

# Project Management



# Overview

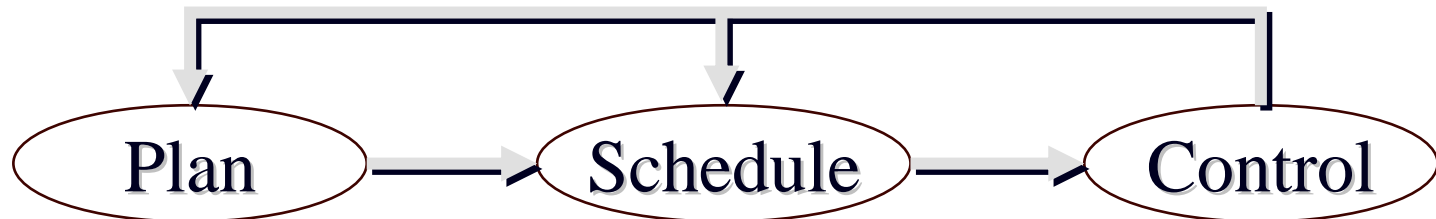
- Characteristics of a Project
- Project Management
- Project-Planning and Control Techniques
- Computer Software for Project Management
- An Evaluation of CPM/PERT
- Wrap-Up: What World-Class Companies Do

# Characteristics of a Project

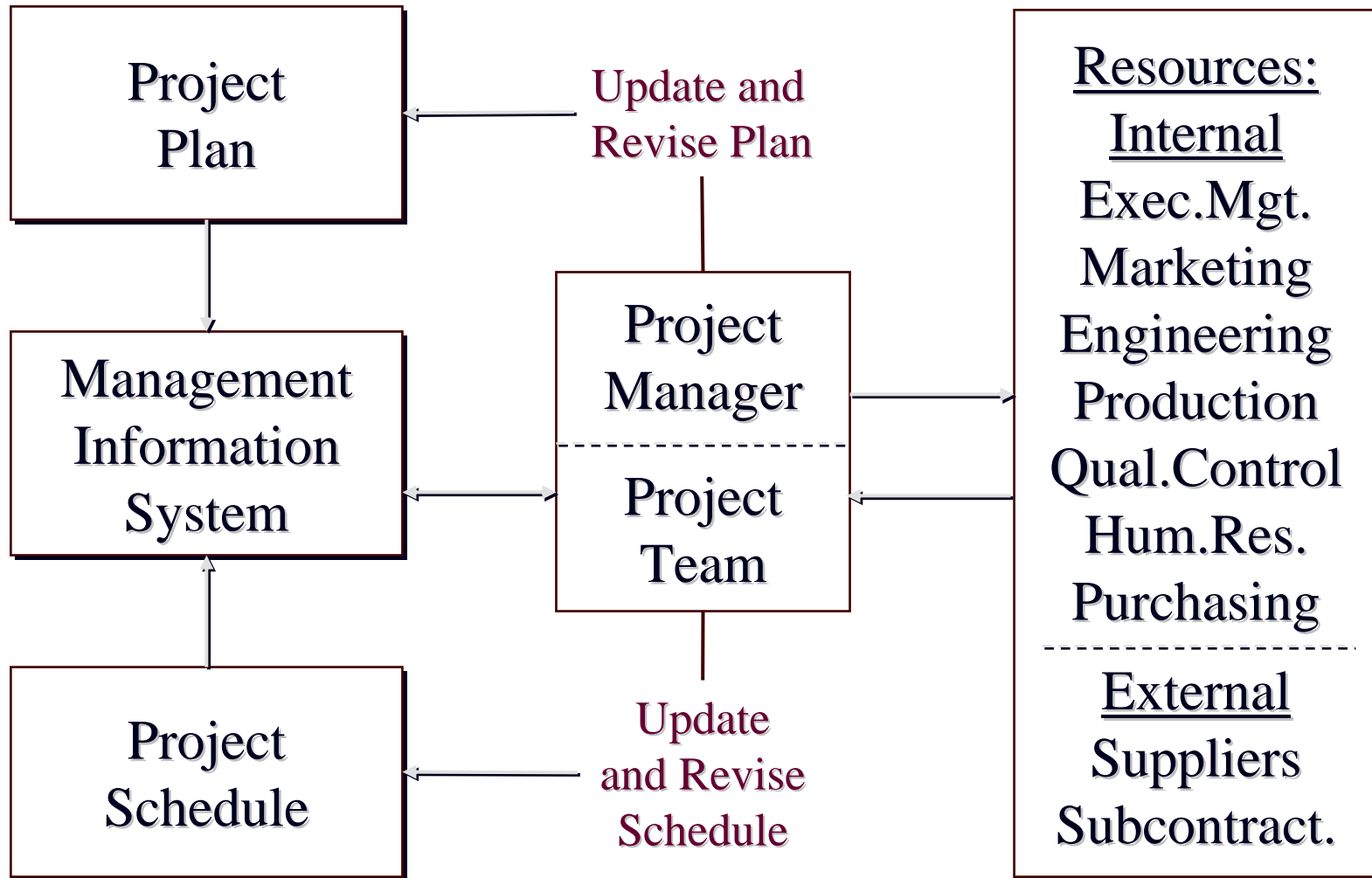
- A unique, one-time effort
- Requires the completion of a large number of interrelated activities
- Resources, such as time and/or money, are limited
- Typically has its own management structure

# Project Management

- A project manager is appointed to head the project management team
- The team members are drawn from various departments and are temporarily assigned to the project
- The team is responsible for planning, scheduling and controlling the project to its completion



# Project Team



# Planning Projects

- Tasks:
  - Develop internal and external resource requirements and time-phase them to the project activities
- Means of Task Accomplishment:
  - Activity descriptions, milestone charts, cash flow charts, CPM/PERT, engineering designs, time and cost estimates, material delivery plans, and so on.
- Timing of Tasks:
  - Before project is begun and modified as required during project

# Scheduling Projects

- Tasks:
  - Develop/revise detailed guides for each resource indicating quantity, quality, and timing
- Means of Task Accomplishment:
  - Milestone charts for departments, subcontractors, and suppliers; cash flow schedule; CPM/PERT: begin-activity and complete-activity dates, and updated activity slack
- Timing of Tasks:
  - Slightly before project is begun and continued throughout project

# Controlling Projects

- Tasks:
  - Sense noncompliance of resources with schedules, standards, and budgets; take corrective actions, shift resources, develop alternatives
- Means of Task Accomplishment:
  - Department budget reports, activity cost reports, quality compliance reports, time performance reports
- Timing of Tasks:
  - During project

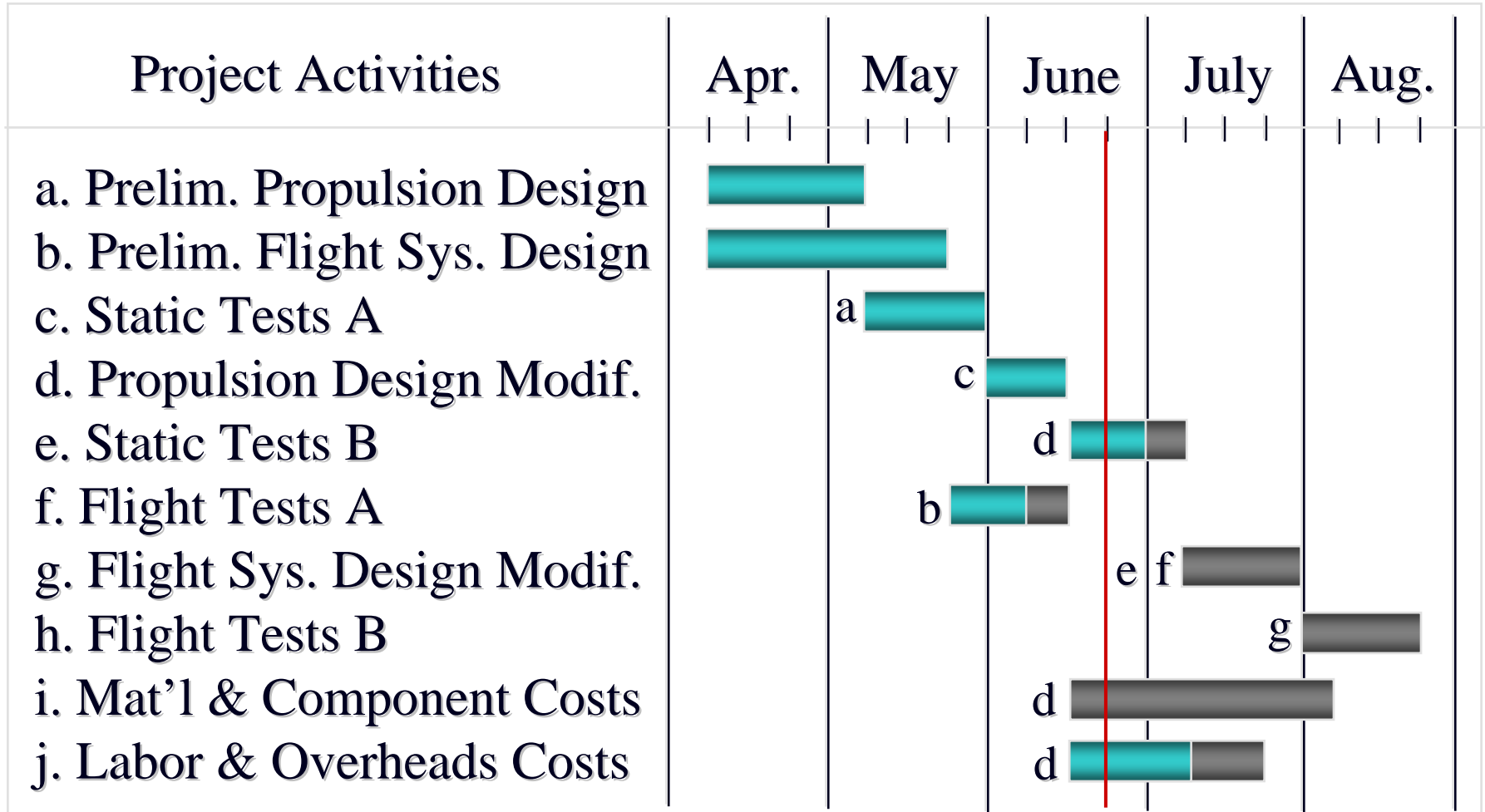
# Scheduling and Control Charts

- Horizontal Bar Charts
  - A version of the Gantt chart
  - Used to plan and schedule activities
  - As the project progresses, the status of activities is plotted on the chart, compared to the plan, and, if necessary, corrective action is taken
  - ... more

# Scheduling and Control Charts

- Horizontal Bar Charts (continued)
  - Advantages
    - Easy to understand
    - Easy to modify and update
    - Low cost
  - Disadvantages
    - Cumbersome for large project
    - Must be keep up to date
    - Does not indicate the relationships among the activities

# Horizontal Bar Chart



# Critical Path Method (CPM)

- Designed to provide intense micro-control
- The system is dynamic; it continues to provide periodic reports as the project progresses

# Manager's View of CPM

## INPUTS

- List of project activities
- Precedence relationship among activities
- Estimate of each activity's duration

CPM processing procedures

## OUTPUTS

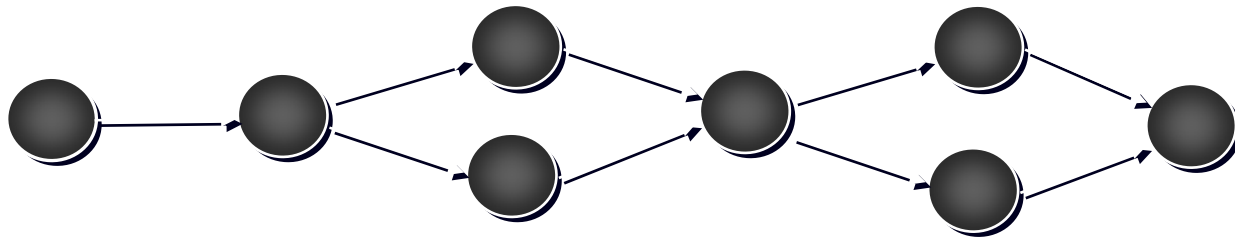
- Estimated duration of project
- Identification of critical activities
- Amount of slack for each activity

# CPM Terminology

- Activity
  - A task or a certain amount of work required in the project
  - Requires time to complete
  - Represented by an arrow
- Dummy Activity
  - Indicates only precedence relationships
  - Does not require any time of effort

# CPM Terminology

- Event
  - Signals the beginning or ending of an activity
  - Designates a point in time
  - Represented by a circle (node)
- Network
  - Shows the sequential relationships among activities using nodes and arrows



# CPM Terminology

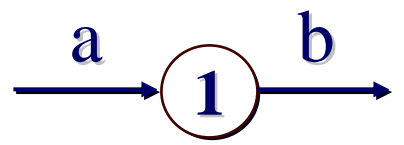
- Path
  - A connected sequence of activities leading from the starting event to the ending event
- Critical Path
  - The longest path (time); determines the project duration
- Critical Activities
  - All of the activities that make up the critical path

# CPM Terminology

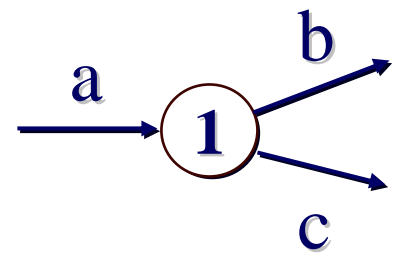
- Earliest Start (ES)
  - The earliest that an activity can begin; assumes all preceding activities have been completed
- Earliest Finish (EF)
  - $ES + \text{activity time}$
- Latest Finish (LF)
  - The latest that an activity can finish and not change the project completion time
- Latest Start (LS)
  - $LF - \text{activity time}$

# CPM Network Conventions

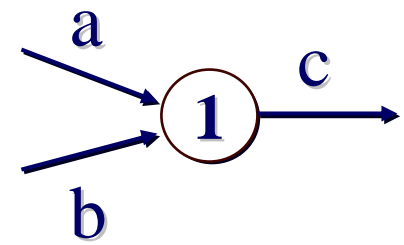
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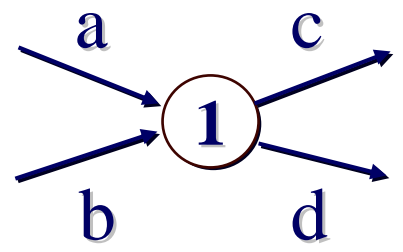
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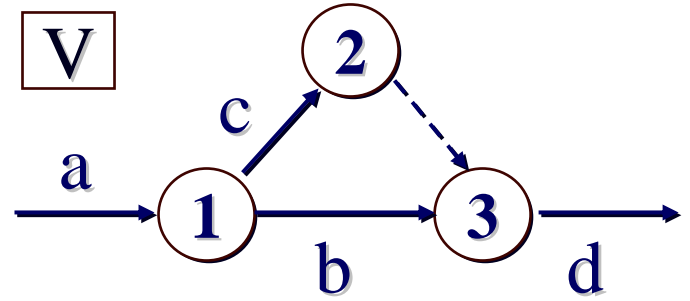
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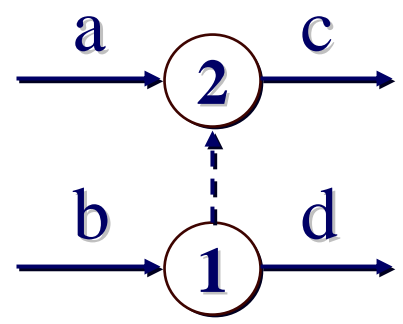
IV



V



VI



# Steps in CPM Analysis

- Draw the CPM network
  - A graphic view of the relationships among the required activities
- Analyze the paths through the network
  - Determine the length of each path (the time required to complete each path)
  - Starting at the beginning of the network and working toward the end (from left to right), determine the ES and the EF for each activity
  - . . . more

# Steps in CPM Analysis

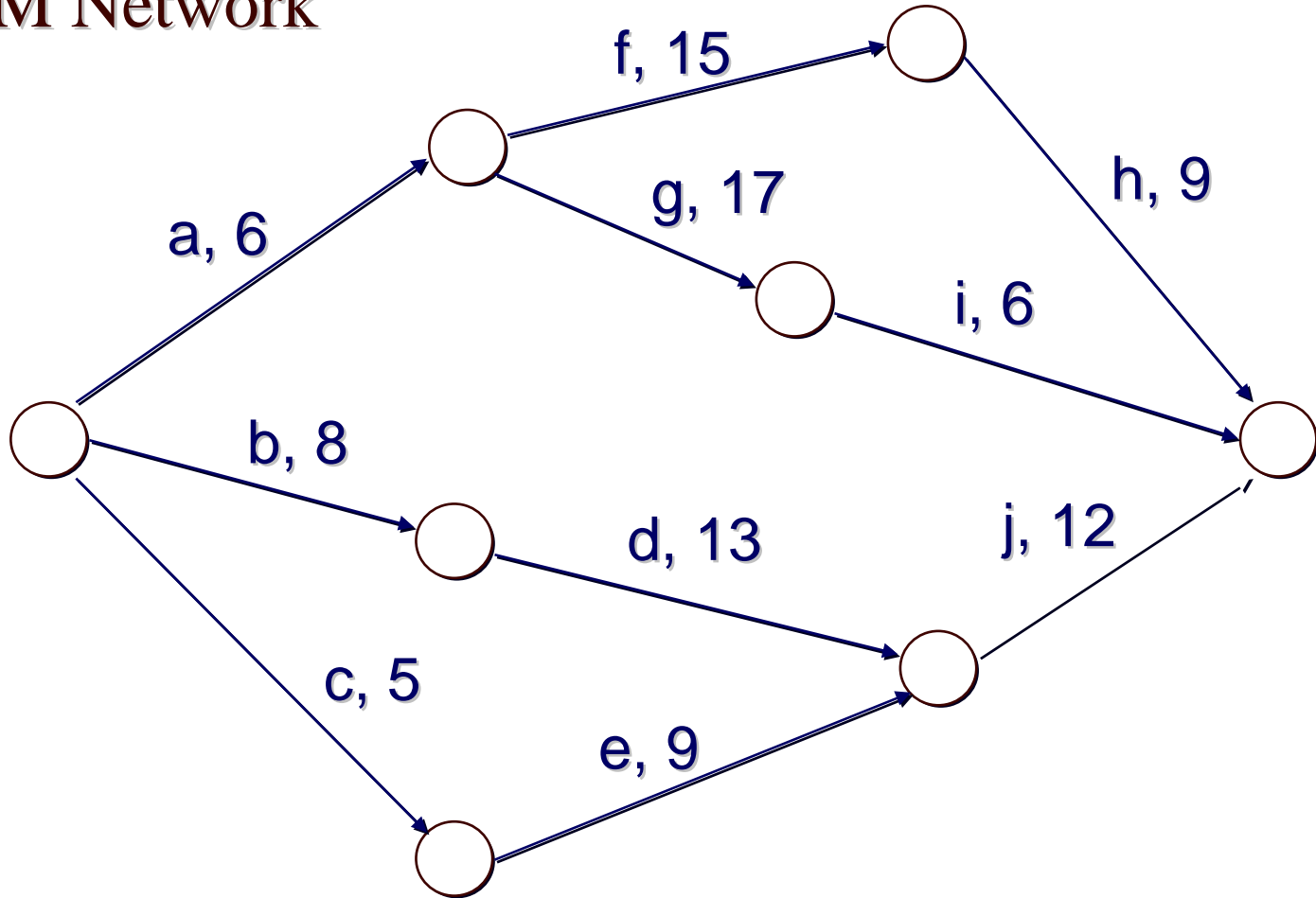
- Path analysis (continued)
  - Identify the critical path(s) (the longest path[s] through the network)
  - The critical path(s) determines how long the project will take
- . . . more

# Steps in CPM Analysis

- Determine the slack for each activity
  - Working from the end of the project network (from right to left), find the LF and the LS for each activity
  - Compute the activity's slack
$$\text{slack} = \text{LS} - \text{ES} = \text{LF} - \text{EF}$$
  - Slack is the maximum amount of time that this activity can be delay in its completion before it becomes a critical activity, i.e., delays completion of the project

# CPM Example

- CPM Network



# CPM Example

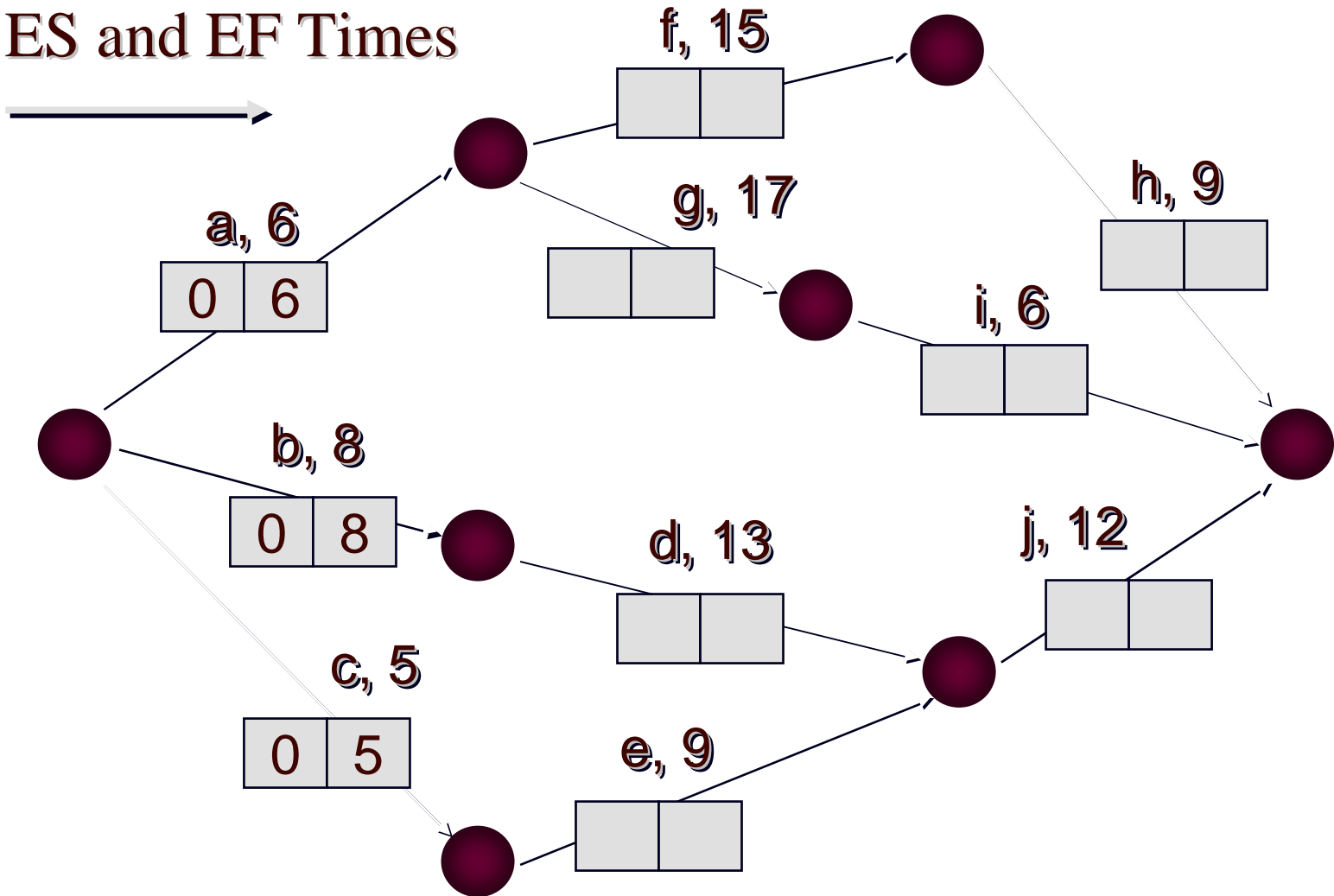
- Paths Enumerated

Path	Length of Path
a-f-h	$6 + 15 + 9 = 30$
a-g-I	$6 + 17 + 6 = 29$
b-d-j	$8 + 13 + 12 = 33^*$
c-e-j	$5 + 9 + 12 = 26$

\* Critical path

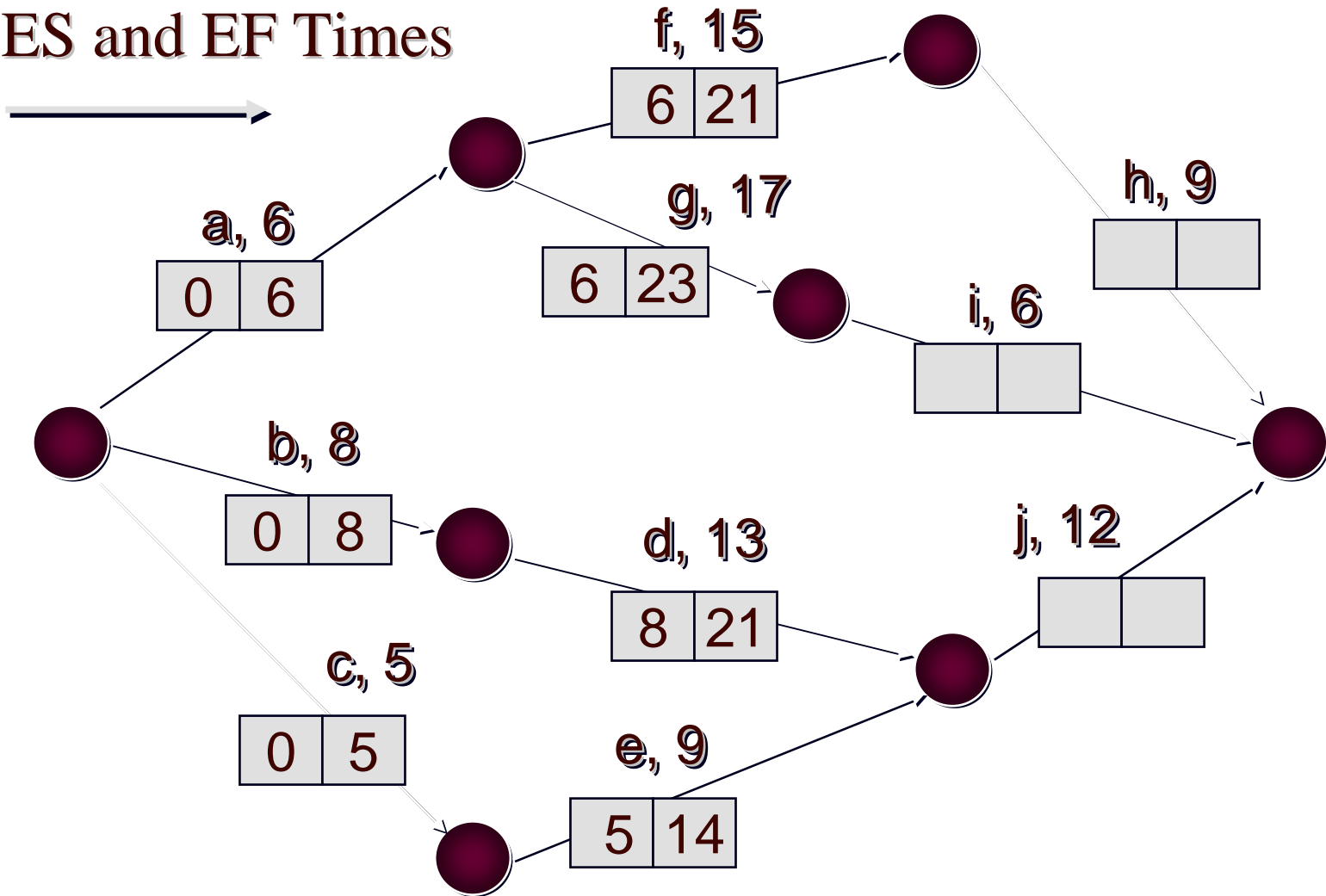
# CPM Example

- ES and EF Times



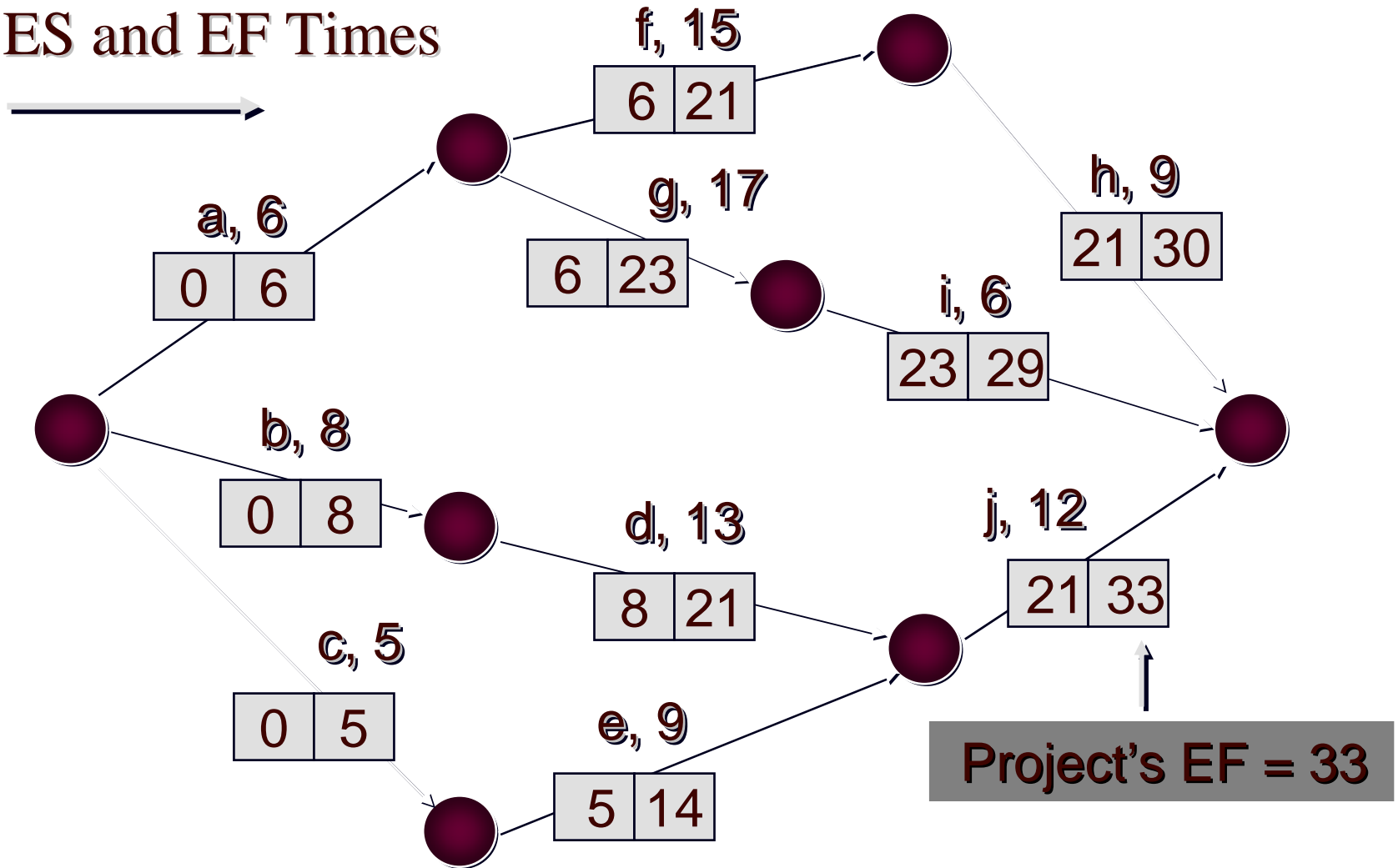
# CPM Example

- ES and EF Times



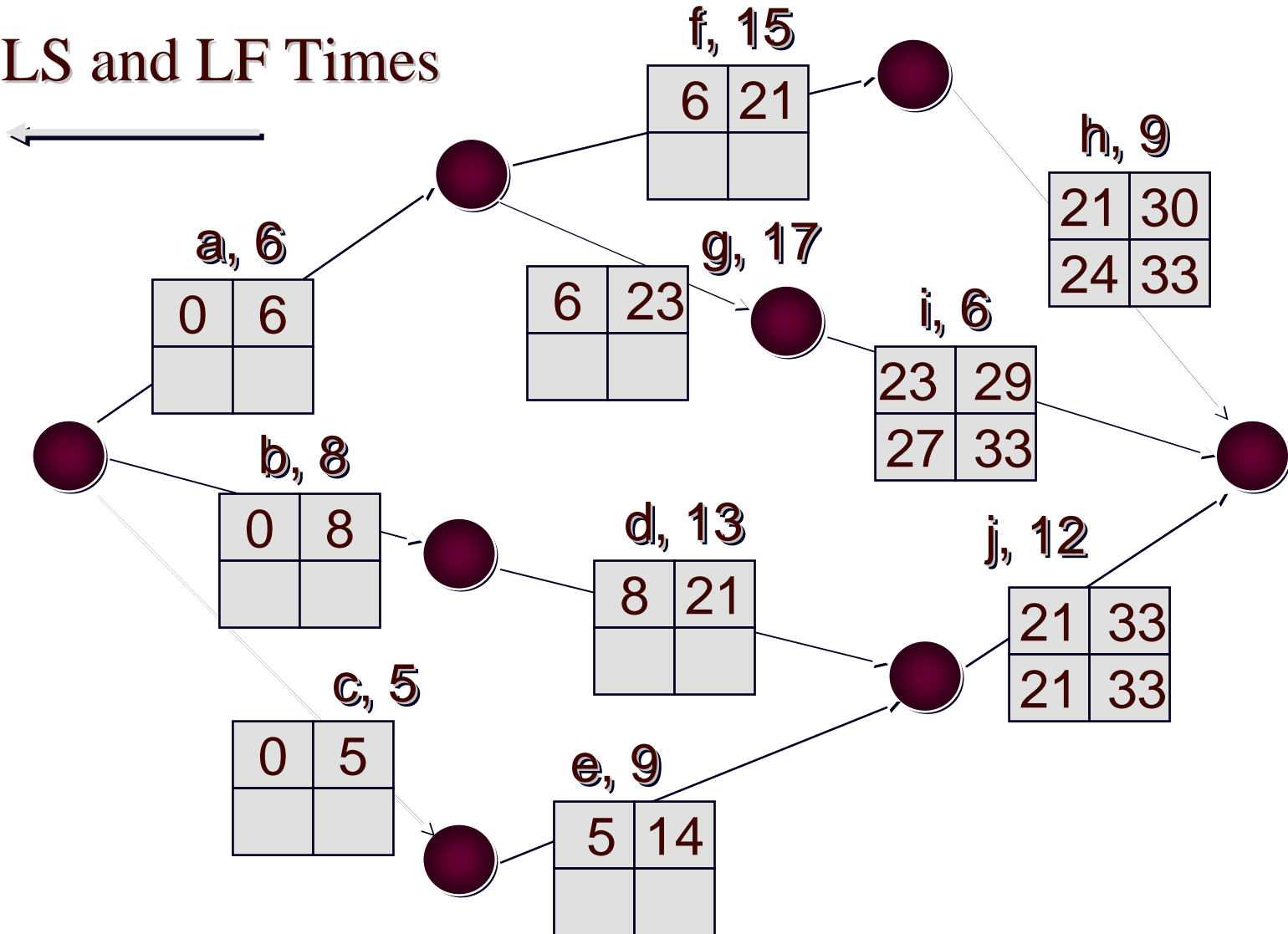
# CPM Example

- ES and EF Times



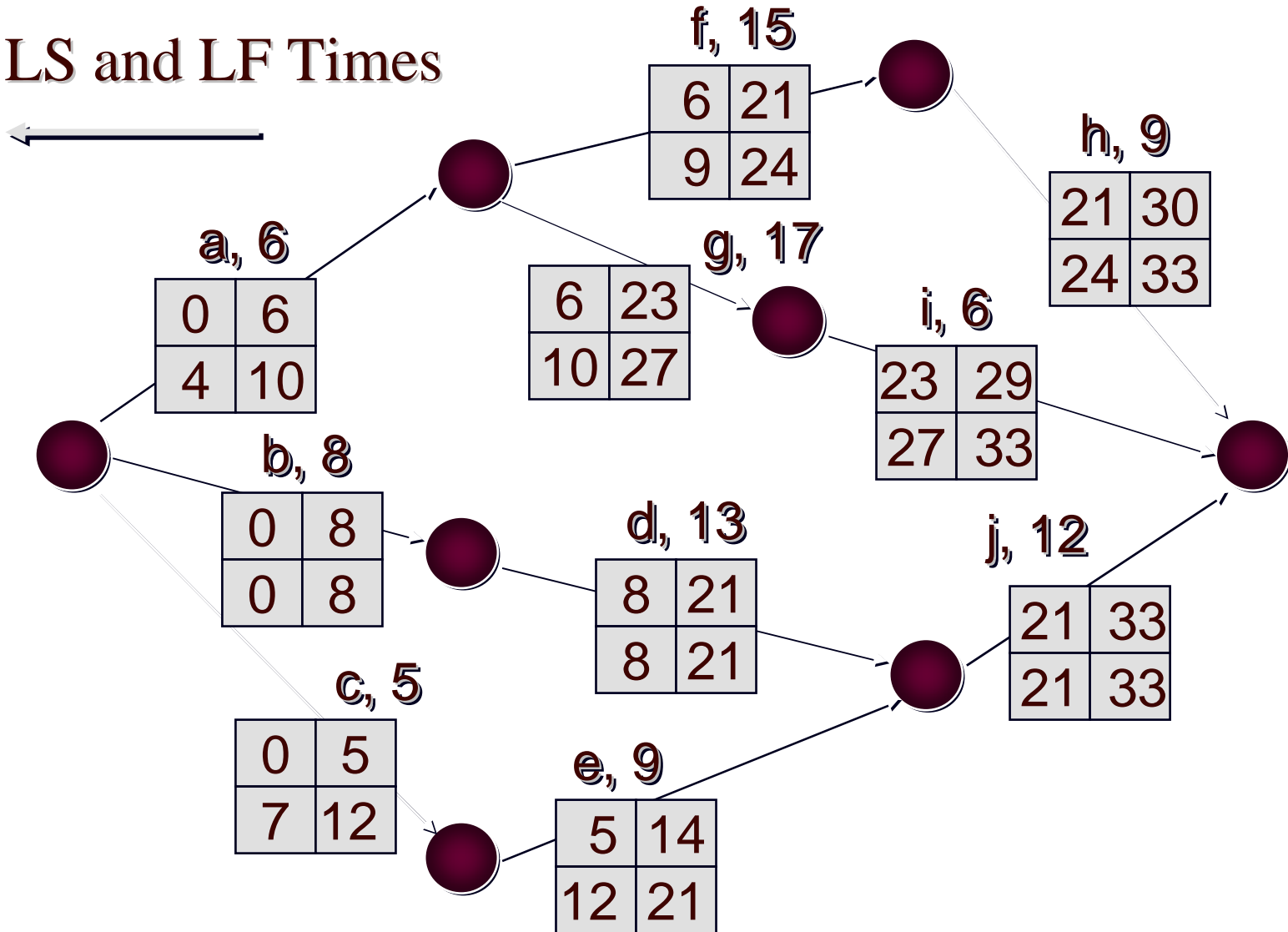
# CPM Example

- LS and LF Times



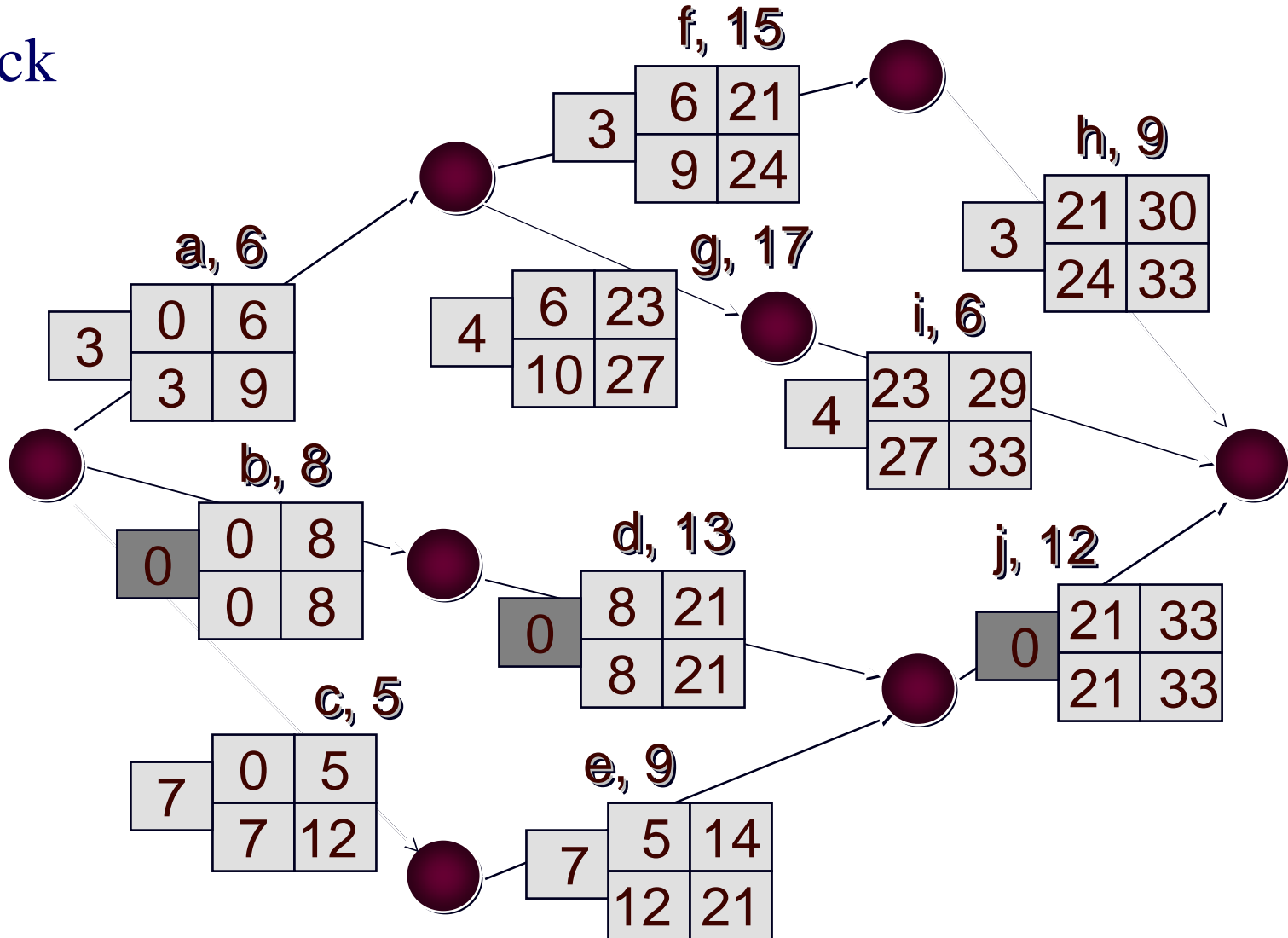
# CPM Example

- LS and LF Times



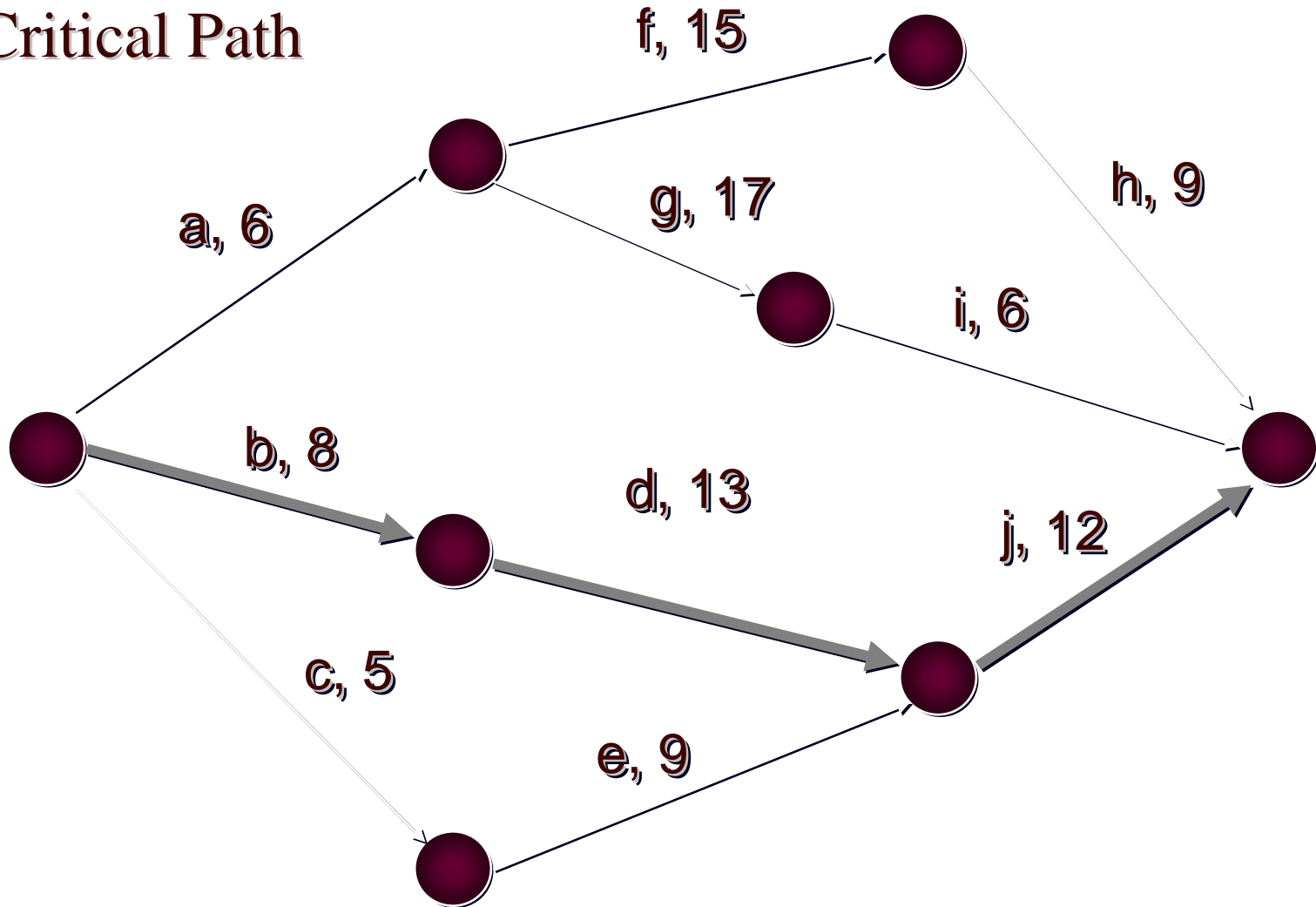
# CPM Example

Slack



# CPM Example

- Critical Path



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

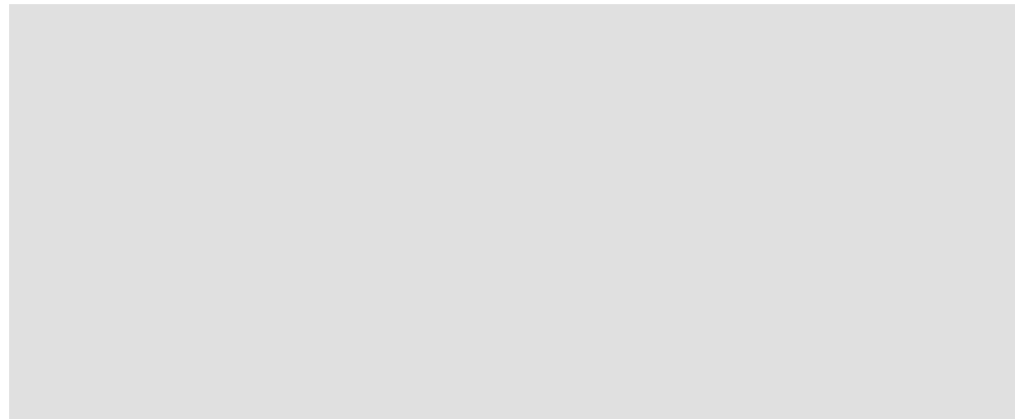
- The technique is based on the assumption that an activity's duration follows a probability distribution instead of being a single value.
- The probabilistic information about the activities is translated into probabilistic information about the project.

# PERT

- Three time estimates are required to compute the parameters of an activity's duration distribution:
  - pessimistic time ( $t_p$ ) - the time the activity would take if things did not go well
  - most likely time ( $t_m$ ) - the consensus best estimate of the activity's duration
  - optimistic time ( $t_o$ ) - the time the activity would take if things did go well
- . . . more

# PERT

- From these three time estimates about an activity, two probability distribution parameters are calculated: the mean ( $t_e$ ) and the variance ( $V_t$ ).



$$t_e = (t_o + 4t_m + t_p) / 6$$

$$V_t = [ (t_p - t_o) / 6 ]^2$$

# Steps in PERT Analysis

- Draw the network.
- Analyze the paths through the network and find the critical path.
- The length of the critical path is the mean of the project duration probability distribution which is assumed to be normal.
- . . . more

# Steps in PERT Analysis

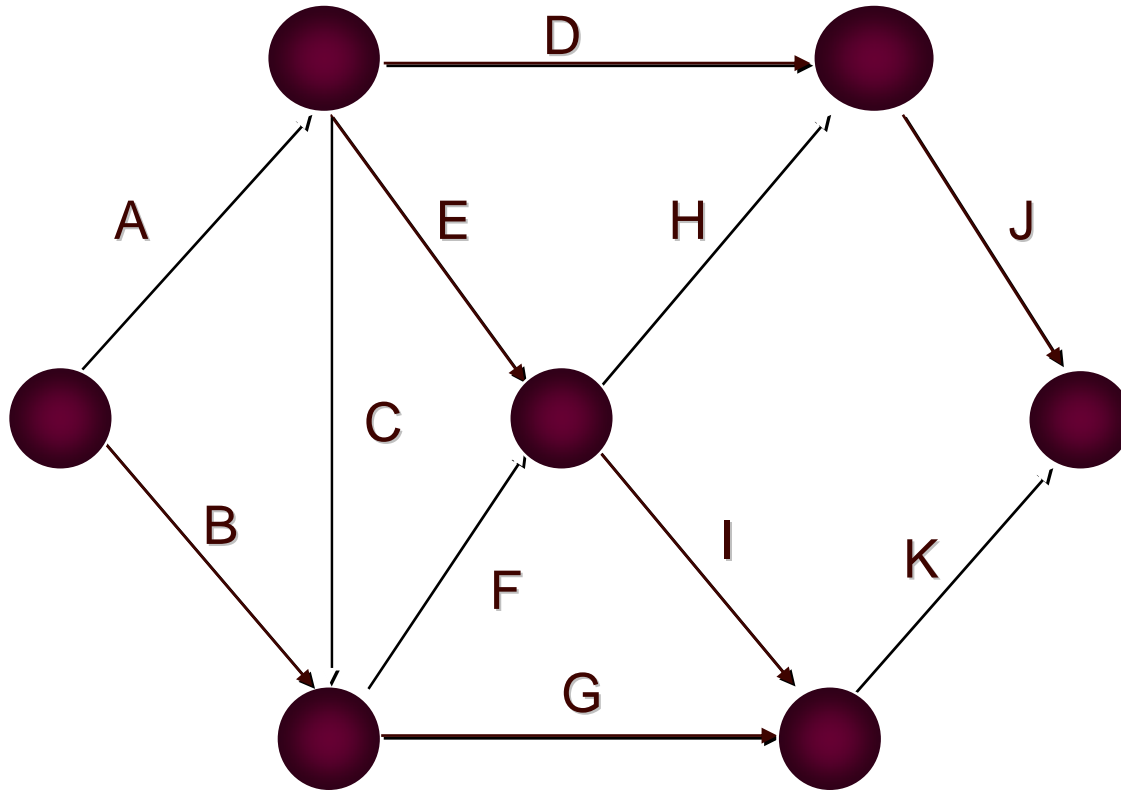
- The standard deviation of the project duration probability distribution is computed by adding the variances of the critical activities (all of the activities that make up the critical path) and taking the square root of that sum
- Probability computations can now be made using the normal distribution table.

# PERT Example

<u>Activity</u>	<u>Immed. Predec.</u>	<u>Optimistic Time (Hr.)</u>	<u>Most Likely Time (Hr.)</u>	<u>Pessimistic Time (Hr.)</u>
A	--	4	6	8
B	--	1	4.5	5
C	A	3	3	3
D	A	4	5	6
E	A	0.5	1	1.5
F	B,C	3	4	5
G	B,C	1	1.5	5
H	E,F	5	6	7
I	E,F	2	5	8
J	D,H	2.5	2.75	4.5
K	G,I	3	5	7

# PERT Example

- PERT Network



# PERT Example

- Activity Expected Time and Variance

<u>Activity</u>	<u>Expected Time</u>	<u>Variance</u>
A	6	4/9
B	4	4/9
C	3	0
D	5	1/9
E	1	1/36
F	4	1/9
G	2	4/9
H	6	1/9
I	5	1
J	3	1/9
K	5	4/9

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# PERT Example

- Earliest/Latest Times

<u>Activity</u>	<u>ES</u>	<u>EF</u>	<u>LS</u>	<u>LF</u>	<u>Slack</u>
A	0	6	0	6	0 *critical
B	0	4	5	9	5
C	6	9	6	9	0 *
D	6	11	15	20	9
E	6	7	12	13	6
F	9	13	9	13	0 *
G	9	11	16	18	7
H	13	19	14	20	1
I	13	18	13	18	0 *
J	19	22	20	23	1
K	18	23	18	23	0 *

# PERT Example

- Probability the project will be completed within 24 hours

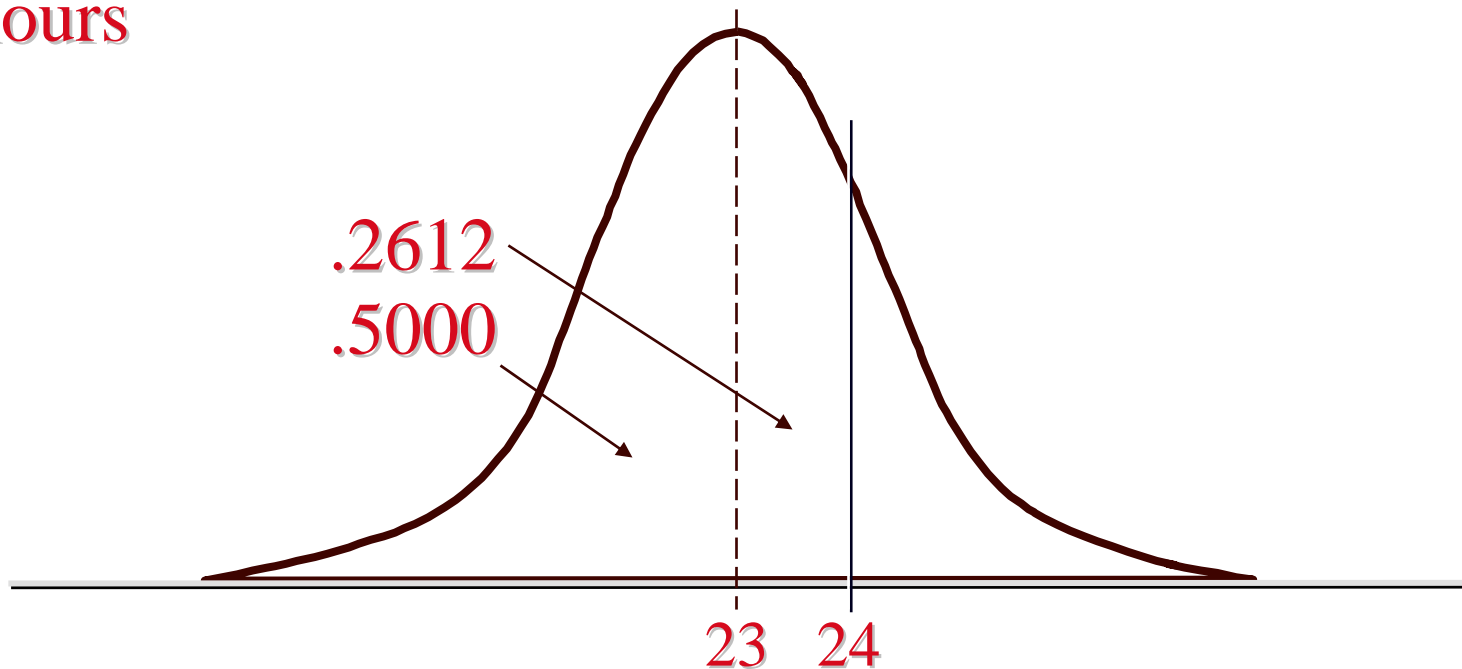
$$\begin{aligned}V_{\text{path}} &= V_A + V_C + V_F + V_I + V_K \\ &= 4/9 + 0 + 1/9 + 1 + 4/9 \\ &= 2\end{aligned}$$

$$\sigma_{\text{path}} = 1.414$$

$$z = (24 - 23)/\sigma = (24-23)/1.414 = .71$$

# PERT Example

- Probability the project will be completed within 24 hours



From the Standard Normal Distribution table:

$$P(z \leq .71) = .5 + .2612 = .7612$$

# Activity Cost-Time Tradeoffs

- Project managers may have the option or requirement to crash the project, or accelerate the completion of the project.
- This is accomplished by reducing the length of the critical path(s).
- The length of the critical path is reduced by reducing the duration of the activities on the critical path.
- . . . more

# Cost-Time Tradeoffs

- If each activity requires the expenditure of an amount of money to reduce its duration by one unit of time, then the project manager selects the least cost critical activity, reduces it by one time unit, and traces that change through the remainder of the network.
- . . . more

# Cost-Time Tradeoffs

- As a result of a reduction in an activity's time, a new critical path may be created.
- When there is more than one critical path, each of the critical paths must be reduced.
- If the length of the project needs to be reduced further, the process is repeated.

# Computer Software for Project Management

- *Artemis Views* (Artemis Management Systems)
- *FastTrack Schedule* (AEC Software)
- *Microsoft Project* (Microsoft Corp.)
- *Oracle Projects* (Oracle Corp.)
- *PowerProject* (ASTA Development)
- *Primavera Project Planner* (Primavera Systems)
- *SuperProject* (Computer Associates International)
- *TurboProject* (IMSI)

# Evaluation of CPM/PERT

- Activities are assumed to be independent.
- It is assumed that there is a precise breaking point where one activity ends and another begins.
- Initially-critical activities might not receive the attention they deserve until it is too late.
- Activity time estimates might be biased.
- The cost of CPM/PERT might not be justified by the value of the information it provides.
- Personnel might not understand the statistical underpinnings of PERT.

# Wrap-Up: World-Class Practice

- The project organizations are flexible enough to respond aggressively to business opportunities.
- Personnel are selected and trained to be flexible in moving from department to department and project to project as needed.
- Scheduling and control charts are frequently used because of their simplicity, flexibility, low cost, and effectiveness as communication devices.
- CPM, PERT, and PERT/Cost are also used to provide computerized activity-by-activity planning and control.