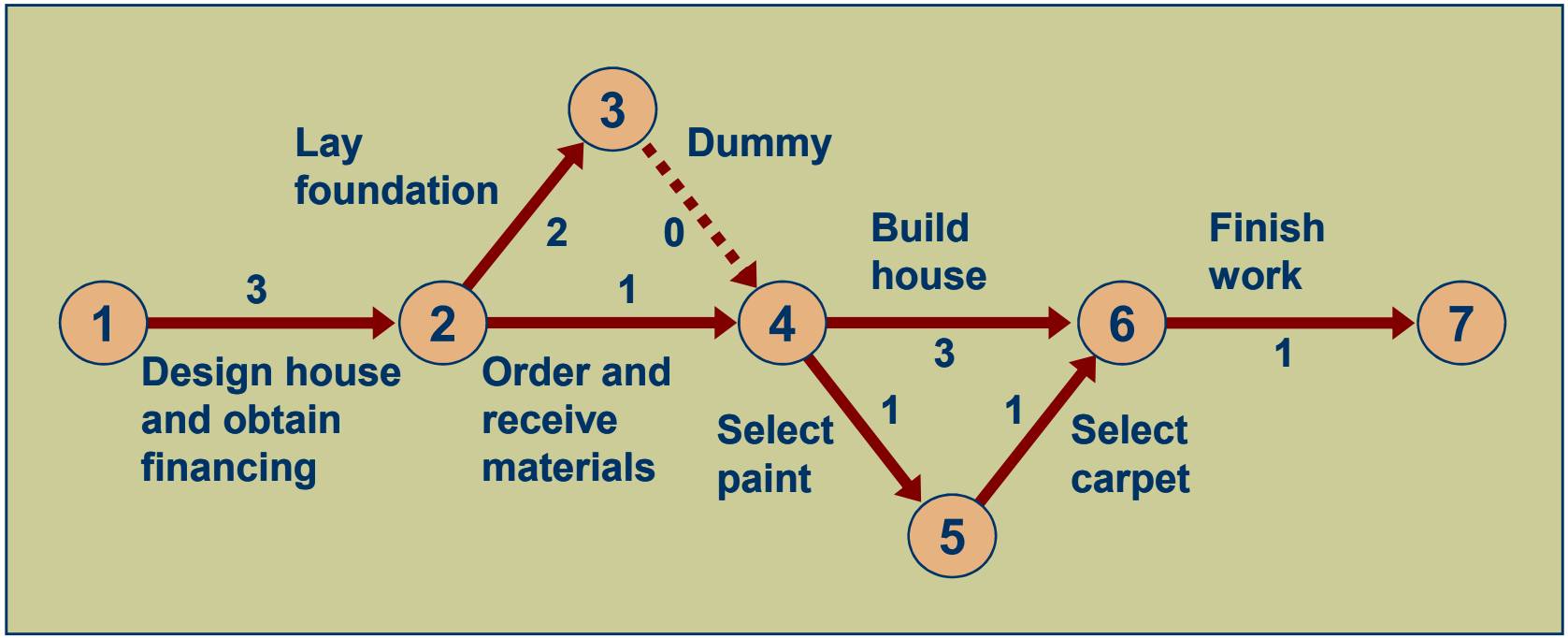
- Critical Path Method (CPM)
  - DuPont & Remington-Rand (1956)
  - Deterministic task times
  - Activity-on-node network construction
- Project Evaluation and Review Technique (PERT)
  - US Navy, Booz, Allen & Hamilton
  - Multiple task time estimates; probabilistic
  - Activity-on-arrow network construction

Project Network

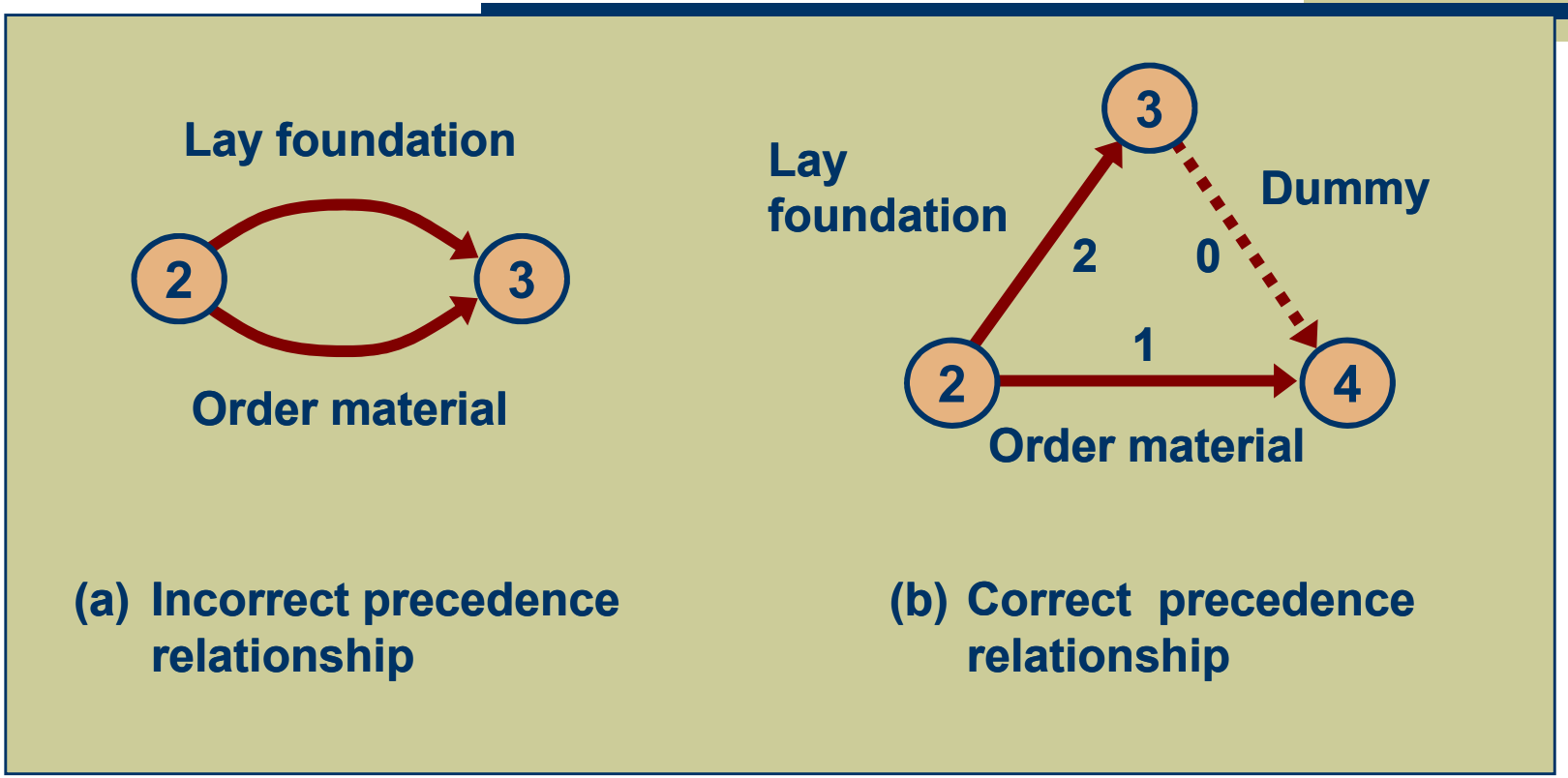
- Activity-on-node (AON)
  - nodes represent activities, and arrows show precedence relationships
- Activity-on-arrow (AOA)
  - arrows represent activities and nodes are events for points in time
- Event
  - completion or beginning of an activity in a project
- Dummy
  - two or more activities cannot share same start and end nodes



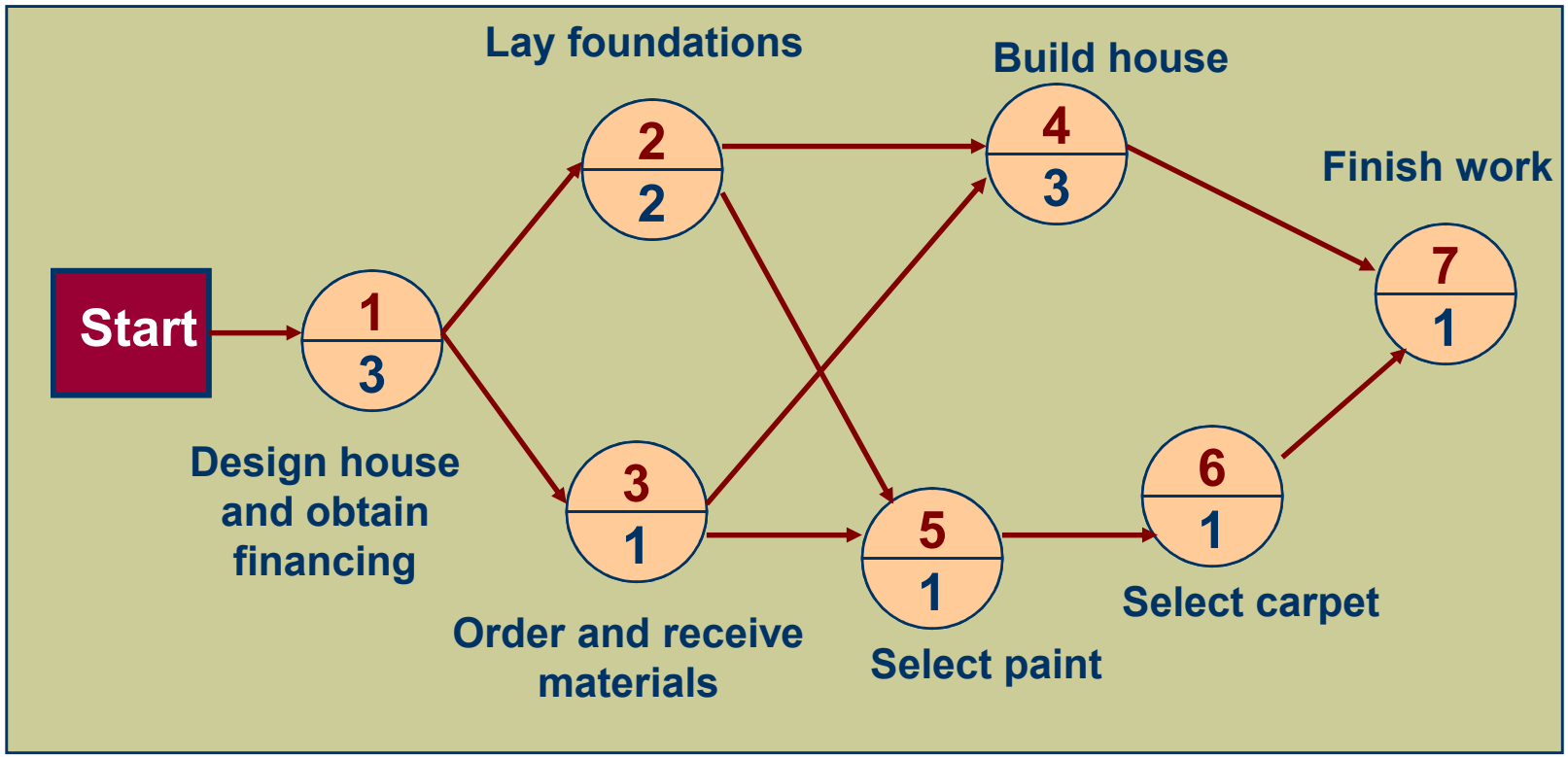
AOA Project Network for a House



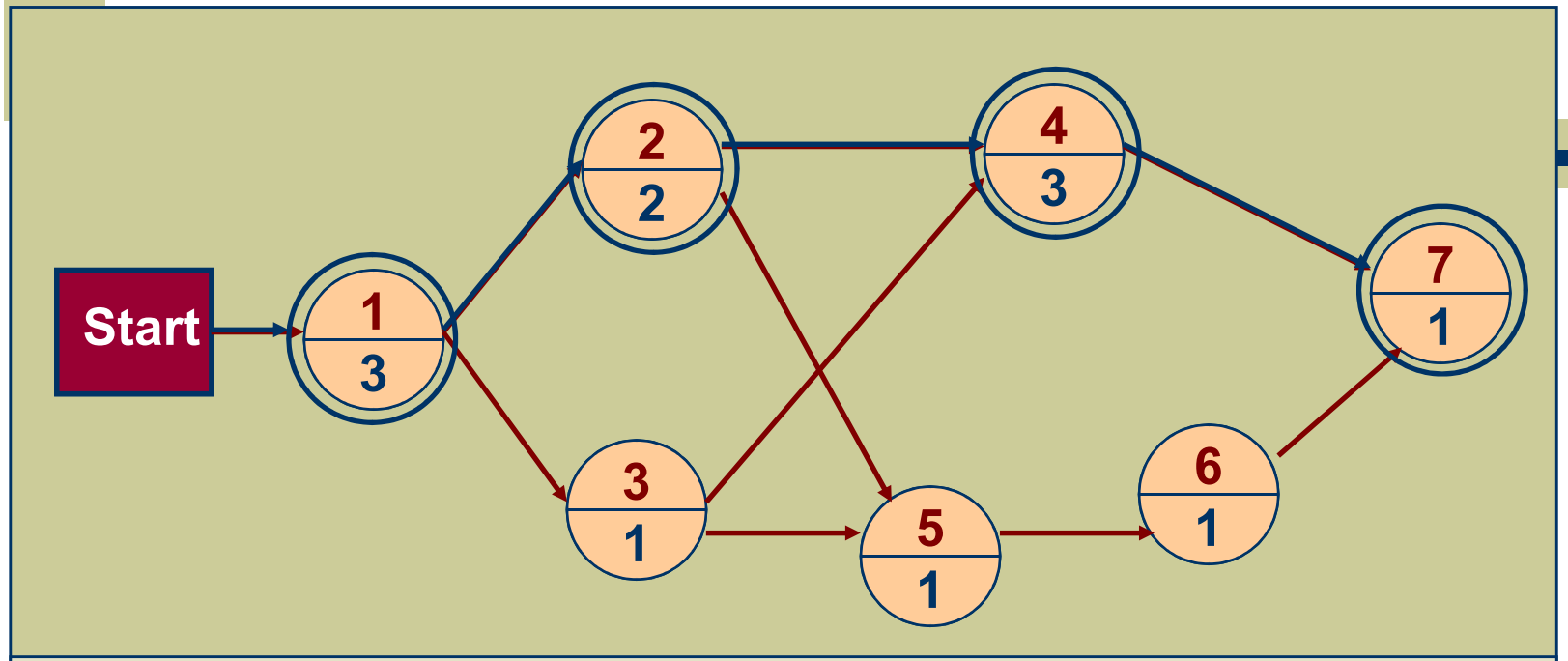
Concurrent Activities



AON Network for House Building Project



Critical Path



A: 1-2-4-7
3 + 2 + 3 + 1 = 9 months

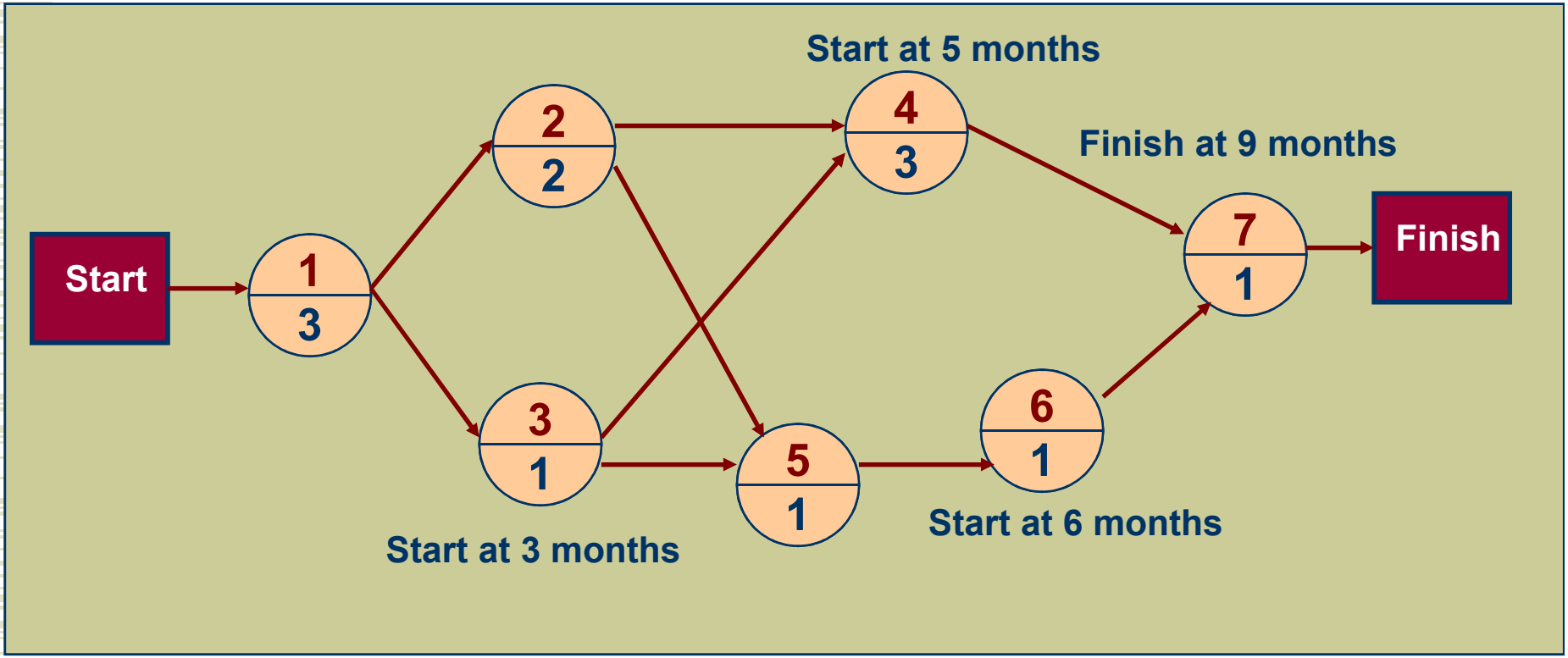
B: 1-2-5-6-7
3 + 2 + 1 + 1 + 1 = 8 months

C: 1-3-4-7
3 + 1 + 3 + 1 = 8 months

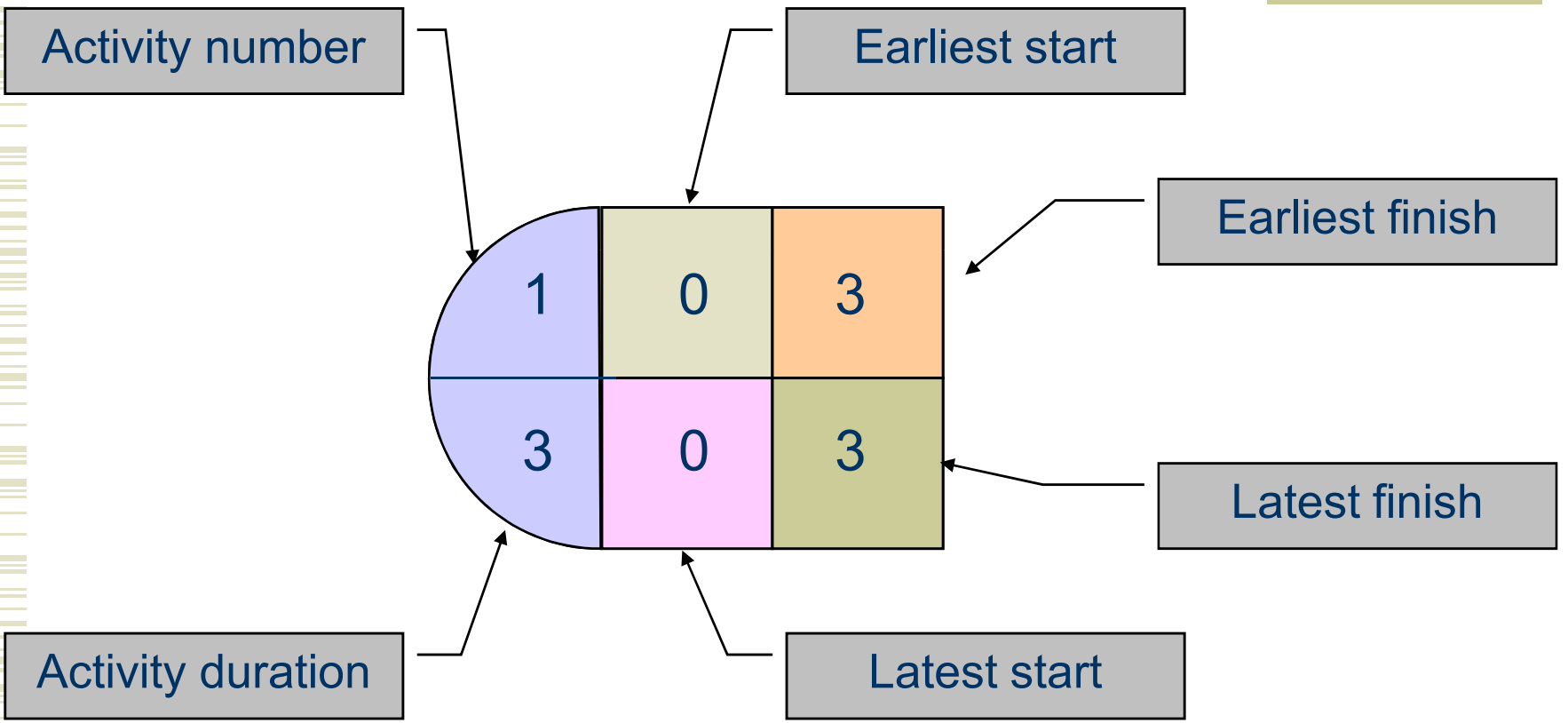
D: 1-3-5-6-7
3 + 1 + 1 + 1 + 1 = 7 months

- Critical path
  - Longest path through a network
  - Minimum project completion time

Activity Start Times



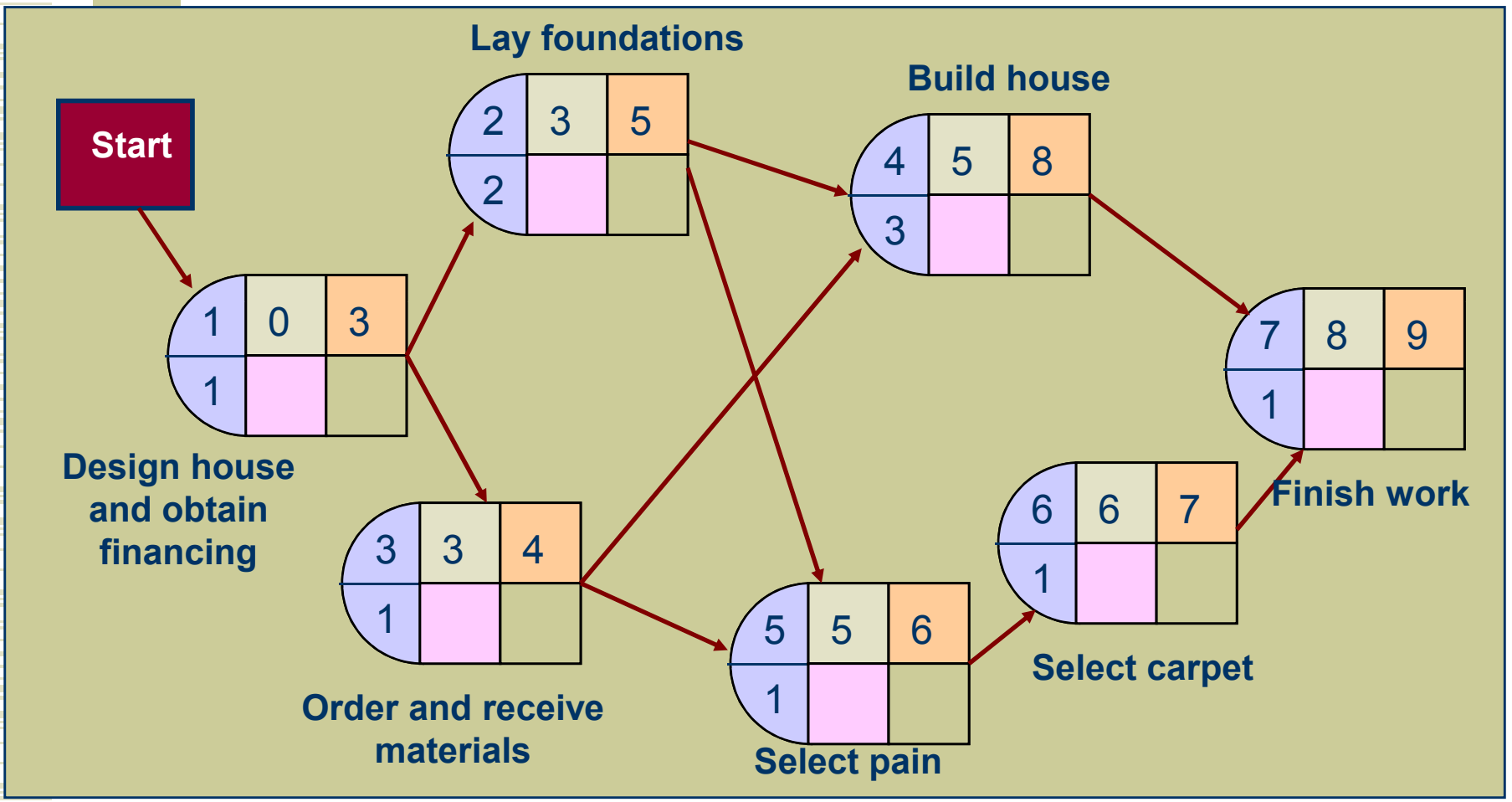
Node Configuration



Activity Scheduling

- Earliest start time (ES)
  - earliest time an activity can start
  - ES = maximum EF of immediate predecessors
- Forward pass
  - starts at beginning of CPM/PERT network to determine earliest activity times
- Earliest finish time (EF)
  - earliest time an activity can finish
  - earliest start time plus activity time
  - EF= ES + t

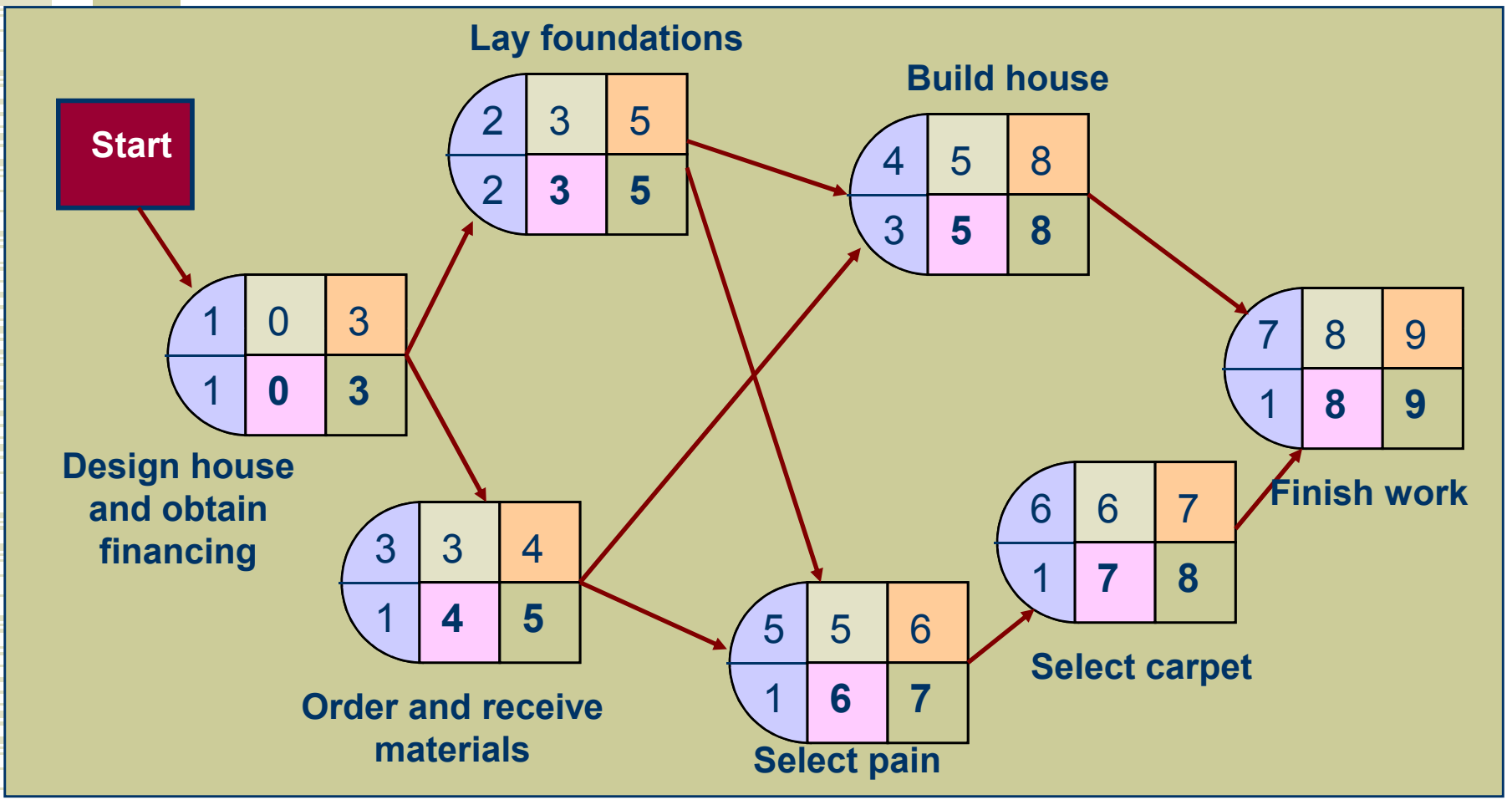
Earliest Activity Start and Finish Times



Activity Scheduling (cont.)

- Latest start time (LS)
  - Latest time an activity can start without delaying critical path time
  - LS= LF – *t*
- Latest finish time (LF)
  - latest time an activity can be completed without delaying critical path time
  - LF = minimum LS of immediate predecessors
- Backward pass
  - Determines latest activity times by starting at the end of CPM/PERT network and working forward

Latest Activity Start and Finish Times



Activity Slack

Activity	LS	ES	LF	EF	Slack S
*1	0	0	3	3	0
*2	3	3	5	5	0
3	4	3	5	4	1
*4	5	5	8	8	0
5	6	5	7	6	1
6	7	6	8	7	1
*7	8	8	9	9	0
* Critical Path					

Probabilistic Time Estimates

- Beta distribution
  - a probability distribution traditionally used in CPM/PERT

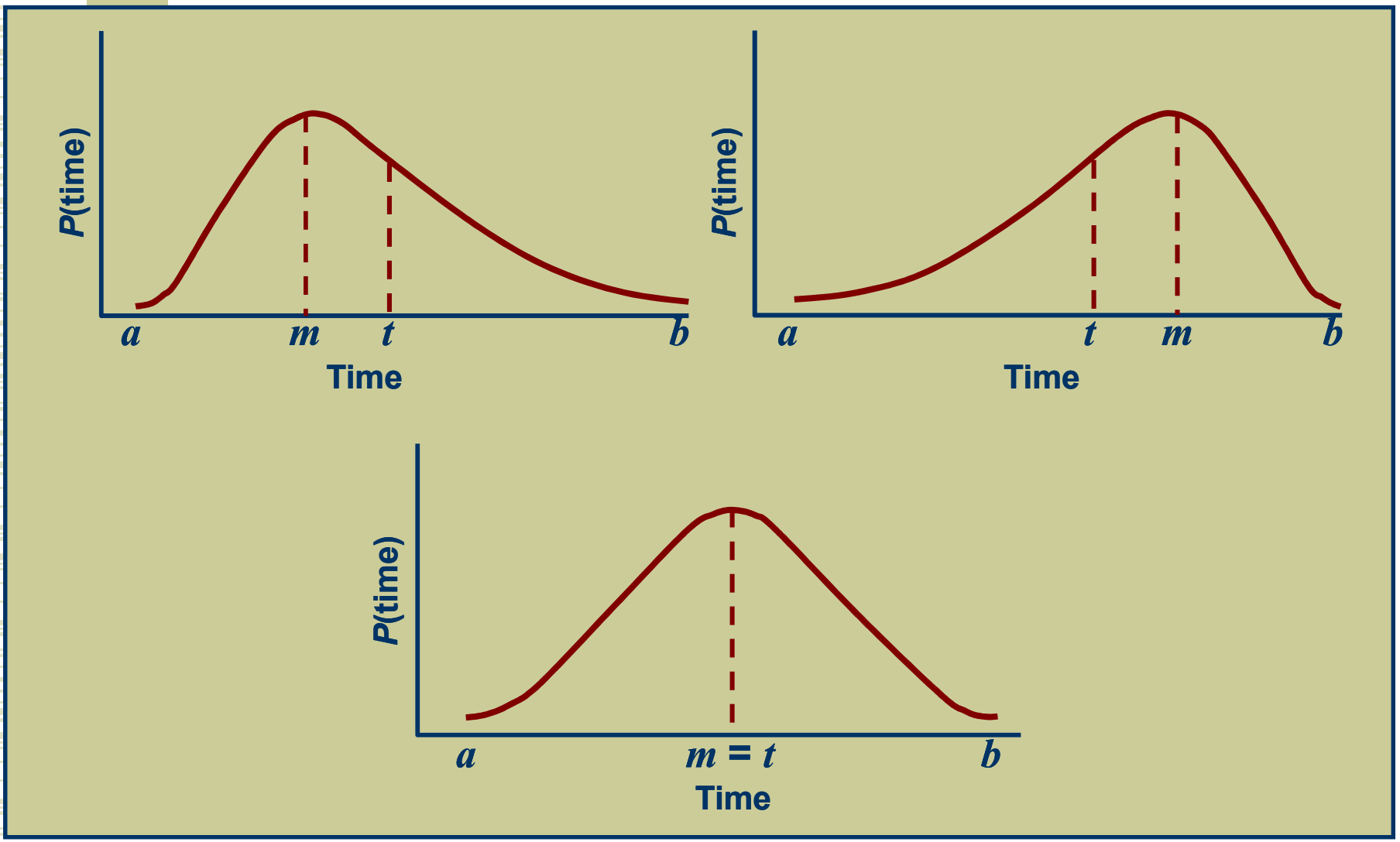
Mean (expected time): $t = \dfrac{a + 4m + b}{6}$

Variance: $\sigma^2 = \left(\dfrac{b - a}{6}\right)^2$

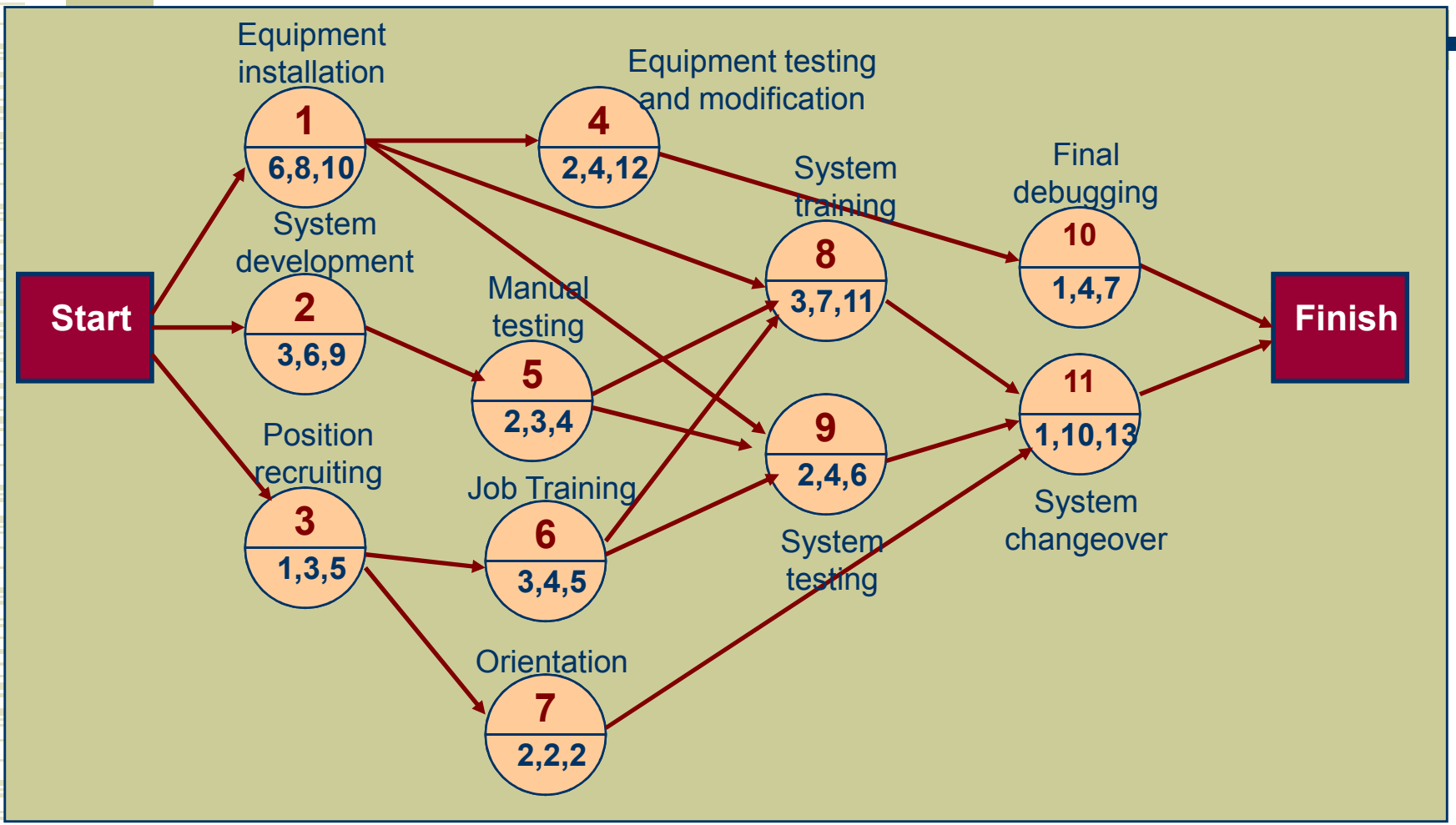
where

a = optimistic estimate
m = most likely time estimate
b = pessimistic time estimate

Examples of Beta Distributions



Project Network with Probabilistic Time Estimates: Example



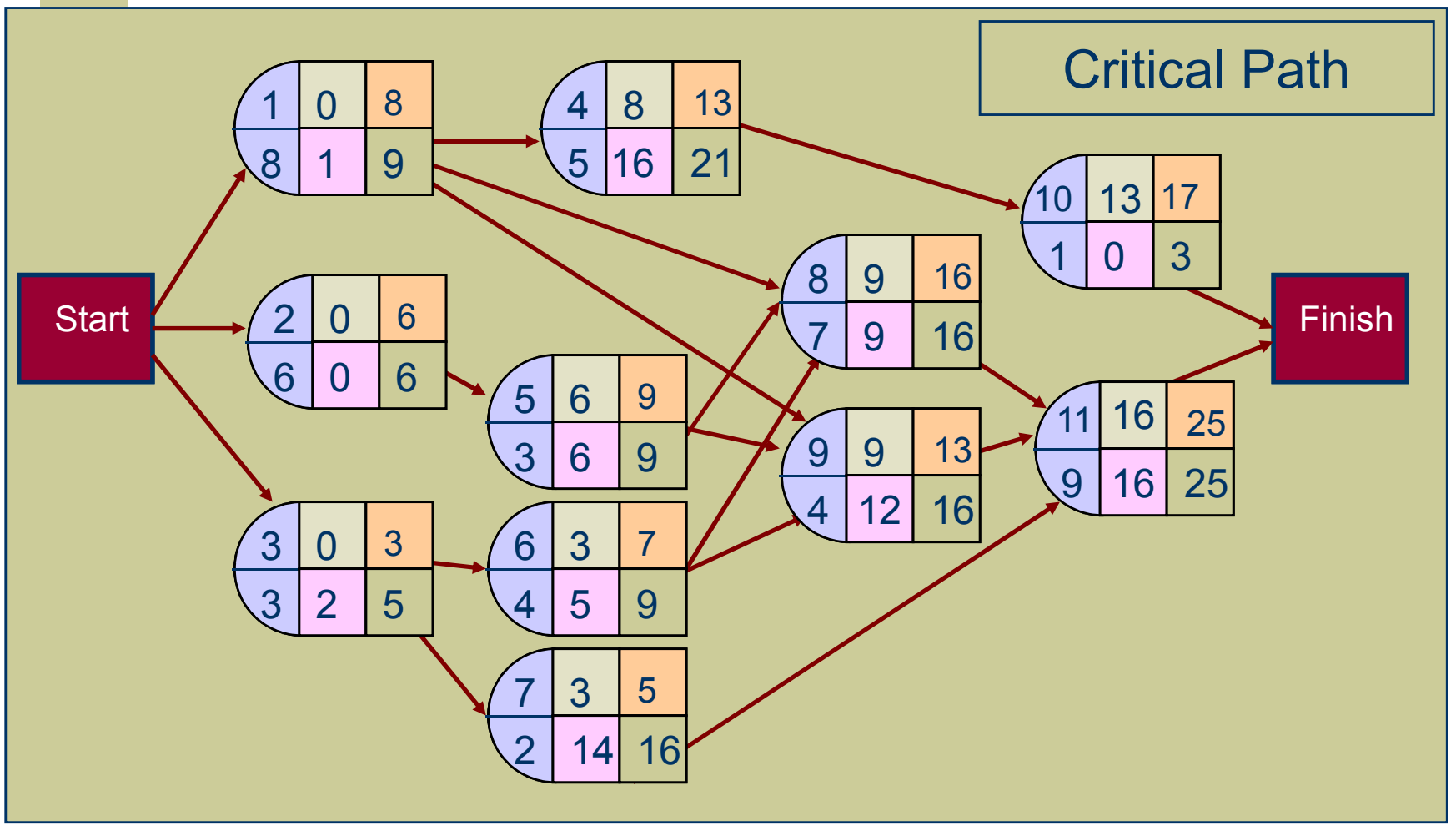
Activity Time Estimates

ACTIVITY	TIME ESTIMATES (WKS)			MEAN TIME	VARIANCE
	a	*m*	*b*	*t*	σ^2
1	6	8	10	8	0.44
2	3	6	9	6	1.00
3	1	3	5	3	0.44
4	2	4	12	5	2.78
5	2	3	4	3	0.11
6	3	4	5	4	0.11
7	2	2	2	2	0.00
8	3	7	11	7	1.78
9	2	4	6	4	0.44
10	1	4	7	4	1.00
11	1	10	13	9	4.00

Activity Early, Late Times, and Slack

ACTIVITY	t	σ^2	ES	EF	LS	LF	S
1	8	0.44	0	8	1	9	1
2	6	1.00	0	6	0	6	0
3	3	0.44	0	3	2	5	2
4	5	2.78	8	13	16	21	8
5	3	0.11	6	9	6	9	0
6	4	0.11	3	7	5	9	2
7	2	0.00	3	5	14	16	11
8	7	1.78	9	16	9	16	0
9	4	0.44	9	13	12	16	3
10	4	1.00	13	17	21	25	8
11	9	4.00	16	25	16	25	0

Earliest, Latest, and Slack



Total project variance

$$\sigma^2 = б_2^2 + б_5^2 + б_8^2 + б_{11}^2$$

$$\sigma = 1.00 + 0.11 + 1.78 + 4.00$$

$$= 6.89 \text{ weeks}$$

Microsoft Excel - Exhibit9.1.ProjectManagement.xls

File Edit View Insert Format Tools Data OM Tools Window Help

Project Management — OM Student - Example 9.1

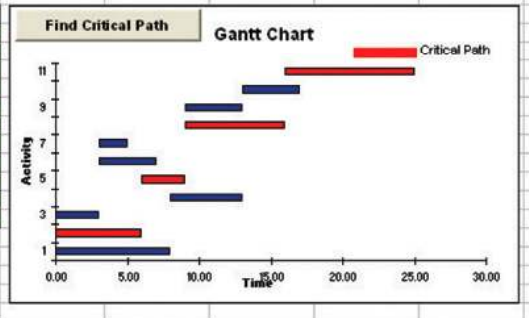
Input:

Input activities, time estimates and activity predecessors. Click on "Find Critical Path" to display the critical path on the Gantt

			Time estimates			Calculations		
Activity	Label	Optimistic	Most Likely	Pessimistic	Mean	Std dev	Variance
1	Equip. install.	6.00	8.00	10.00	8.00	0.67	0.44
2	System dev.	3.00	6.00	9.00	6.00	1.00	1.00
3	Position recruit.	1.00	3.00	5.00	3.00	0.67	0.44
4	Equip. testing	2.00	4.00	12.00	5.00	1.67	2.78
5	Manual testing	2.00	3.00	4.00	3.00	0.33	0.11
6	Job training	3.00	4.00	5.00	4.00	0.33	0.11
7	Orientation	2.00	2.00	2.00	2.00	0.00	0.00
8	System training	3.00	7.00	11.00	7.00	1.33	1.78
9	System testing	2.00	4.00	6.00	4.00	0.67	0.44
10	Final debugging	1.00	4.00	7.00	4.00	1.00	1.00
11	System Change	1.00	10.00	13.00	9.00	2.00	4.00

Activity	Time	Activity Predecessor		
1	8.00			
2	6.00			
3	3.00			
4	5.00	1		
5	3.00	2		
6	4.00	3		
7	2.00	3		
8	7.00	1	5	6
9	4.00	2	4	6
10	4.00	4		
11	9.00	8	9	7

Find Critical Path



Output:

Project Schedule

Task	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Activity Slack	Critical Path Variance
1	0.000	8.000	1.000	8.000	1.000	
2	0.000	6.000	0.000	6.000	0.000	1.000
3	0.000	3.000	2.000	5.000	2.000	
4	8.000	13.000	16.000	21.000	8.000	
5	6.000	9.000	6.000	9.000	0.000	0.111
6	3.000	7.000	5.000	9.000	2.000	
7	3.000	5.000	14.000	16.000	11.000	
8	9.000	16.000	9.000	16.000	0.000	1.778
9	9.000	13.000	12.000	16.000	3.000	
10	13.000	17.000	21.000	25.000	8.000	
11	16.000	25.000	16.000	25.000	0.000	4.000
Project Completion Time		25		Project variance		6.889
				Project std.dev		2.625

Probabilistic Network Analysis

Determine probability that project is completed within specified time

$$Z = \frac{x - \mu}{\sigma}$$

where

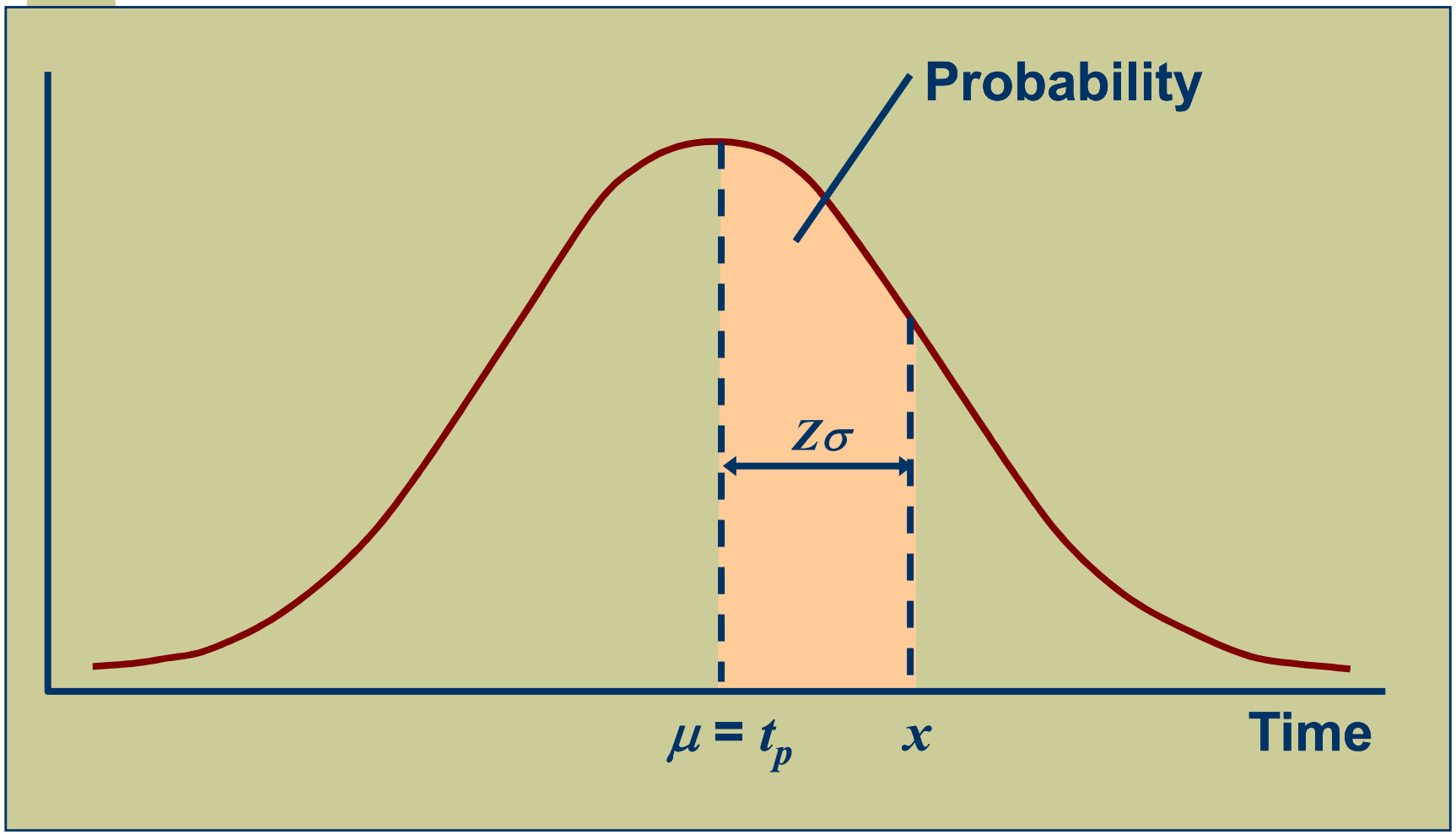
$\mu = t_p$ = ***project mean time***

σ = ***project standard deviation***

x = ***proposed project time***

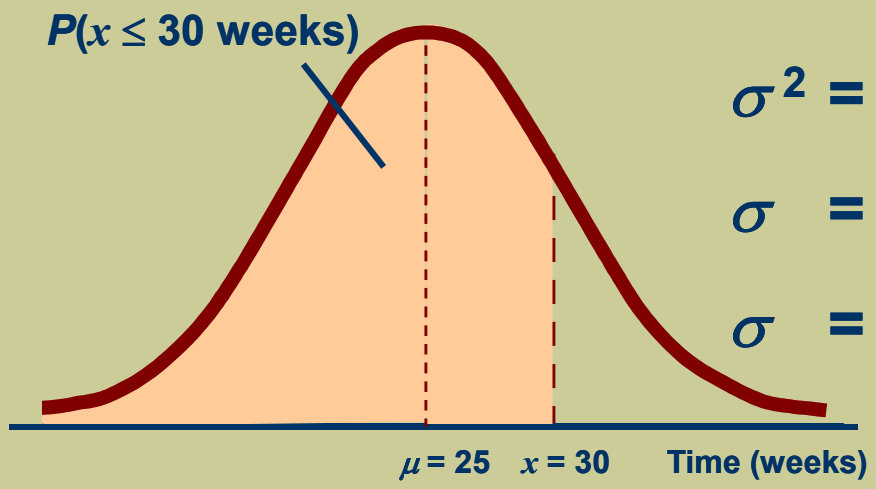
Z = ***number of standard deviations x is from mean***

Normal Distribution of Project Time



Southern Textile Example

What is the probability that the project is completed within 30 weeks?



$\sigma^2 = 6.89$ weeks

$\sigma = \sqrt{6.89}$

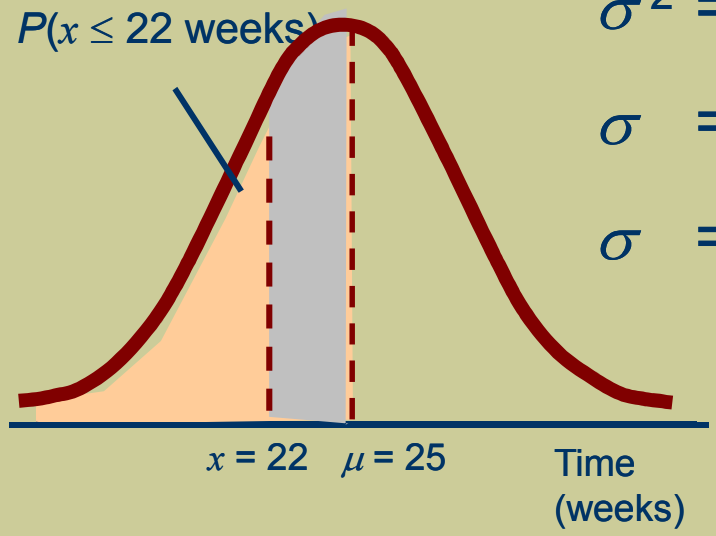
$\sigma = 2.62$ weeks

$$Z = \frac{x - \mu}{\sigma} = \frac{30 - 25}{2.62} = 1.91$$

From Table A.1, (appendix A) a Z score of 1.91 corresponds to a probability of 0.4719. Thus $P(30) = 0.4719 + 0.5000 = 0.9719$

Southern Textile Example

What is the probability that the project is completed within 22 weeks?



$\sigma^2 = 6.89$ weeks

$\sigma = \sqrt{6.89}$

$\sigma = 2.62$ weeks

$$Z = \frac{x - \mu}{\sigma}$$

$$= \frac{22 - 25}{2.62}$$

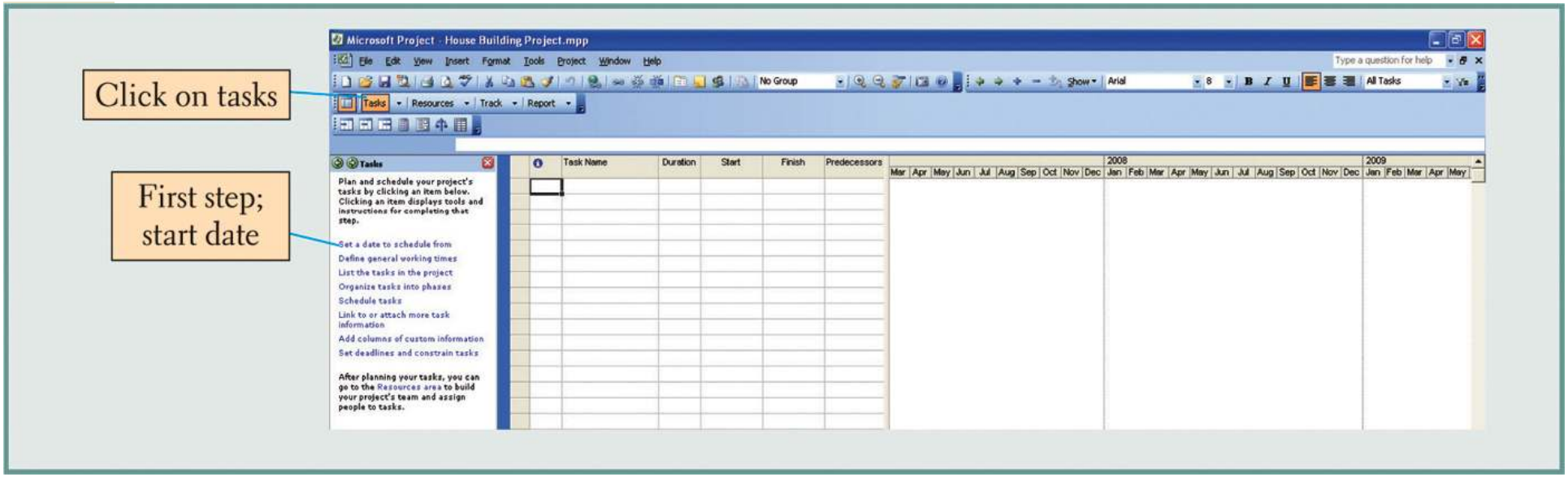
$$= -1.14$$

From Table A.1 (appendix A) a Z score of -1.14 corresponds to a probability of 0.3729. Thus $P(22) = 0.5000 - 0.3729 = 0.1271$

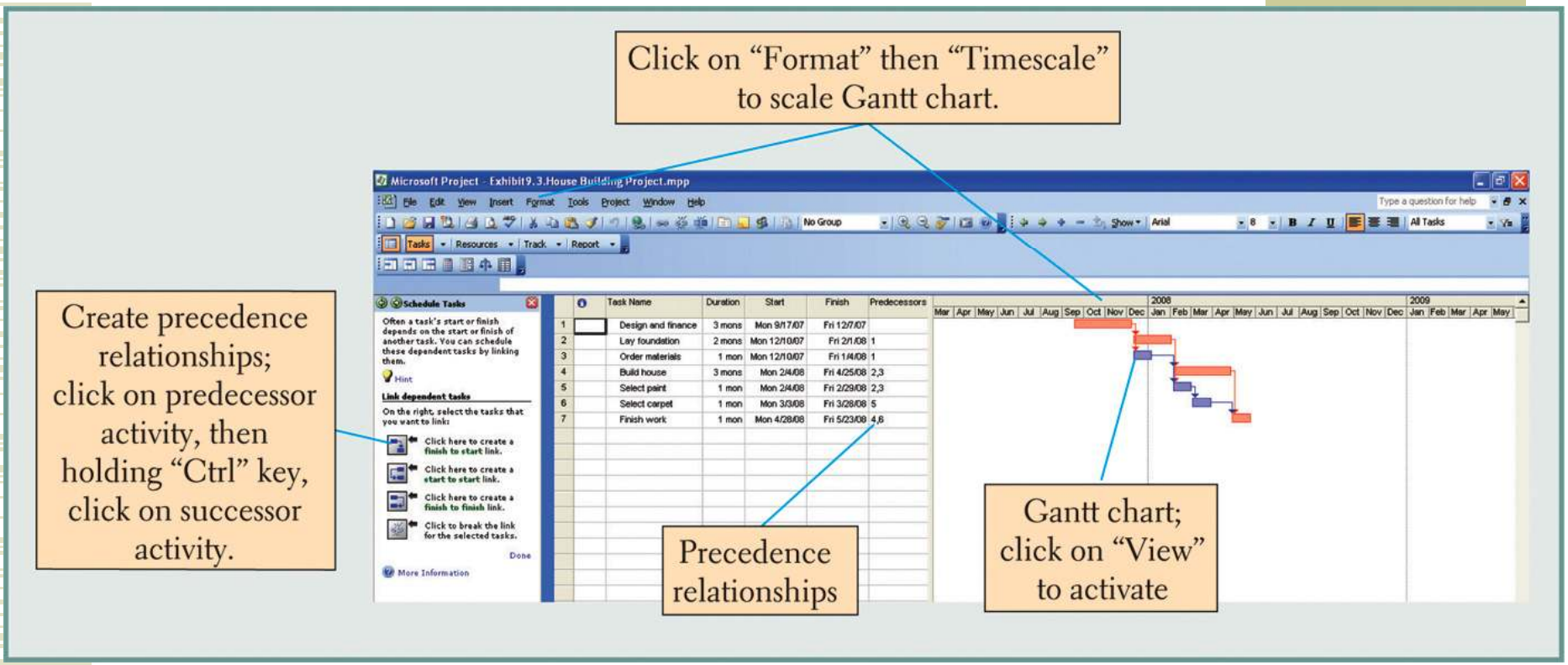
Microsoft Project

- Popular software package for project management and CPM/PERT analysis
- Relatively easy to use

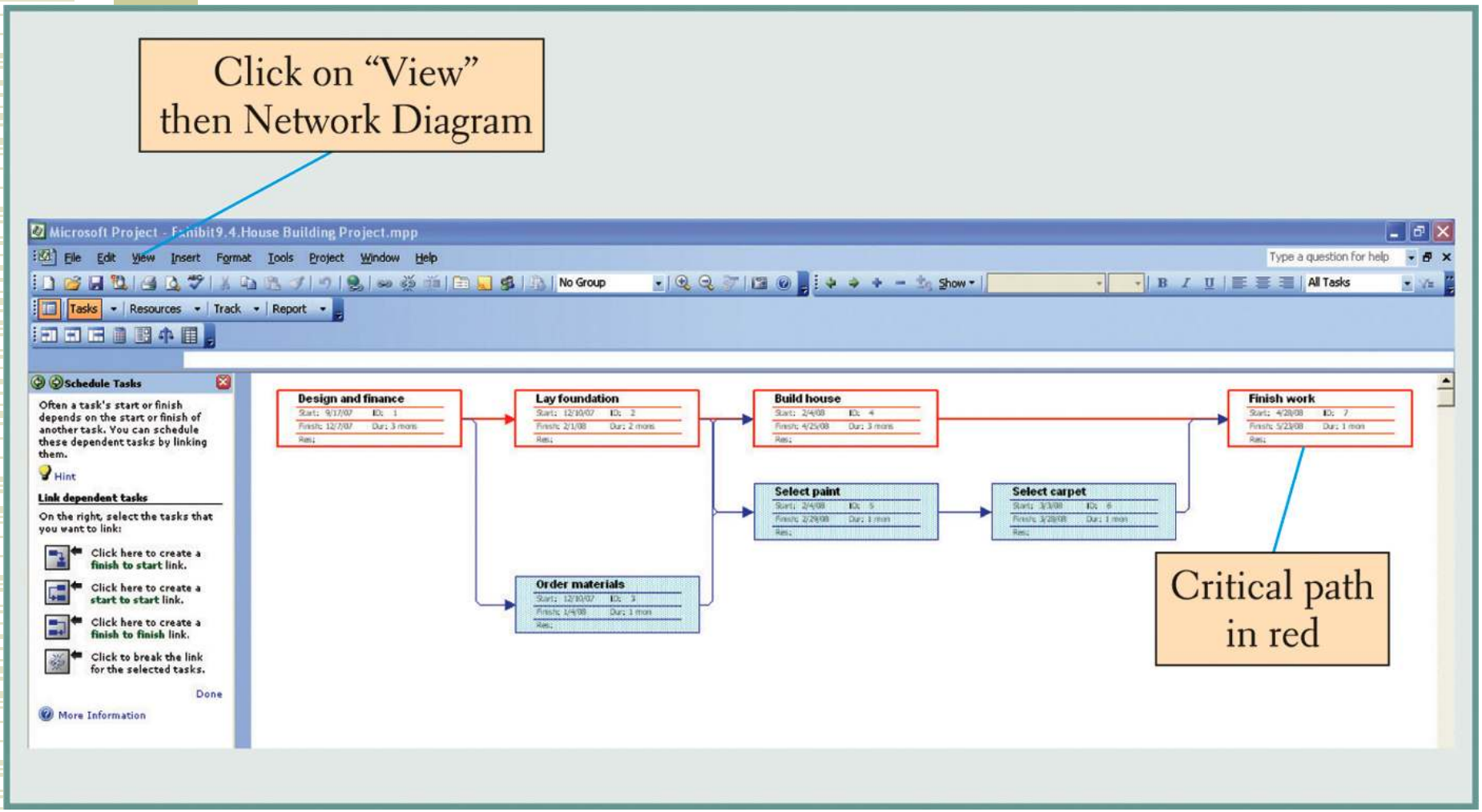
Microsoft Project (cont.)



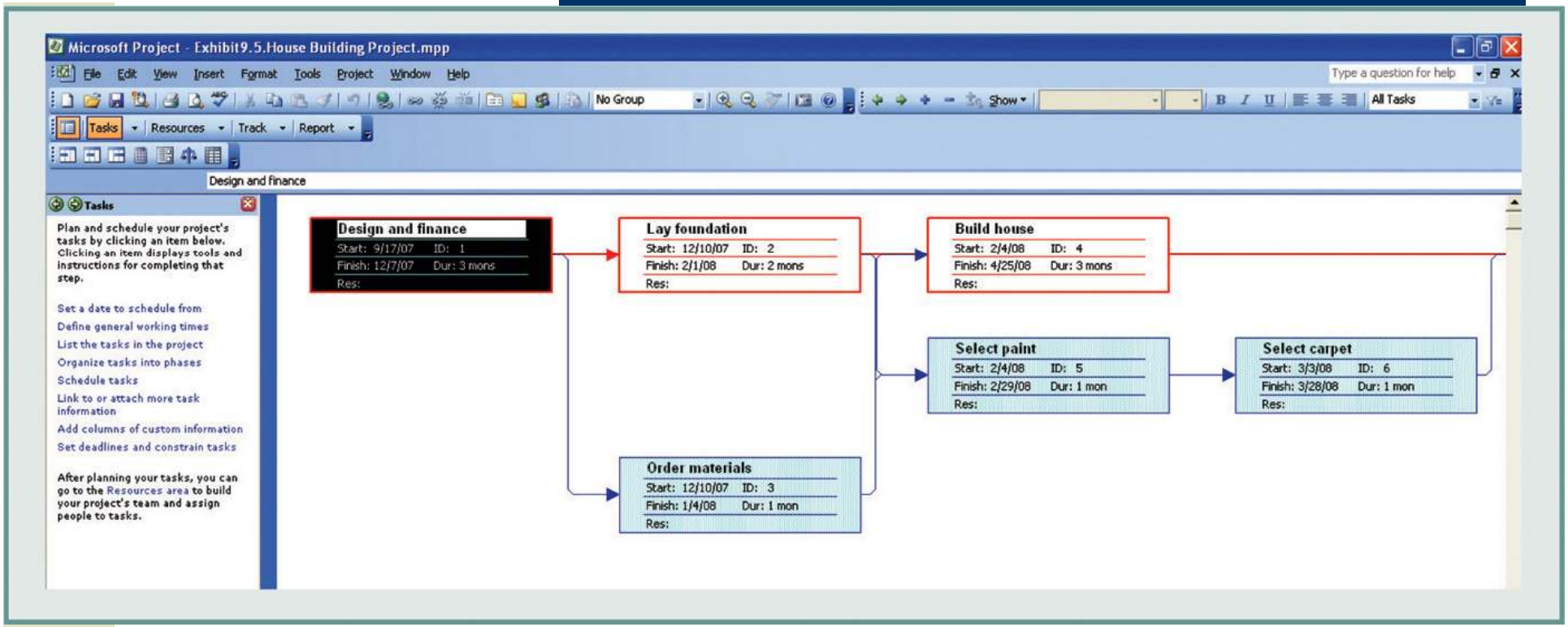
Microsoft Project (cont.)



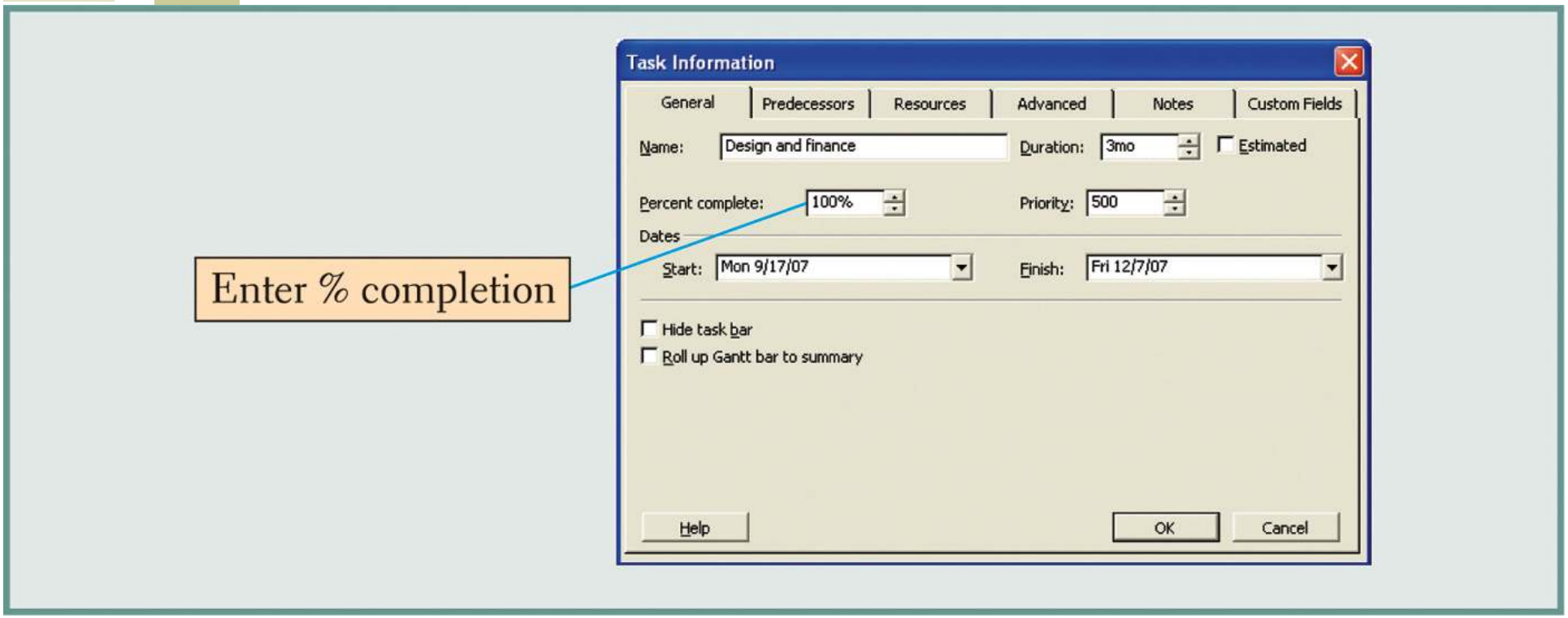
Microsoft Project (cont.)



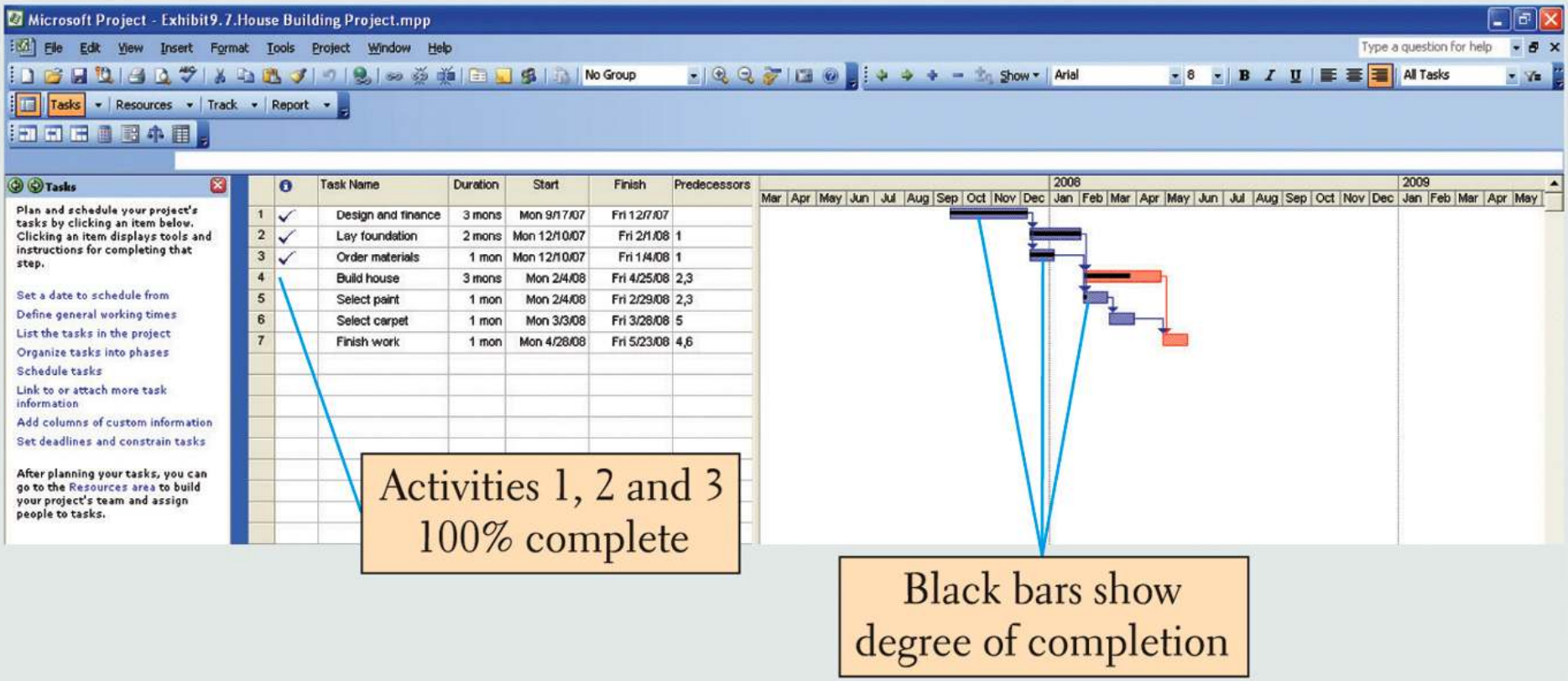
Microsoft Project (cont.)



Microsoft Project (cont.)



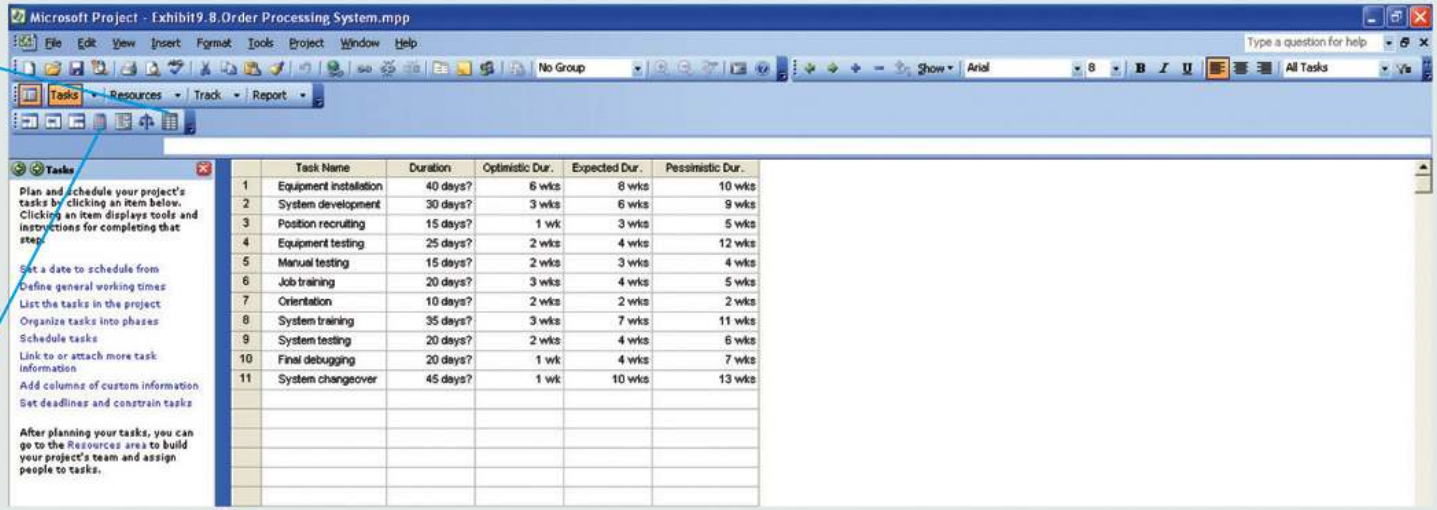
Microsoft Project (cont.)



PERT Analysis with Microsoft Project

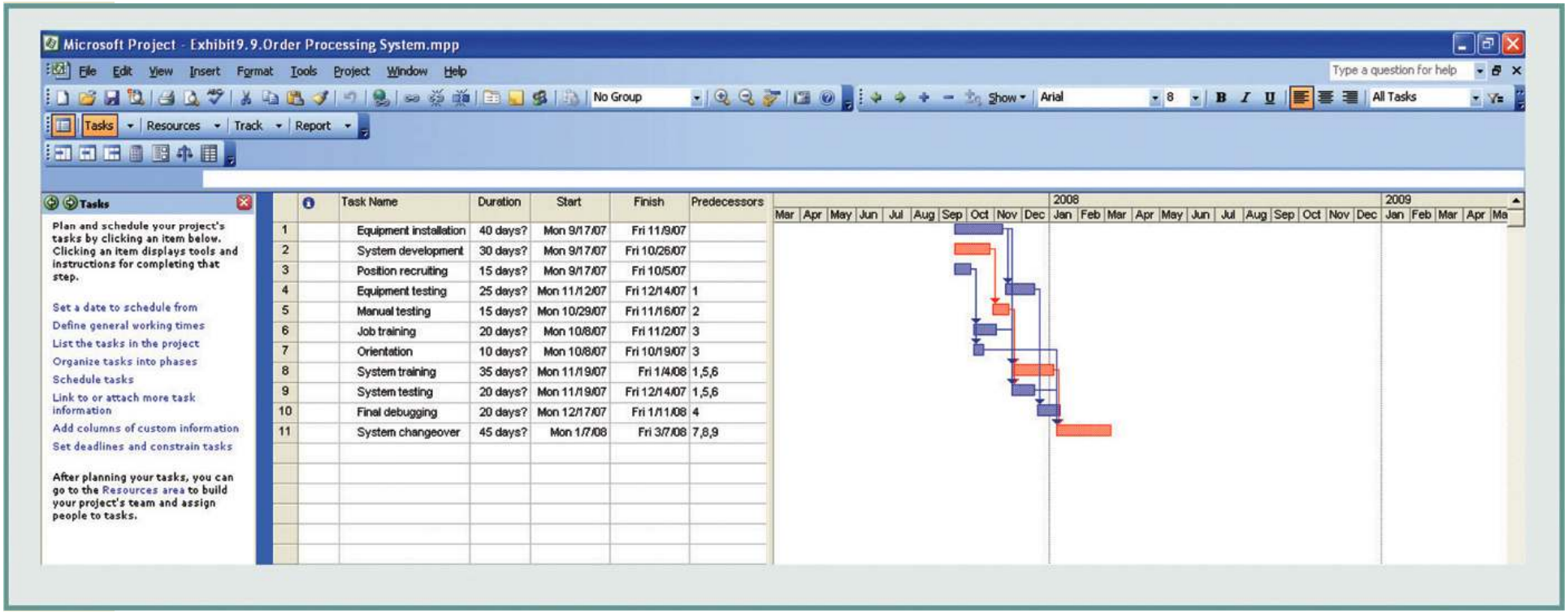
Click on PERT Entry Sheet to enter 3 time estimates

Click on PERT calculator to compute activity duration



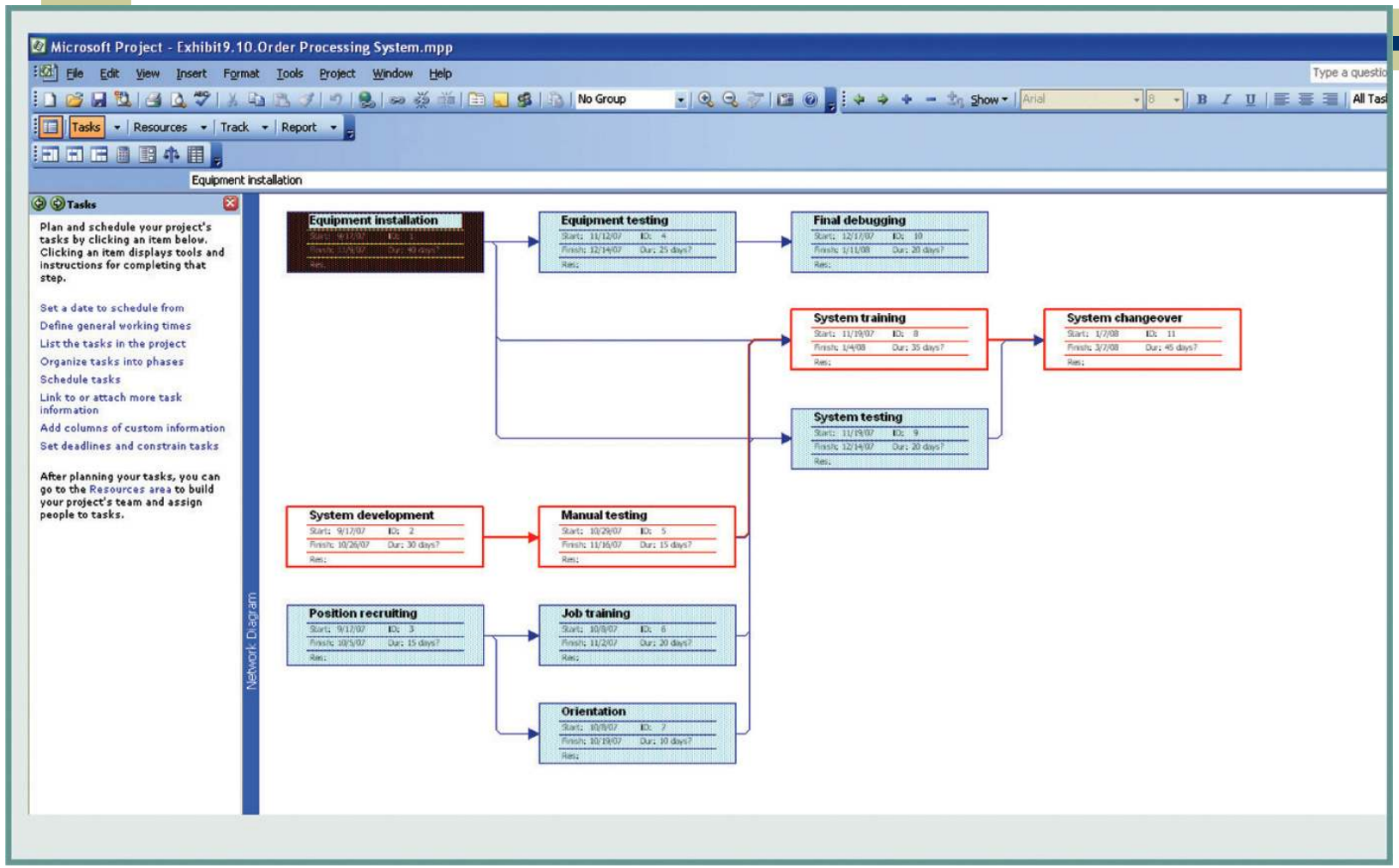
	Task Name	Duration	Optimistic Dur.	Expected Dur.	Pessimistic Dur.
1	Equipment installation	40 days?	6 wks	8 wks	10 wks
2	System development	30 days?	3 wks	6 wks	9 wks
3	Position recruiting	15 days?	1 wk	3 wks	5 wks
4	Equipment testing	25 days?	2 wks	4 wks	12 wks
5	Manual testing	15 days?	2 wks	3 wks	4 wks
6	Job training	20 days?	3 wks	4 wks	5 wks
7	Orientation	10 days?	2 wks	2 wks	2 wks
8	System training	35 days?	3 wks	7 wks	11 wks
9	System testing	20 days?	2 wks	4 wks	6 wks
10	Final debugging	20 days?	1 wk	4 wks	7 wks
11	System changeover	45 days?	1 wk	10 wks	13 wks

PERT Analysis with Microsoft Project (cont.)



	Task Name	Duration	Start	Finish	Predecessors
1	Equipment installation	40 days?	Mon 9/17/07	Fri 11/9/07	
2	System development	30 days?	Mon 9/17/07	Fri 10/26/07	
3	Position recruiting	15 days?	Mon 9/17/07	Fri 10/5/07	
4	Equipment testing	25 days?	Mon 11/12/07	Fri 12/14/07	1
5	Manual testing	15 days?	Mon 10/29/07	Fri 11/16/07	2
6	Job training	20 days?	Mon 10/8/07	Fri 11/2/07	3
7	Orientation	10 days?	Mon 10/8/07	Fri 10/19/07	3
8	System training	35 days?	Mon 11/19/07	Fri 1/4/08	1,5,6
9	System testing	20 days?	Mon 11/19/07	Fri 12/14/07	1,5,6
10	Final debugging	20 days?	Mon 12/17/07	Fri 1/11/08	4
11	System changeover	45 days?	Mon 1/7/08	Fri 3/7/08	7,8,9

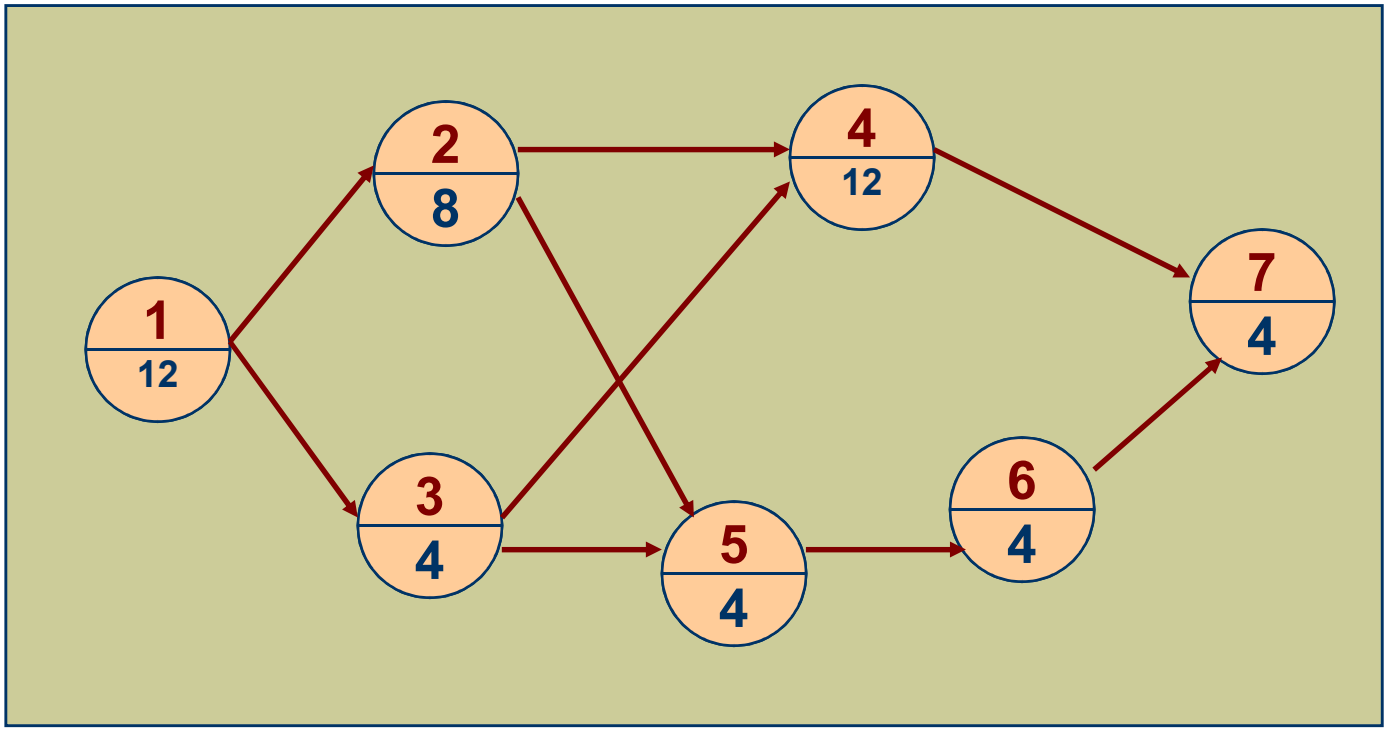
PERT Analysis with Microsoft Project (cont.)



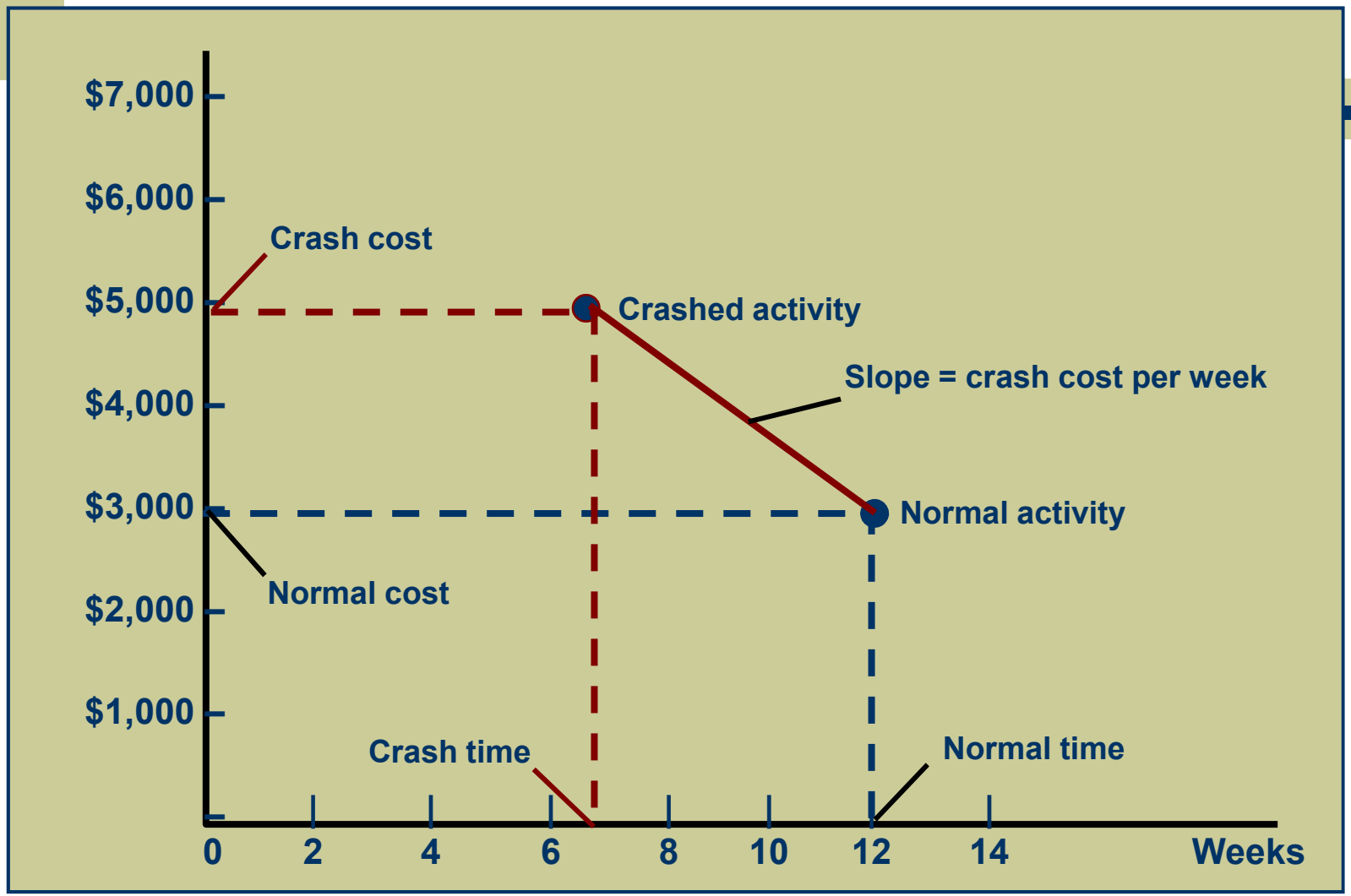
Project Crashing

- Crashing
  - reducing project time by expending additional resources
- Crash time
  - an amount of time an activity is reduced
- Crash cost
  - cost of reducing activity time
- Goal
  - reduce project duration at minimum cost

Project Network for Building a House

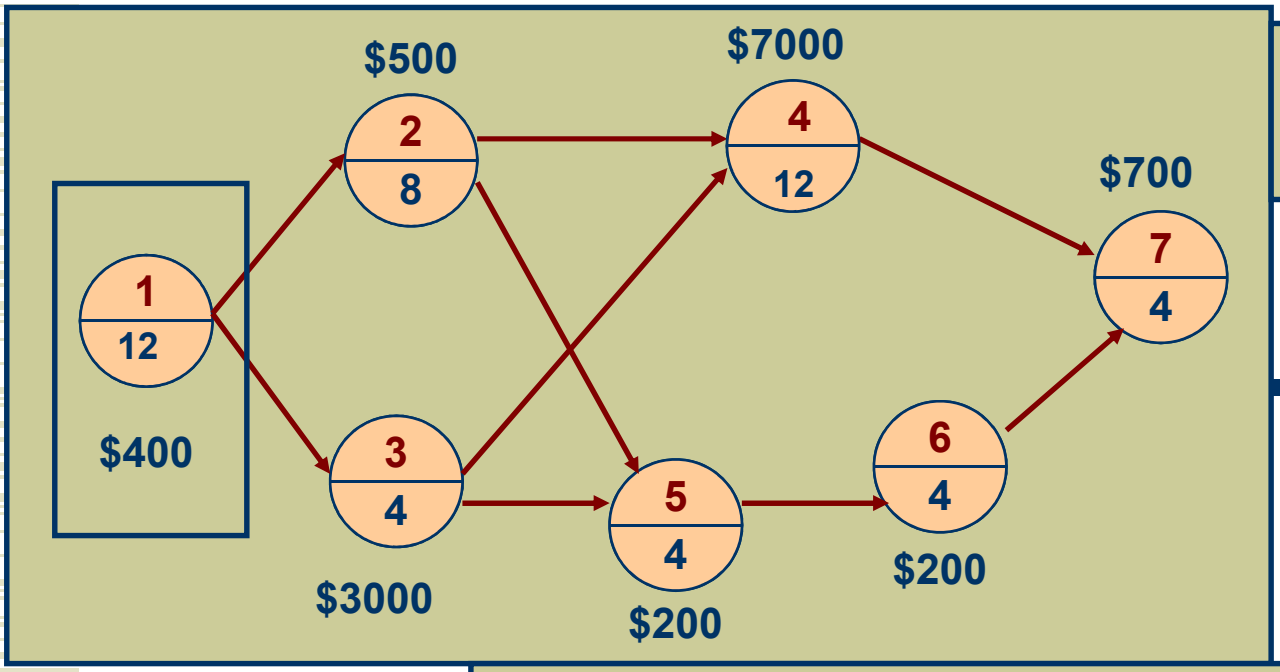


Normal Time and Cost vs. Crash Time and Cost



Project Crashing: Example

ACTIVITY	NORMAL TIME (WEEKS)	CRASH TIME (WEEKS)	NORMAL COST	CRASH COST	TOTAL ALLOWABLE CRASH TIME (WEEKS)	CRASH COST PER WEEK
1	12	7	$3,000	$5,000	5	$400
2	8	5	2,000	3,500	3	500
3	4	3	4,000	7,000	1	3,000
4	12	9	50,000	71,000	3	7,000
5	4	1	500	1,100	3	200
6	4	1	500	1,100	3	200
7	4	3	15,000	22,000	1	7,000
			$75,000	$110,700		

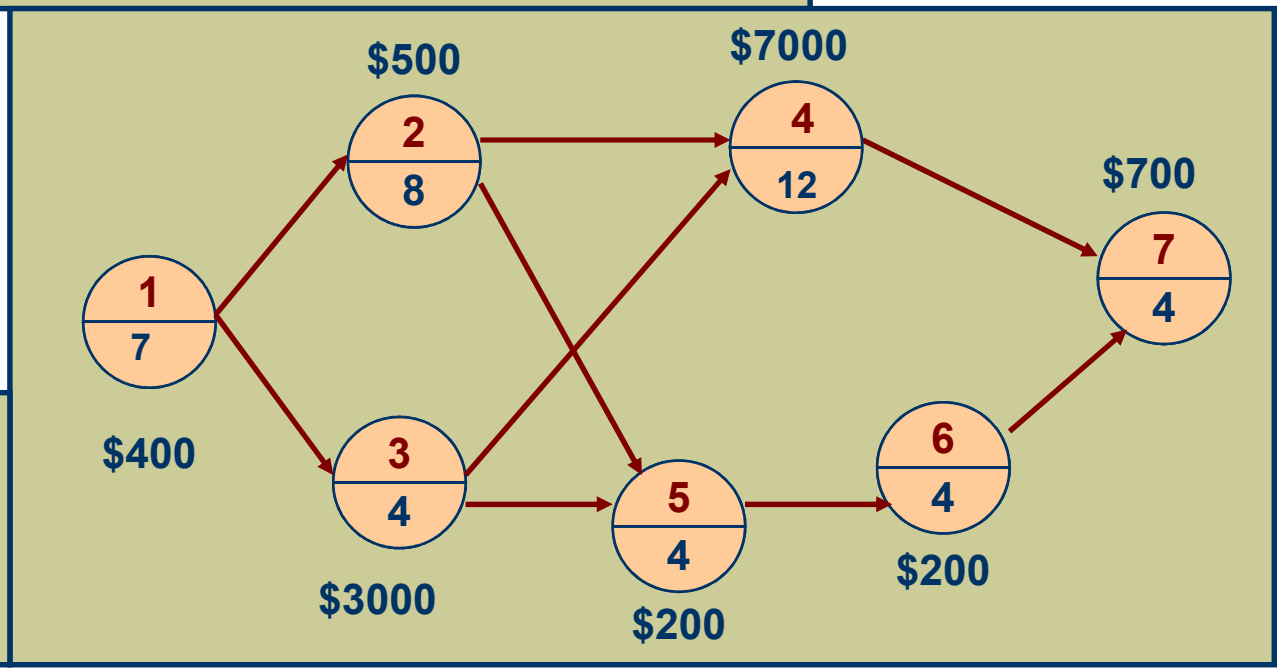


Project Duration: 36 weeks

FROM …

TO…

Project Duration: 31 weeks
Additional Cost: $2000



Time-Cost Relationship

- Crashing costs increase as project duration decreases
- Indirect costs increase as project duration increases
- Reduce project length as long as crashing costs are less than indirect costs

Time-Cost Tradeoff