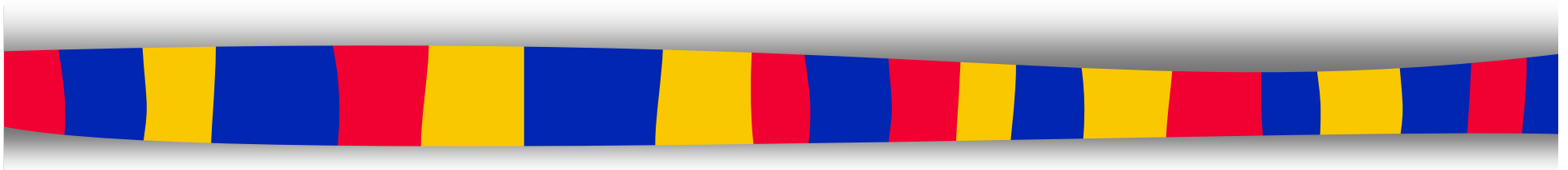


CISC 322

Software Architecture



Project Scheduling (PERT/CPM)

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(Edited For Course Presentation, 2016)

Project

- A project is
 - a temporary endeavour undertaken to create a "unique" product or service
- A project is composed of
 - a number of related activities that are directed to the accomplishment of a desired objective
- A project starts when
 - at least one of its activities is ready to start
- A project is completed when
 - all of its activities have been completed

Activity

- An activity
 - Must have a clear start and a clear stop
 - Must have a duration that can be forecasted
 - May require the completion of other activities before it begins
 - should have some ‘deliverables’ for ease of monitoring

Project plan

- A project plan is a schedule of activities indicating
 - The start and stop for each activity. The start and stop of each activity should be visible and easy to measure
 - When a resource is required
 - Amount of required project resources

Project Planning

- Managers should consider:
 - Resource availability
 - Resource allocation
 - Staff responsibility
 - Cash flow forecasting
- Managers need to monitor and re-plan as the project progresses towards its pre-defined goal

Work Breakdown Structure (WBS)

- Contains a list of activities for a project derived from
 - Previous experience
 - Expert brainstorming
- WBS helps in
 - identifying the main activities
 - break each main activity down into sub-activities which can further be broken down into lower level sub-activities
- WBS problems:
 - Too many levels
 - Too few levels

Project Scheduling

■ Steps

- Define activities
- Sequence activities
- Estimate time
- Develop schedule

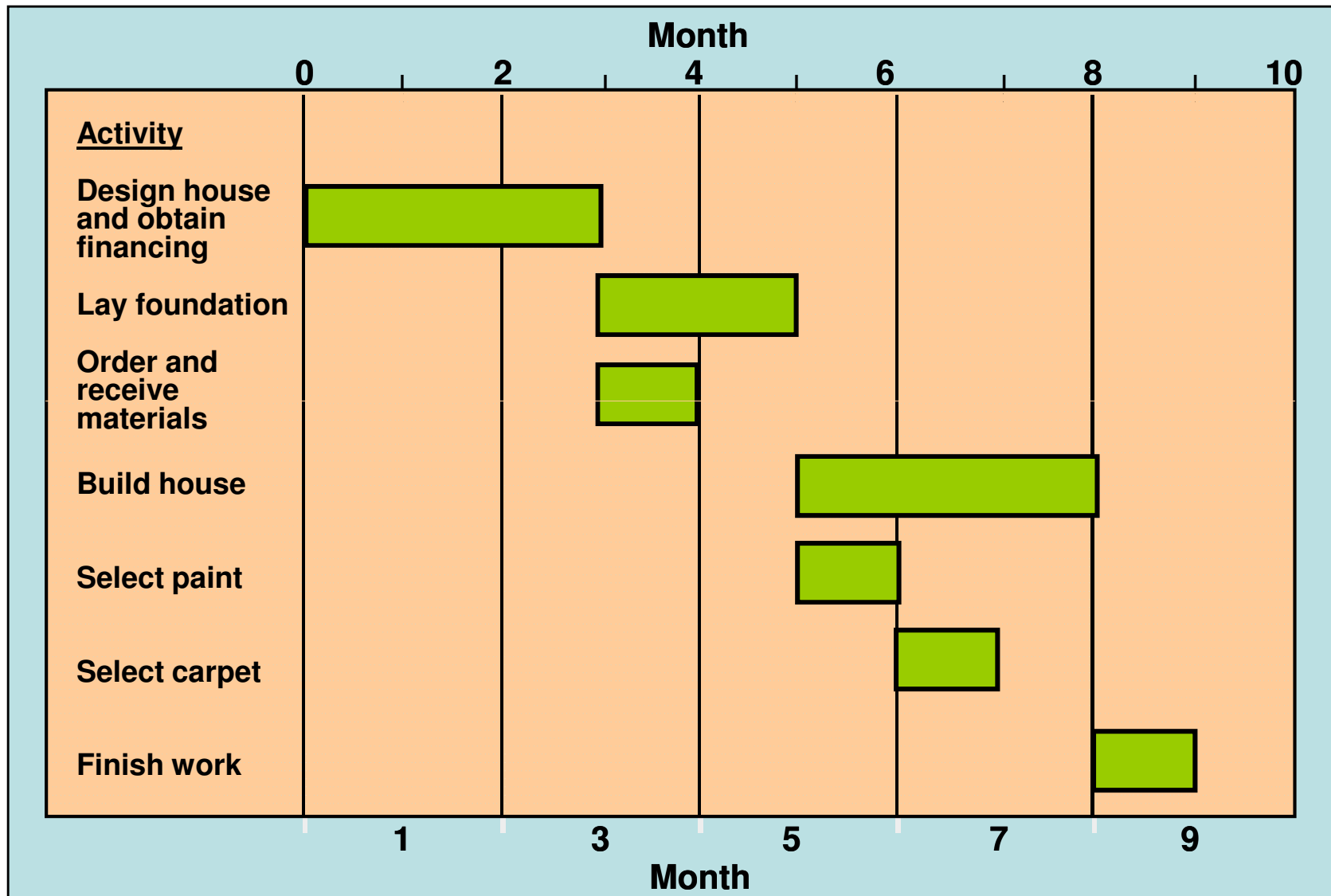
■ Techniques

- Gantt chart
- CPM
- PERT
- Microsoft Project

Gantt Chart

- Developed in 1918 by H.L. Gantt
- Graph or bar chart with a bar for each project activity that shows passage of time
- Provides visual display of project schedule
- Limitations
 - Does not clearly indicate details regarding the progress of activities
 - Does not give a clear indication of interrelation between the activities

Example of Gantt Chart



Activity Description

An Activity Description Table is used when describing a project, for the purposes of doing project management analysis. The Activity Description Table for the House Building example is below.

Task Number	Task Description	Duration of Task	Predecessor Task
1	Design house & obtain financing	3	-
2	Lay foundation	2	Task 1
3	Order & receive materials	1	Task 1
4	Build house	3	Task 2 ,3
5	Select paint	1	Task 2 ,3
6	Select carpet	1	Task 5
7	Finish work	1	Task 4 ,6

PERT/CPM

■ **PERT (Program Evaluation and Review Technique)**

- Developed by U.S. Navy for Polaris missile project
- Developed for R&D projects where activity times are generally uncertain

■ **CPM (Critical Path Method)**

- Developed by DuPont & Remington Rand
- Developed for industrial projects where activity times are generally known

PERT/CPM

- CPM and PERT have been used to plan, schedule, and control a wide variety of projects:
 - R&D of new products and processes
 - Construction of buildings and highways
 - Maintenance of large and complex equipment
 - Design and installation of new systems

Program Evaluation and Review Technique (PERT)

- Primary objectives:
 - Shortest possible time
 - Coping with uncertain activity completion times, e.g.:
 - For a particular activity
 - The most likely completion time is 4 weeks but
 - It could be anywhere between 3 weeks and 8 weeks
- Developed by the US Navy for the planning and control of the Polaris missile program

Critical Path Method (CPM)

- Primary objectives:
 - Plan for the fastest completion of the project
 - Identify activities whose delays is likely to affect the completion date for the whole project
 - Very useful for repetitive activities with well known completion time
- Developed by Du Pont Chemical Company and published in 1958
 - Can we decrease the completion time by spending more money

CPM Calculation

- The forward pass
 - calculate the **earliest** start dates of the activities
 - to calculate the project completion date
- The backward pass
 - calculate the **latest** start dates for activities
 - to identify the critical path from the graph

Critical Path and Events

- Critical event: an event that has zero *slack*
- Critical path: a path joining those critical events
- Benefit of Critical Path Analysis:
 - During planning stage
 - Shortening the critical path will reduce the overall project duration
 - During management stage
 - Pay more attention to those activities which fall in the critical path

Activity Float

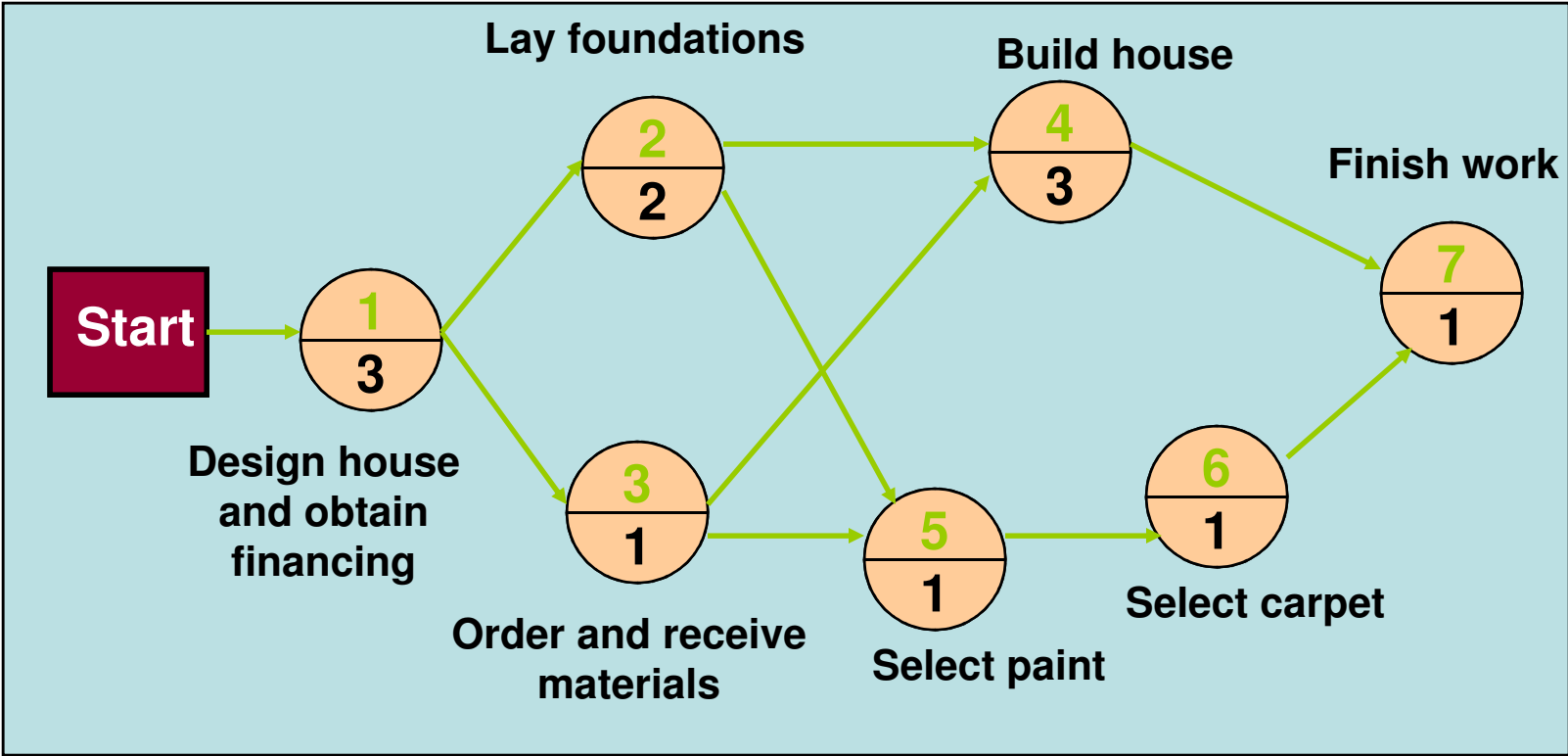
- Time allowed for an activity to delay
- 3 different types:
 - Total float** (without affecting project completion)
= latest start date – earliest start date
 - Free float** (without affecting the next activity)
= earliest start date of *next* activity – latest end date of *previous* activity
 - Interfering float** = total float - free float

Activity Description

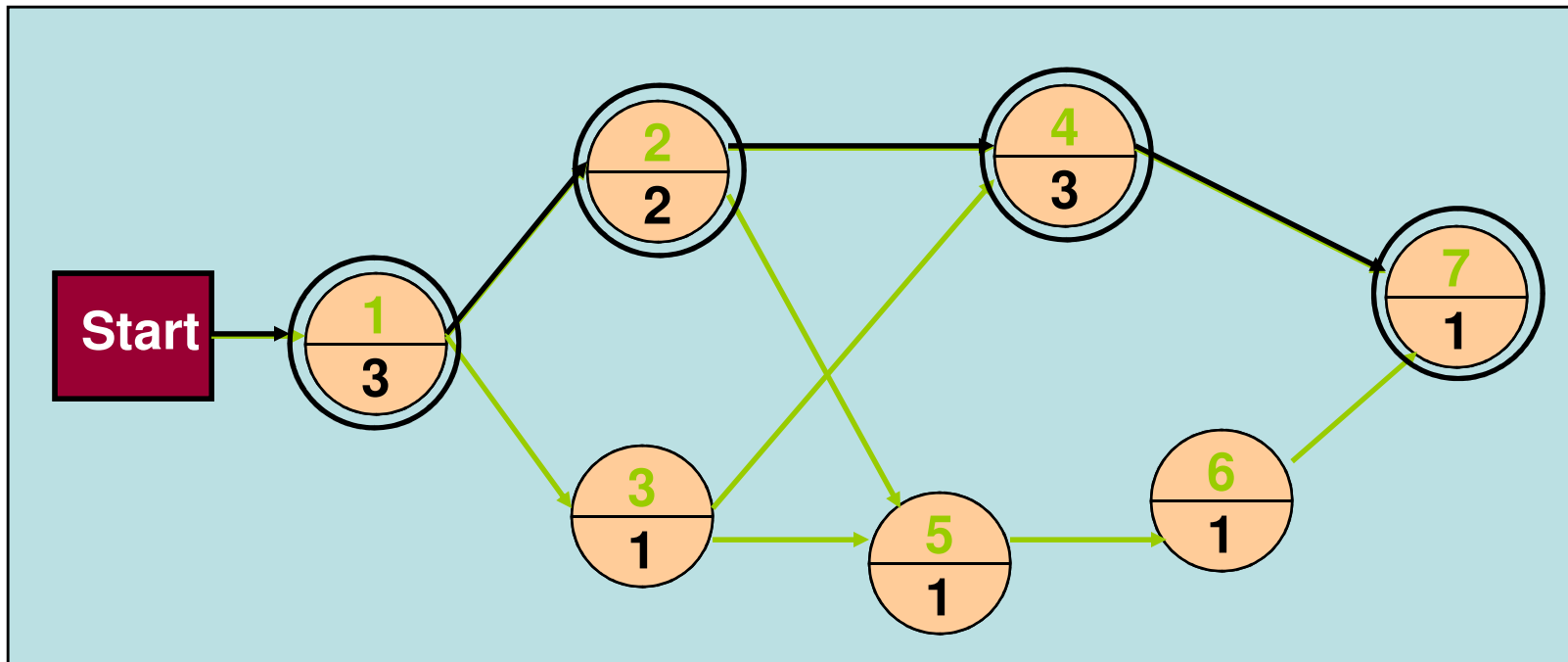
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Scheduling Network for House Building Project



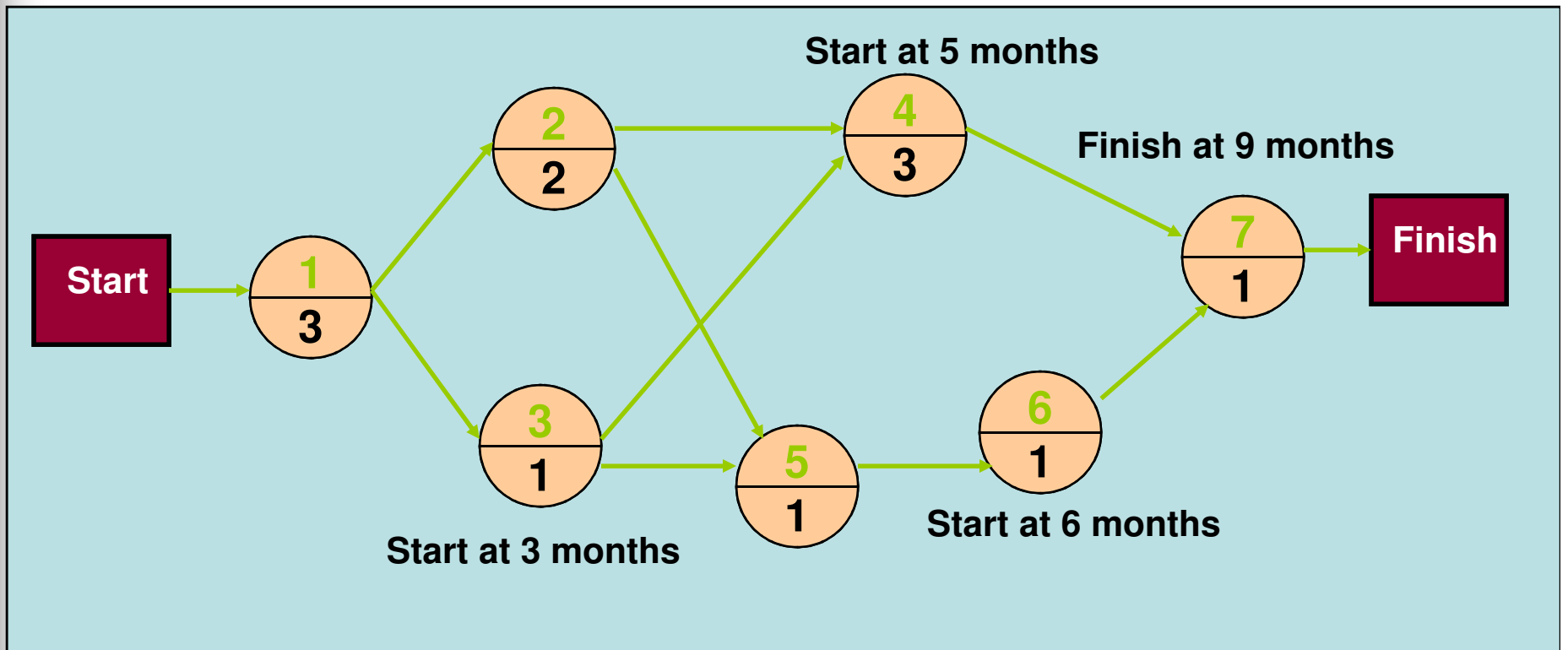
Critical Path



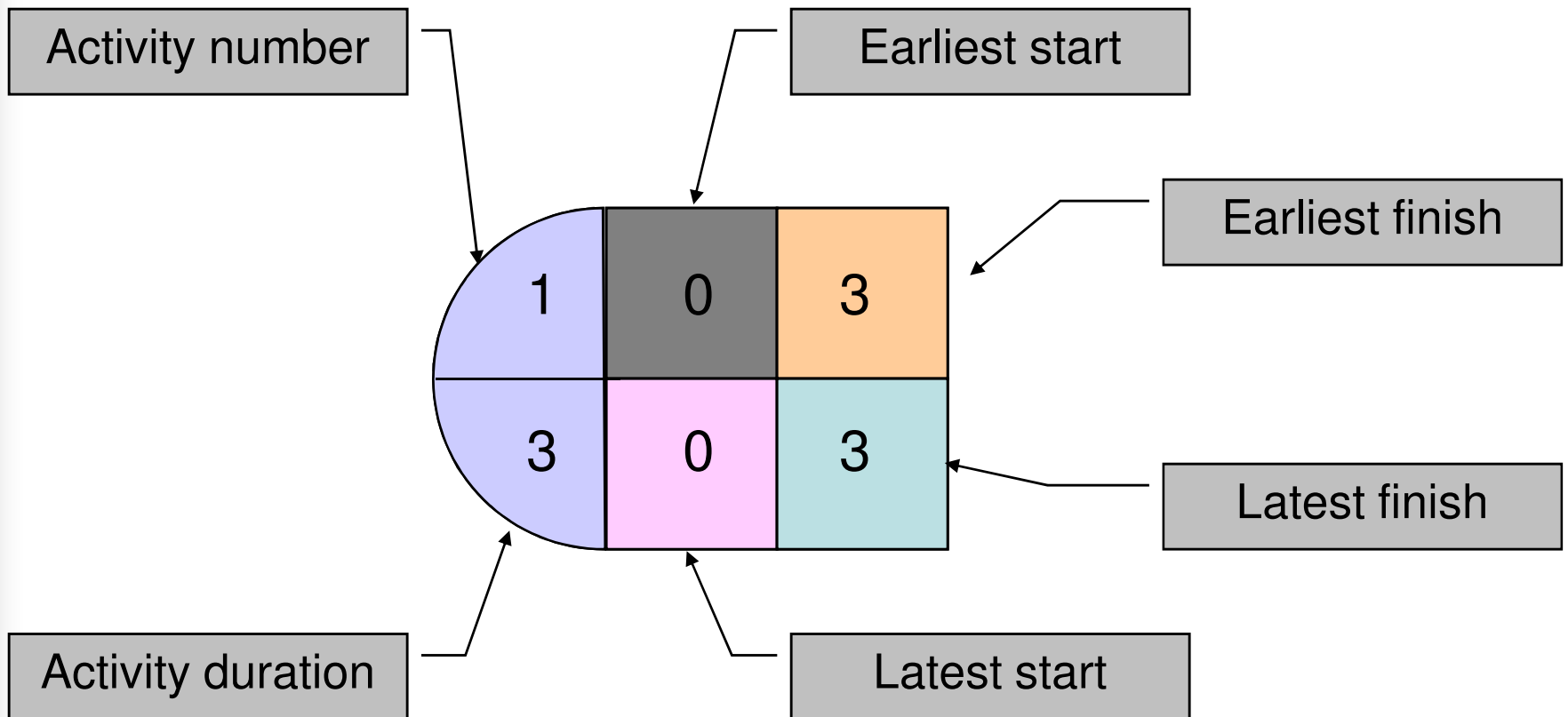
- A: 1-2-4-7
 $3 + 2 + 3 + 1 = 9$ months
- B: 1-2-5-6-7
 $3 + 2 + 1 + 1 + 1 = 8$ months
- C: 1-3-4-7
 $3 + 1 + 3 + 1 = 8$ months
- D: 1-3-5-6-7
 $3 + 1 + 1 + 1 + 1 = 7$ months

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

Activity Start Times



Mode Configuration

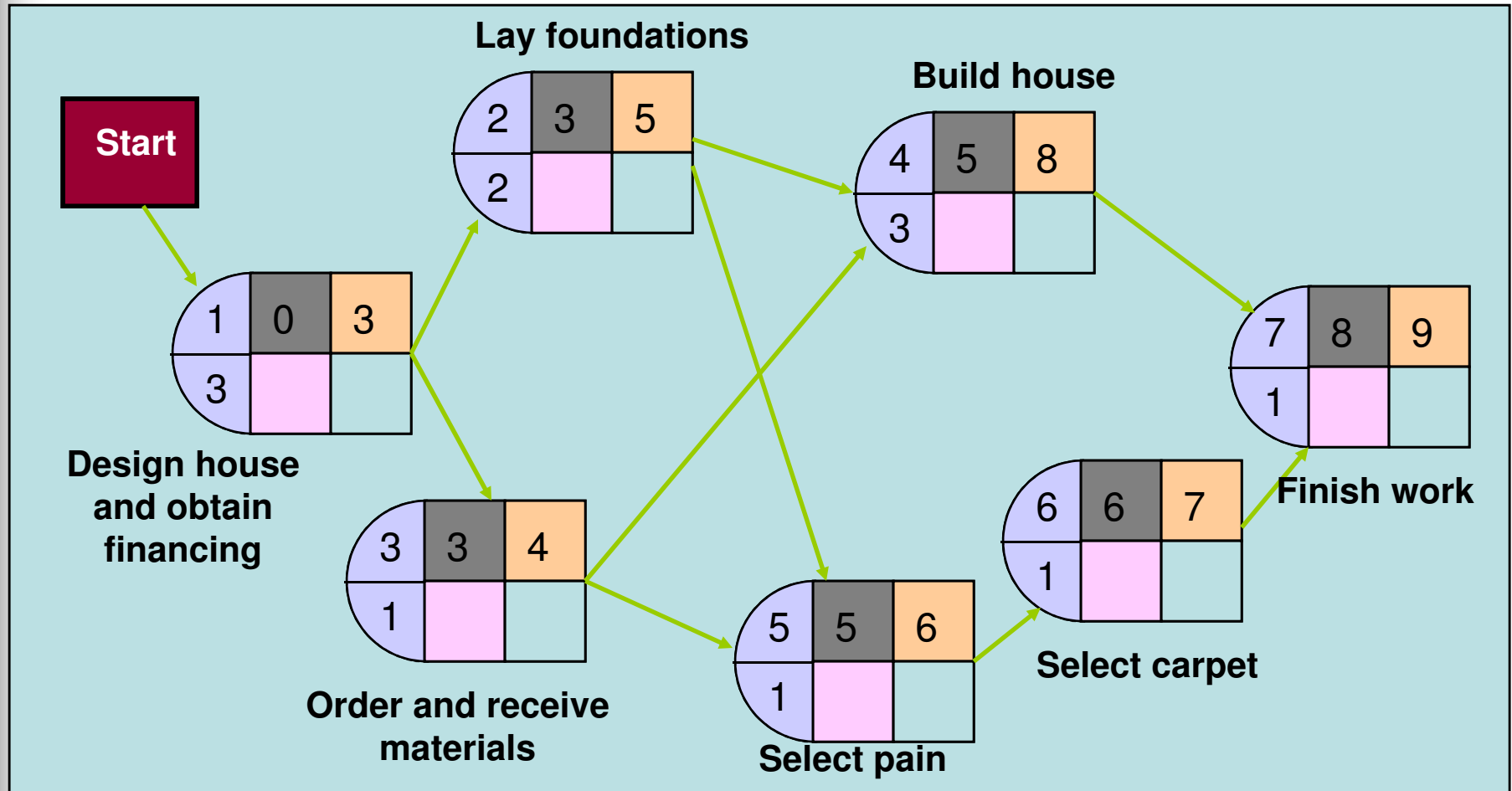


Forward Pass

- Start at the beginning of CPM/PERT network to determine the earliest activity times
- Earliest Start Time (ES)
 - earliest time an activity can start
 - ES = maximum EF of immediate predecessors
- 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



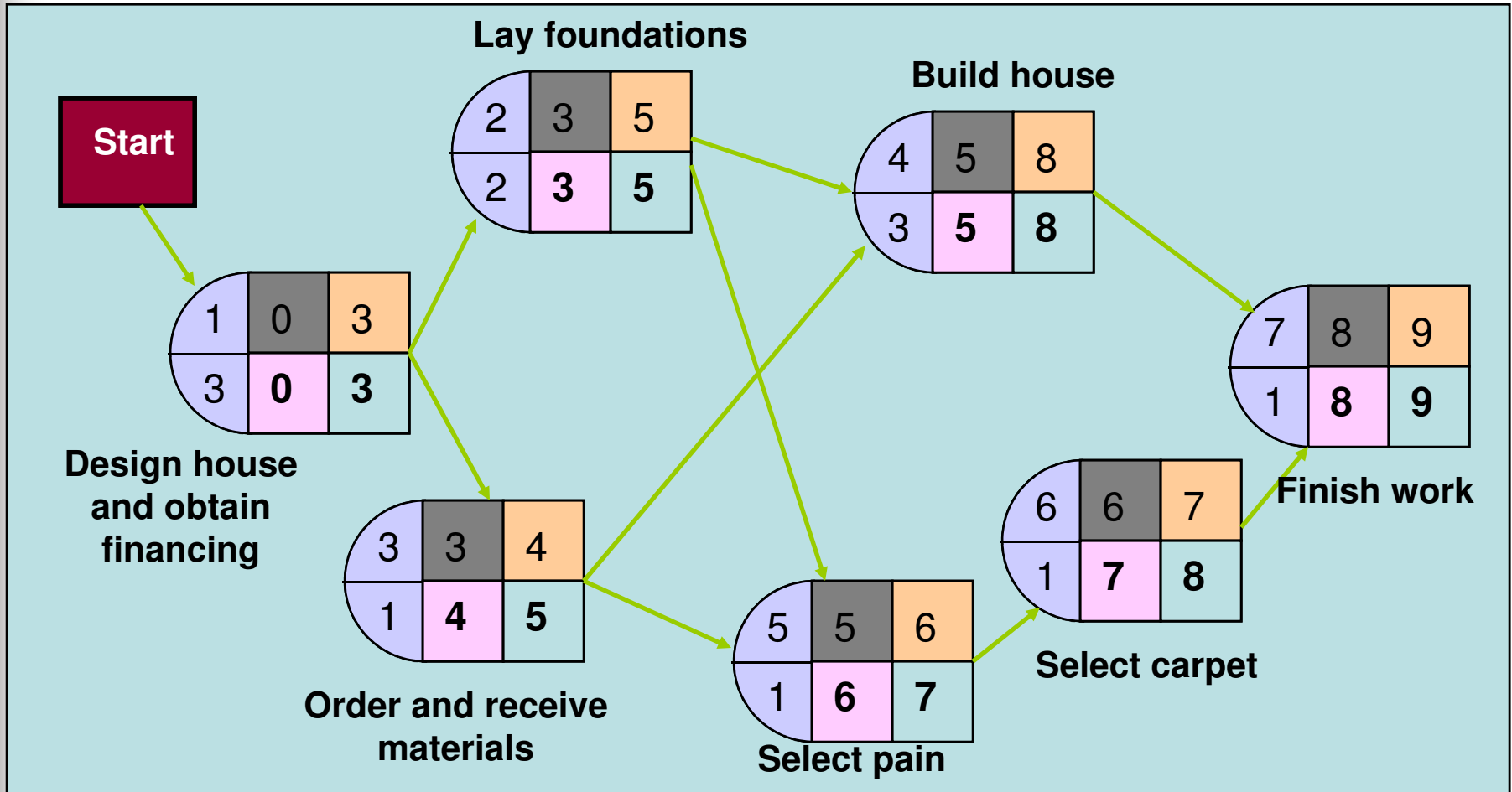
Backward Pass

- Determines latest activity times by starting at the end of CPM/PERT network and working backward
- 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

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					

Slack: amount of time an activity can be delayed without delaying the project

$$\text{activity slack} = LS - ES = LF - EF$$

Critical activities: have zero slack and lie on a critical path.

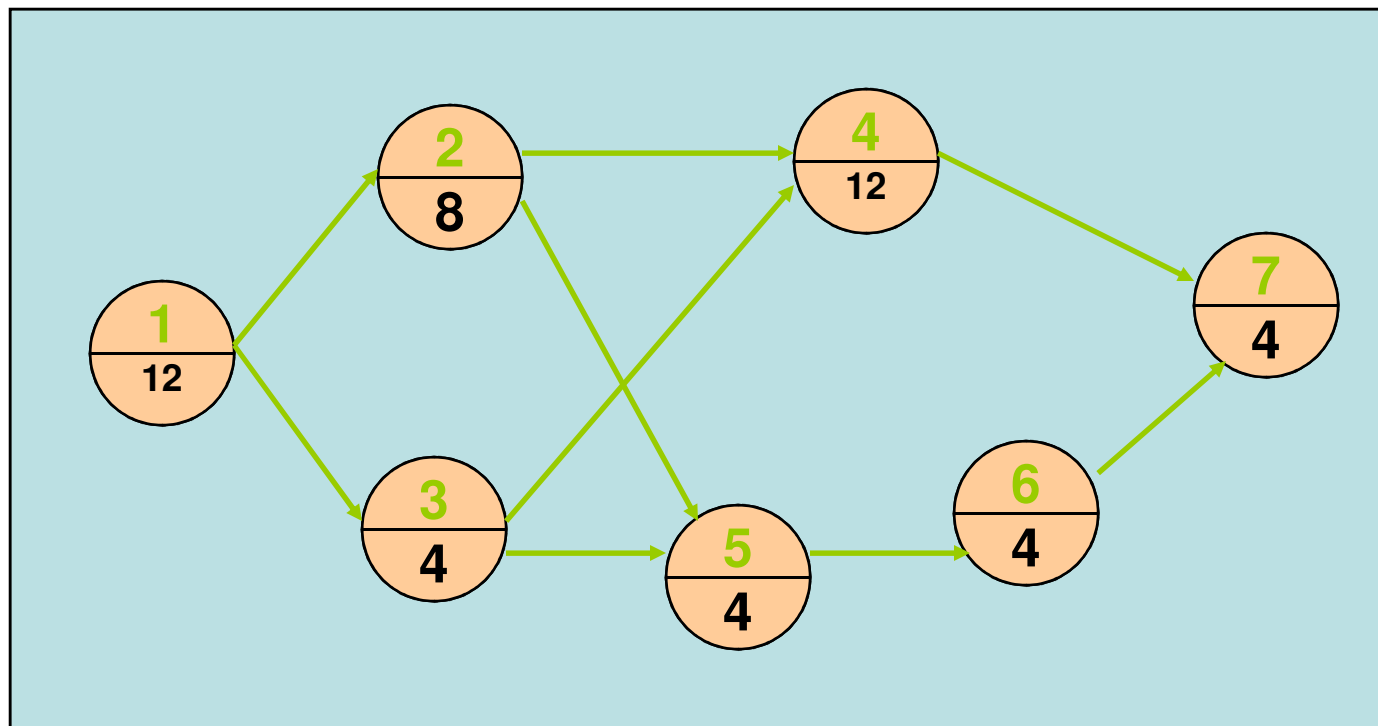
Limitations of PERT/CPM

- Assumes clearly defined, independent activities
- Specified precedence relationships
- Activity times (PERT) follow beta distribution
- Subjective time estimates
- Over-emphasis on critical path
 - Monte Carlo Simulations

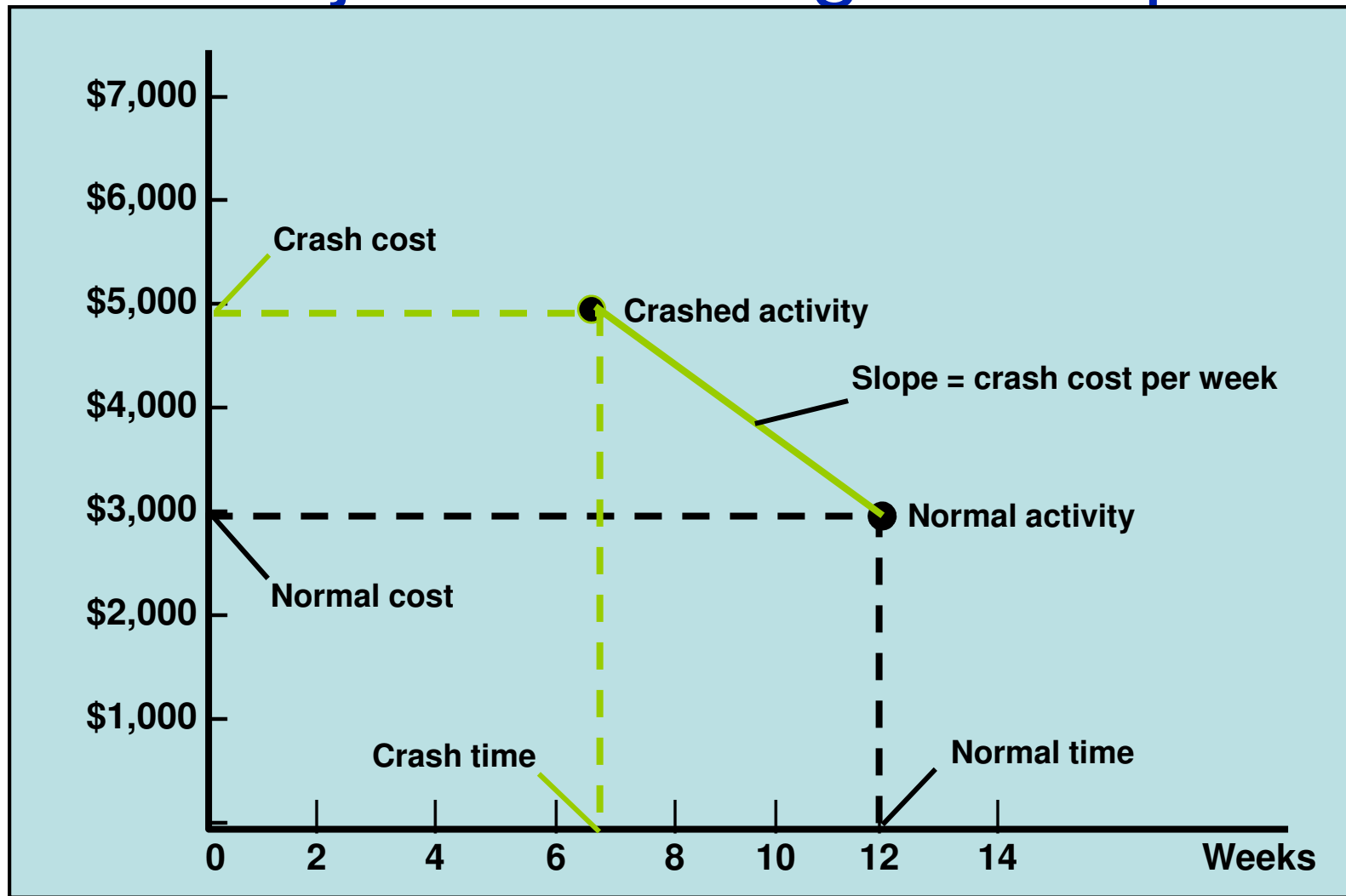
Project Crashing

- 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 Crashing: Example

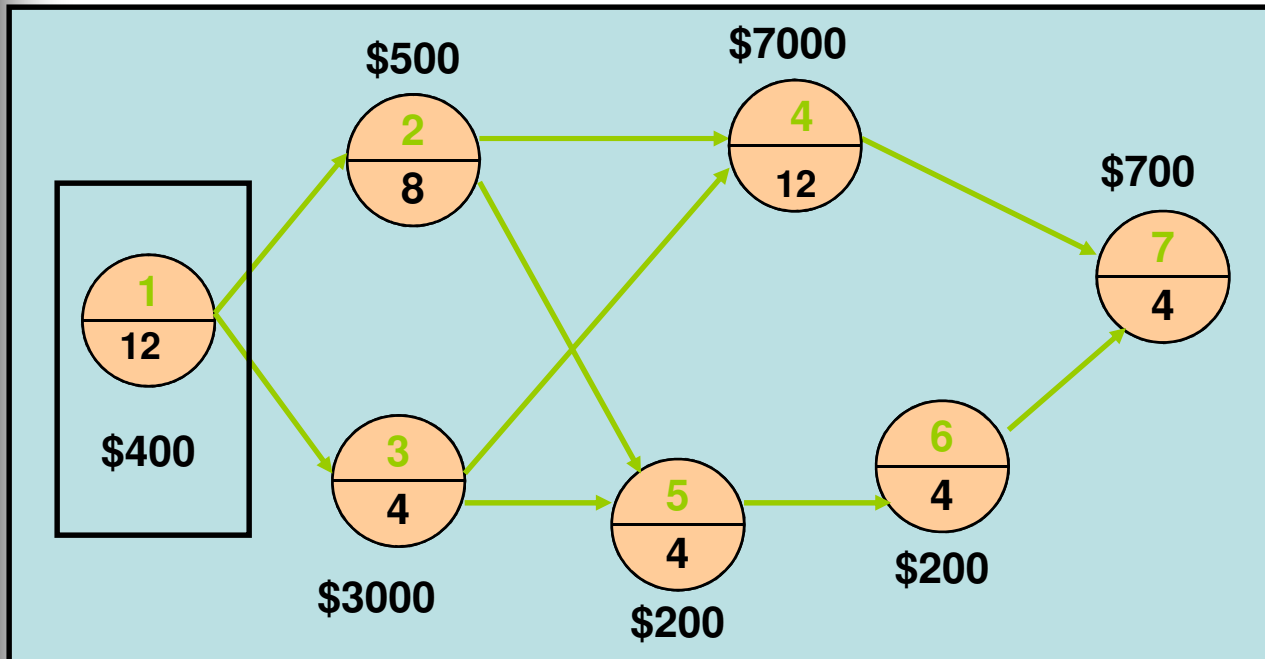


Project Crashing: Example



Normal Activity and Crash Data

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
			<u>\$75,000</u>	<u>\$110,700</u>		

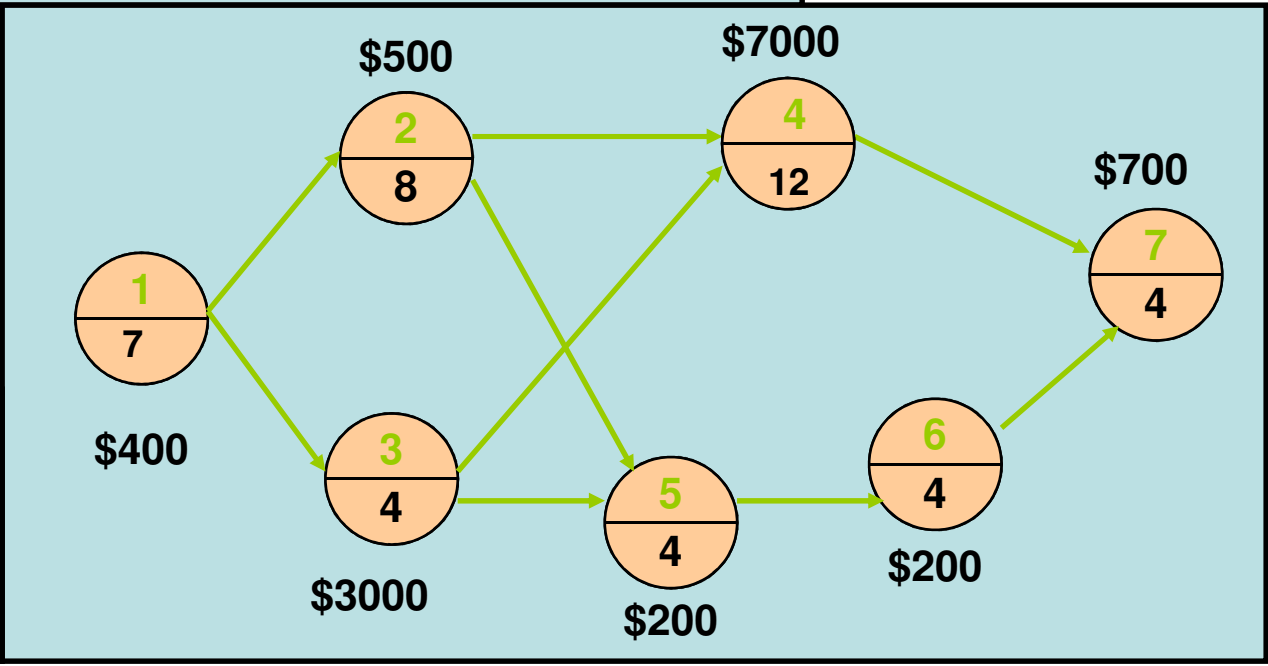


**Project Duration:
36 weeks**

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

