

Project Management

Management

- **Management**
- in all business and organizational activities is the act of getting people together to accomplish desired goals and objectives using available resources efficiently and effectively.

- 1- The science and art of getting things done through others.
2- Is the action of getting people together to complete objectives and goals using available reasons effectively
- **is the process of getting activities completed efficiently and effectively with and through other people.**
- **Management is decision making**

purposes they serve. These processes are aggregated into five groups, defined as the

Project Management function Process

- • Initiating Process
- • Planning Process
- Organizing Process
- • Executing Process
- • Monitoring and Controlling Process
- • Closing Process

planning

- It is the basic function of management. It deals with chalking out a future course of action & deciding in advance the most appropriate course of actions for achievement of pre-determined goals. According to KOONTZ, “Planning is deciding in advance - what to do, when to do & how to do. It bridges the gap from where we are & where we want to be”. A plan is a future course of actions. It is an exercise in problem solving & decision making. Planning is determination of courses of action to achieve desired goals. Thus, planning is a systematic thinking about ways & means for accomplishment of pre-determined goals. Planning is necessary to ensure proper utilization of human & non-human resources. It is all pervasive, it is an intellectual activity and it also helps in avoiding confusion, uncertainties, risks, wastages etc.

is the management of the organization's future in an uncertain environment.

1. Revising project goals and objective.
2. Creating the project management plane. •
3. Determining the alternative. •
4. Forecasting the future. •

organizing

- It is the process of bringing together physical, financial and human resources and developing productive relationship amongst them for achievement of organizational goals. According to Henry Fayol, “To organize a business is to provide it with everything useful for its functioning i.e. raw material, tools, capital and personnel’s”. To organize a business involves determining & providing human and non-human resources to the organizational structure. Organizing as a process involves:
 - Identification of activities.
 - Classification of grouping of activities.
 - Assignment of duties.
 - Delegation of authority and creation of responsibility.
 - Coordinating authority and responsibility relationships.

- **Division of Labour**

Departmentalization

Specialization

- **Unity of Command**

Line of command

One superior

- **Authority and Responsibility**

Line and staff authority

Authority and power

- **Spans of Control**

- **Levels of control**

Centralization and decentralization

Implementation

- Put plan into action
- We have a detailed work plan
- Now, we get the work underway
- We do this by:
 - Choosing participants
 - Making participants available for the project
 - Assigning work to participants
 - Organizing participants into team(s)
 - Providing resources to the team(s)
 - Establish constraints and freedoms for the team(s)

controlling

- It implies measurement of accomplishment against the standards and correction of deviation if any to ensure achievement of organizational goals. The purpose of controlling is to ensure that everything occurs in conformities with the standards. An efficient system of control helps to predict deviations before they actually occur. According to *Theo Haimann*, “Controlling is the process of checking whether or not proper progress is being made towards the objectives and goals and acting if necessary, to correct any deviation”. According to Koontz & O’Donell “Controlling is the measurement & correction of performance activities of subordinates in order to make sure that the enterprise objectives and plans desired to obtain them as being accomplished”. Therefore controlling has following steps:
 - Establishment of standard performance.
 - Measurement of actual performance.
 - Comparison of actual performance with the standards and finding out deviation if any.
 - Corrective action.

Project Management Emergence

- Explosion in human knowledge
- Mass customization of products and services
- Expansion of global markets

Forces Of Project Management

- Forces driving Project Management:
 - 1. exponential expansion of human knowledge
 - 2. growing demand for a broad range of complex, sophisticated, customized goods and services
 - 3. evolution of worldwide competitive markets for the production and consumption of goods and services
- Team-based problem solving v. individual

The Professionalism of Project Management

- Complexity of problems facing the project manager
- Growth in number of project oriented organizations
 - The Project Management Institute (PMI) was established in 1969
 - By 1990 it had 7,500 members
 - 1995, over 17,000 members
 - 1998--exploded to over 44,000 members
- This exponential growth is indicative of the rapid growth in the use of projects
- Importance of PMI as a force in the development of project management as a profession

The Definition of a “Project”

- Must make a distinction between terms:
 - **Program** - an exceptionally large, long-range objective that is broken down into a set of projects
 - **Task** - set of activities comprising a project
 - **Work Packages** - division of tasks
 - **Work Units** - division of work packages
- A specific, finite task to be accomplished

Project Management

A Working Definition

- Project:
 - A problem with a known solution scheduled for completion—unique and non-routine activities
 - A project is a sequence of unique complex and connected activities and having one goal or purpose and that must be completed by a specific time within budget and according to specifications.

What is the project

A project is **a temporary** endeavor undertaken to create **a unique** product, service, or result.

Temporary

- has a definite beginning and a definite end, not ongoing efforts.
- Ceases when objectives have been attained.
- Team disbanded upon completion.



What is the project (continue)

Unique:

the product or services is different in some way from other products or services.

The presence of repetitive element does not change the fundamental uniqueness of the project work.

Progressively Elaborated:

Progressively means “proceeding in steps” containing steadily by increments.

Elaborated means “worked out with care and detail; developed thoroughly”.



PROJECT IS CONVERTING



IDEA
DESIGN
PLAN

CONCRETE INTETY
FACTORY
BUILDING
HIGHWAY
SERVICES
PRODUCTS



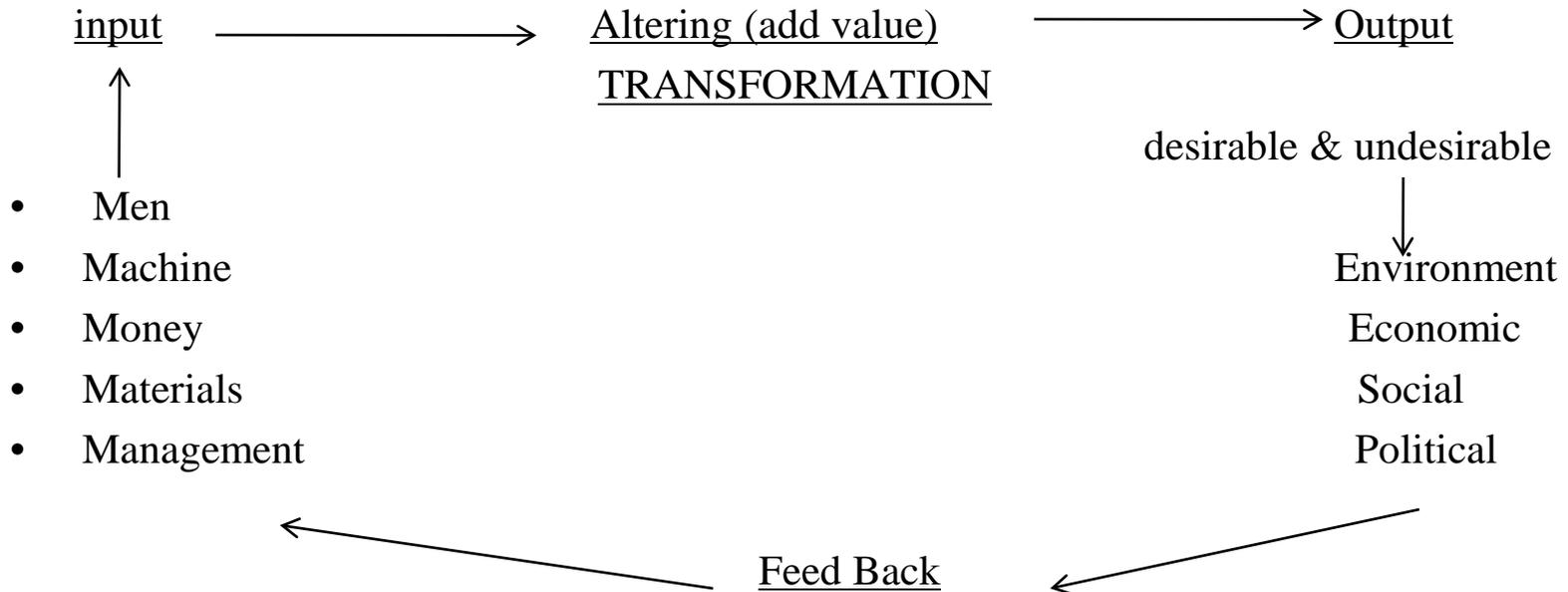
• PROJECTS

- AUTOMOBILE FACTORY
- BUILD A HOUSE
- CONSTRUCT HOSPITAL
- CONCEIVE NEW PRODUCT
- DONE ONCE

PRODUCTIONS

PRODUCE AUTOMOBILE
OPERATE HOUSEHOLDE
TREAT PATIENTS
MANUFACTURE
DONE REPETITIVELY

NATURE OF PROJECT AND PRODUCTION



Projects versus operations

Similarities between project and operations

- Both performed by people even 1 person.
- Both are constrained by resources.
- Both are planned, executed and controlled.
- Both are done for a purpose and have interrelated activities.

Difference between projects and operations

- Operations are on going and repetitive.
- Projects are temporary endeavor undertaken to create unique products or services that are progressively elaborated.



Projects and strategic

- **Projects are typically authorized as a result of one or more of the following strategic considerations:**
 - A market demand.
 - An organizational need.
 - A customer request.
 - A technological advanced.
 - A legal requirement.



What is Project Management?

- **The application of knowledge, skills, tools, and techniques to project activities in order to meet stakeholder needs and expectations.**
- **Managing a project includes:**
 - Identifying requirement
 - Establishing **Clear and achievable** objectives
 - Balancing the competing demands for quality, scope, time and cost.
 - Adapting the specifications ,plans, and approach to the different concerns and expectations of the various *stakeholders*



What is project management?

- Project Management:
 - The science and art of solving the problem within predetermined time and resource parameters
 - Project management is the application of skills knowledge tools and techniques to meet the needs and expectations of stakeholders for a project.
 - Shouldering just enough risk to escape with your career intact!!!

What is Project Management?

- **Project managers:**

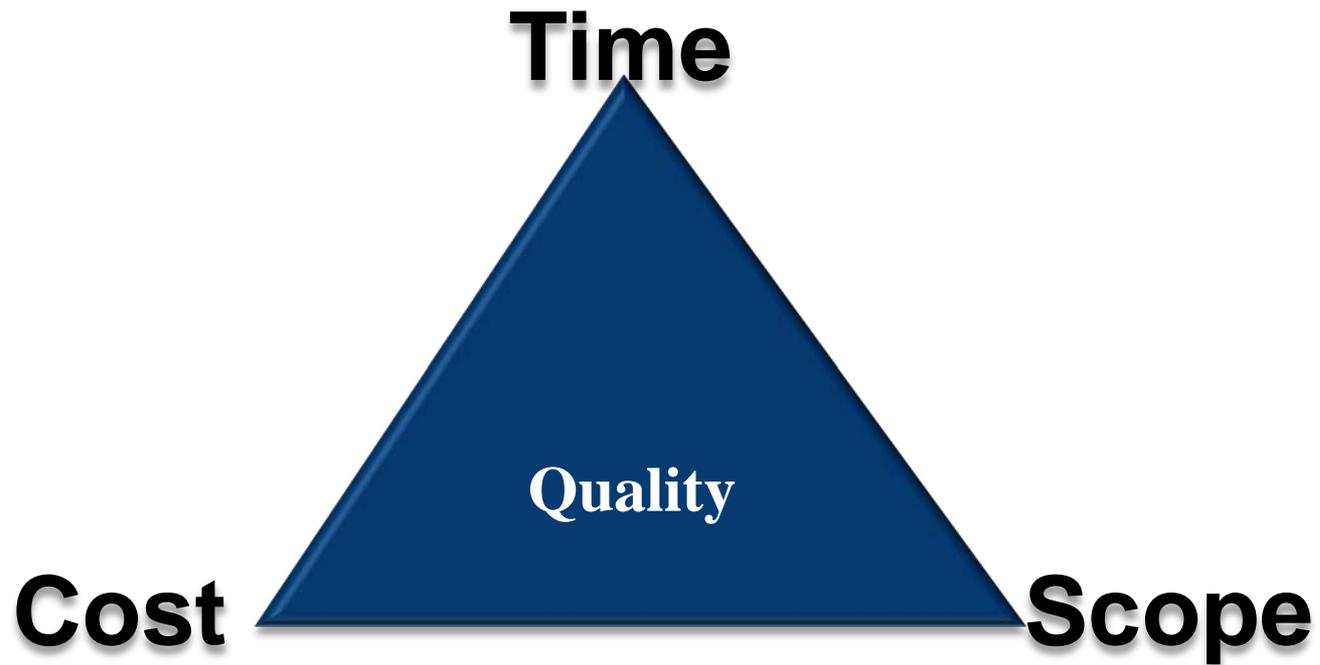
Often talk of a “triple constraint”- project **scope**, **time** and **cost** in managing competing project requirements. Project quality is affected by balancing these three factors.

- **The project management team:**

has a professional responsibility to their stakeholders including customers, the performing organization, and the public.



Triple Constraint



- Project management is a set of principles and tools for :
- -Defining
- -planning
- -executing
- -controlling
- -completing a project
- Projects are oriented towards a goal
- There is something unique about every project
- Projects have a finite duration
- Project require coordination of interrelated activities

Project objectives:

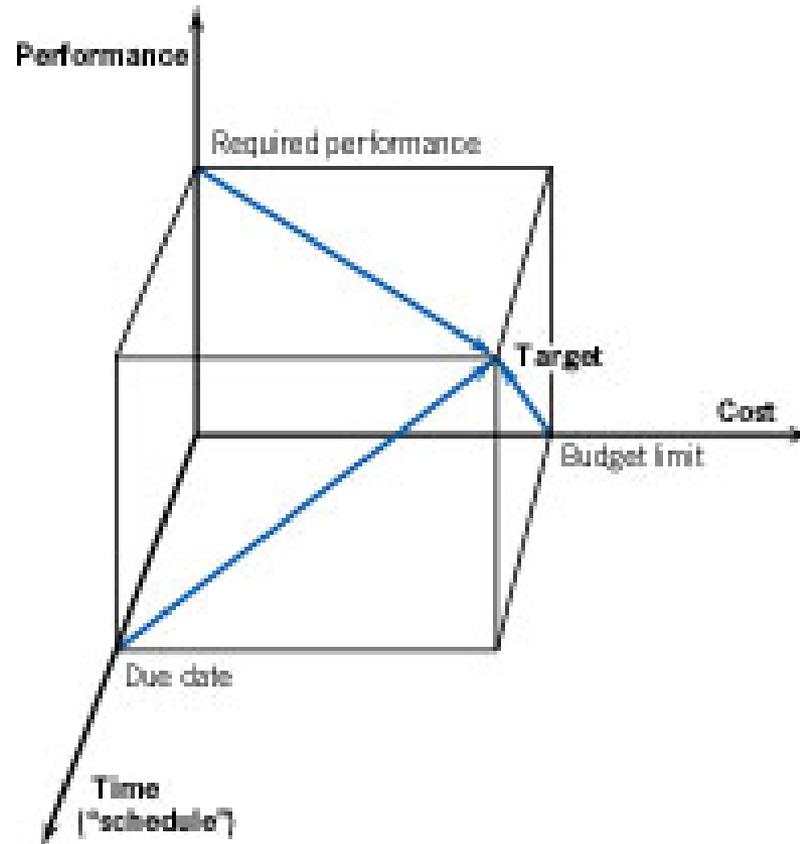
- Construction projects are often complex with potential for cost and time
- Overruns or the finished facility performing less well than planned to minimize risks the client should select the contract strategy that matches the objectives of the project. These must be clearly established and prioritized before any design or other work begins.
- The client must decide the relative importance of the three main objectives **time, cost and performance** of the completed project

Objectives of a Project

- Project Objectives:
 - Performance
 - Time
 - Cost
- Expectations of clients *inherent part of the project specifications*

Objectives of a Project

- 3 Project Objectives:



Characteristics of a Project

- 1- Uniqueness: one time operational non repetitive .
- 2- limited time and resource .
- 3- establish to achieve specific objectives .
- 4- well defined collection of activities.
- 5-Interdependencies

Why Project Management?

- Companies have experienced:
 - Better customer relations
 - Shorter overall delivery times
 - Lower costs and higher profit margins
 - Higher quality and reliability
 - Higher worker morale

Why (not) Project Management?

- Companies have also experienced some negatives:
 - Greater organizational complexity
 - Increased likelihood of organizational policy violations
 - Higher costs
 - More management difficulties
 - Low personnel utilization

The Project Life Cycle

- Stages of a Conventional Project:
 - Slow beginning
 - Buildup of size
 - Peak
 - Begin a decline
 - Termination

The Project Life Cycle

- Selection of the project
- Project planning

scope of work & network development

basic scheduling

time cost tradeoffs

resource considerations in projects

Project Implementation

Project controlling and completion

Selection of the project

- Project identification
- Project appraisal
- Project selection

Project identification

- Receptive to new ideas
- Vision of future growth
- Long term objectives
- SWOT analysis
- Preliminary project analysis

Project appraisal

- Market appraisal
- Technical appraisal
- Financial appraisal
- Economics appraisal
- Ecological appraisal
- A feasibility report considers all these issues prior to project adoption

Market appraisal

- Aggregate future demand
- Market share
- Current and future competition
- Location and accessibility of consumers
- Technological scenario /obsolescence
- Possible pricing option

Technical appraisal

- Engineering aspects
- Location
- Size
- Production process

Financial appraisal

- Cash flow over time
- Profitability
- Break event point
- Net present value
- Internal rate of return
- Payback period
- Risk

Economic appraisal

-
- Benefits and costs(in shadow prices)
- Distribution of income in society
- Level of savings and investment in society
- Self sufficiency ,employment and social order

Ecological appraisal

- Environmental damage
- Air
- Water
- Noise
- Other
- Restoration measures and cost

Basic scheduling

- Project representation as network
- Estimation of activity durations
- Forward and backward passes
- Determination of activity floats
- Critical path for selective control and minimum project duration

Time cost tradeoff

- Normal and crash activity durations
- Linear /nonlinear/discontinuous/discrete time cost relationships
- Project cost- duration efficient frontier
- Total project (direct and indirect) Cost

Resource aggregation

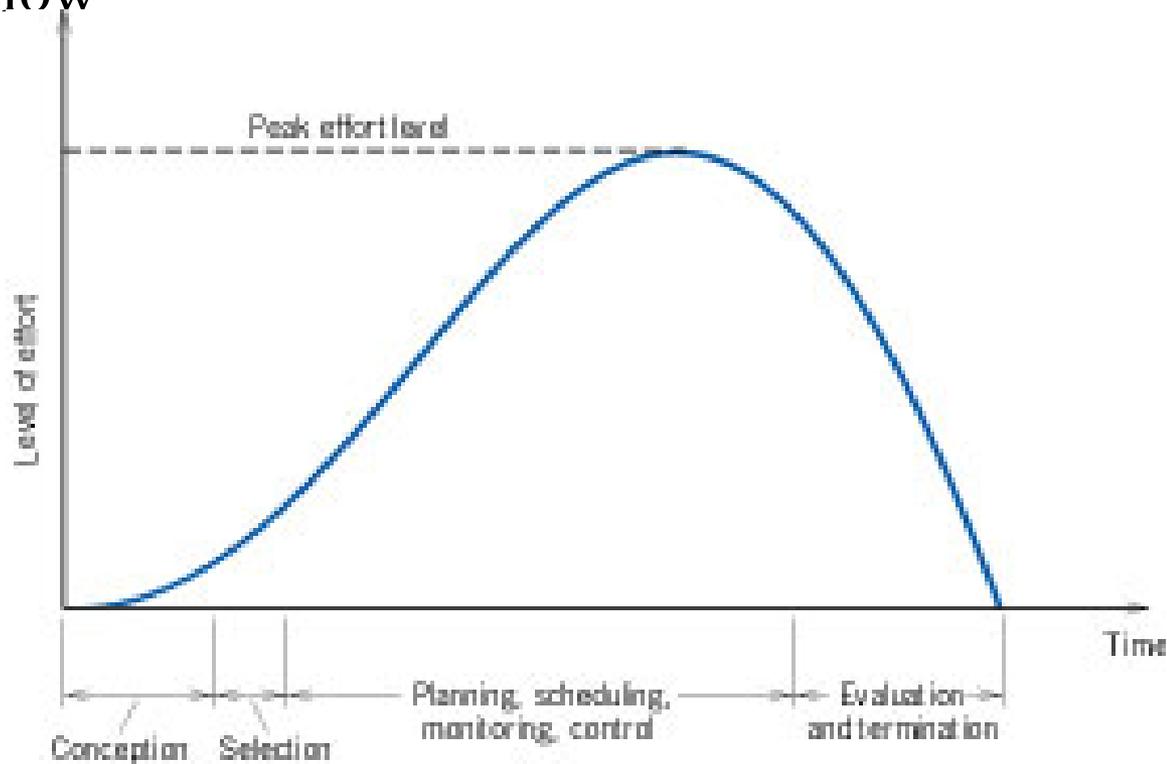
- Project schedule
- Resource consumption profile for each resource
- Provisioning of resource over time
- Project Scheduling and Control Techniques
- Gantt Chart
- Critical Path Method (CPM)
- Program Evaluation and Review Technique (PERT)

The Project Life Cycle

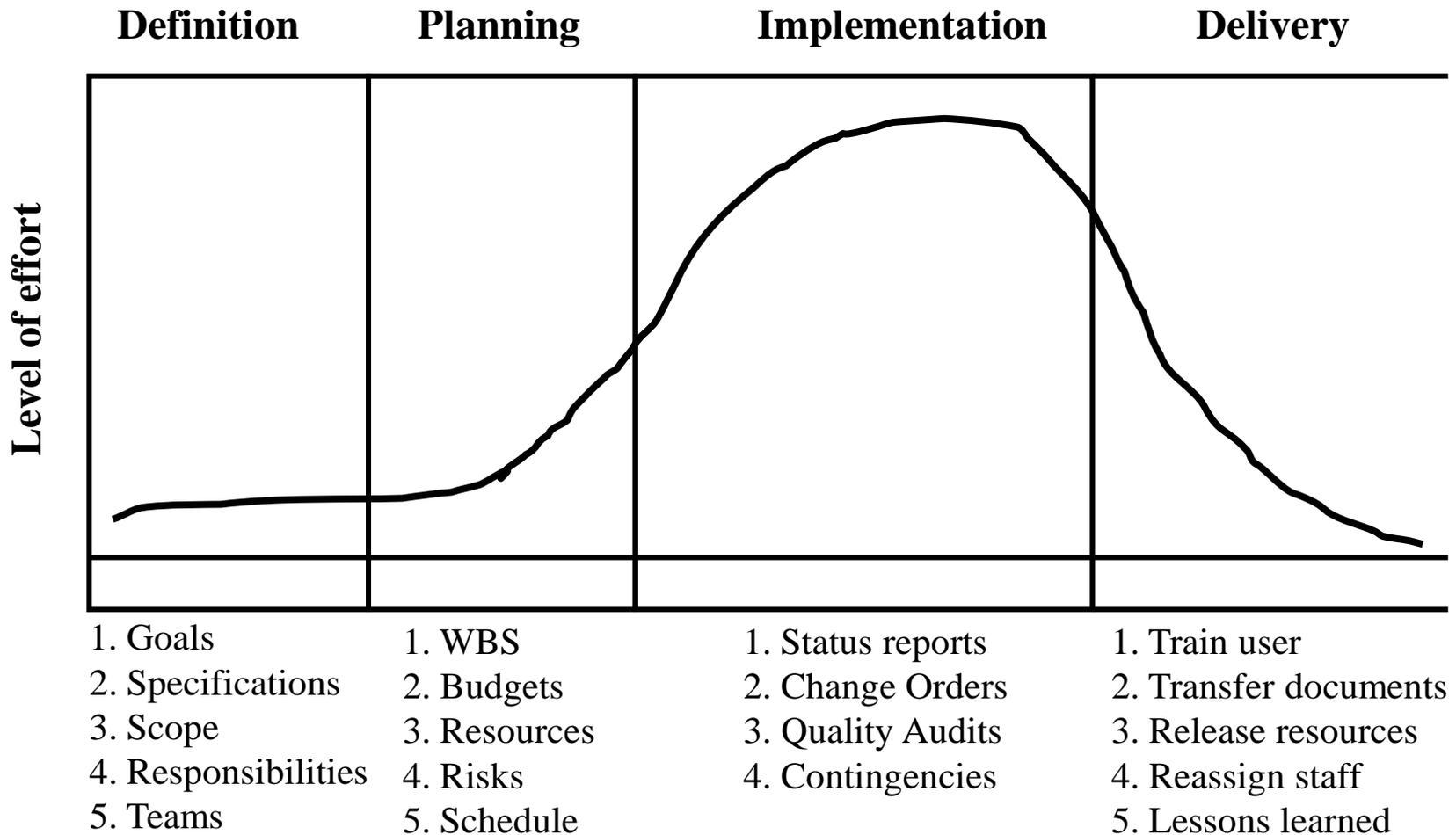
- Projects also exist which do not follow the conventional project life cycle
- Comprised of subunits that have little use as a stand alone unit, yet become useful when put together

The Project Life Cycle

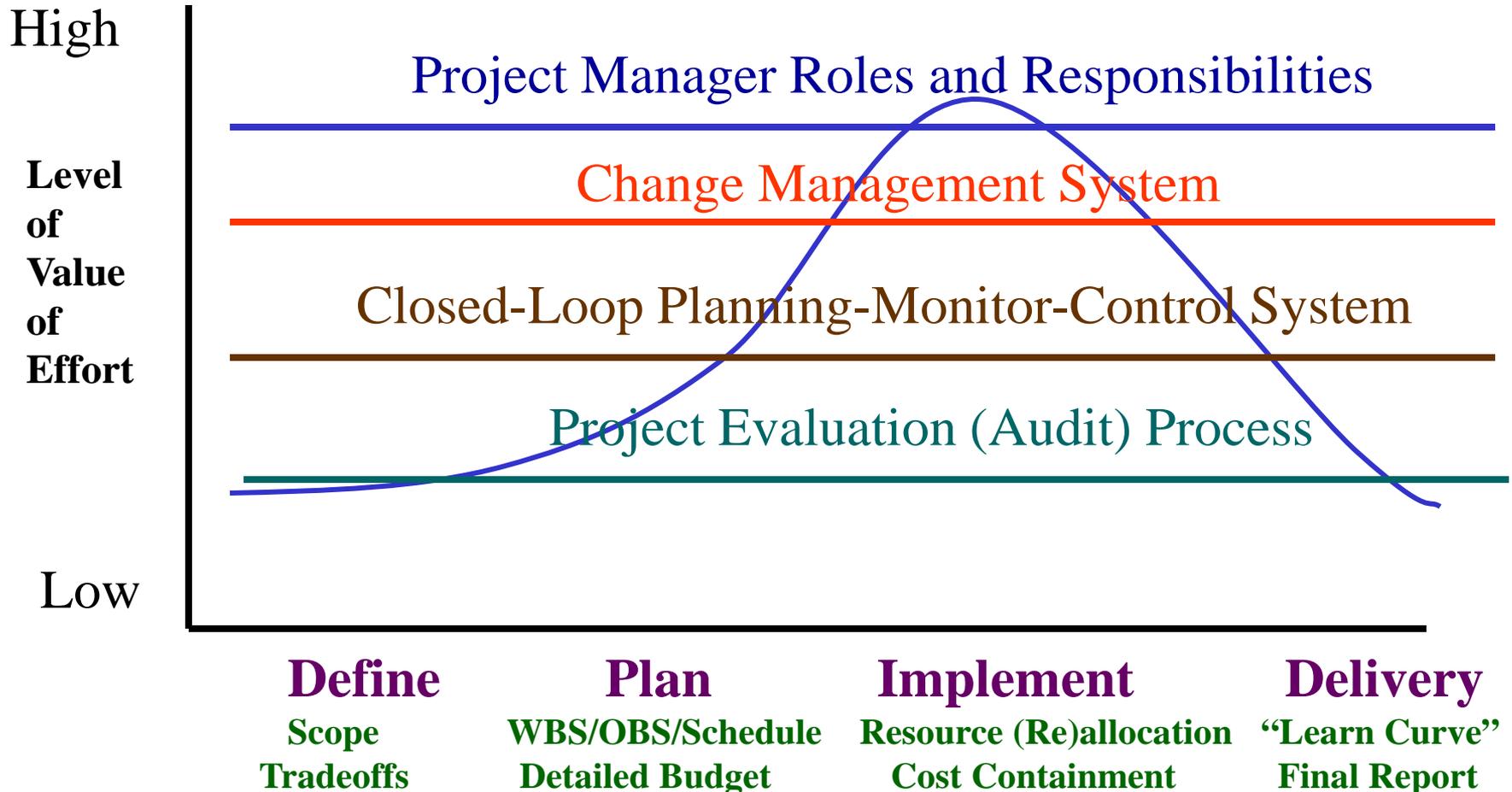
- Time distribution of project effort is characterized by slow-rapid-slow



Project Management Life Cycle



Proactive Project Life Cycle



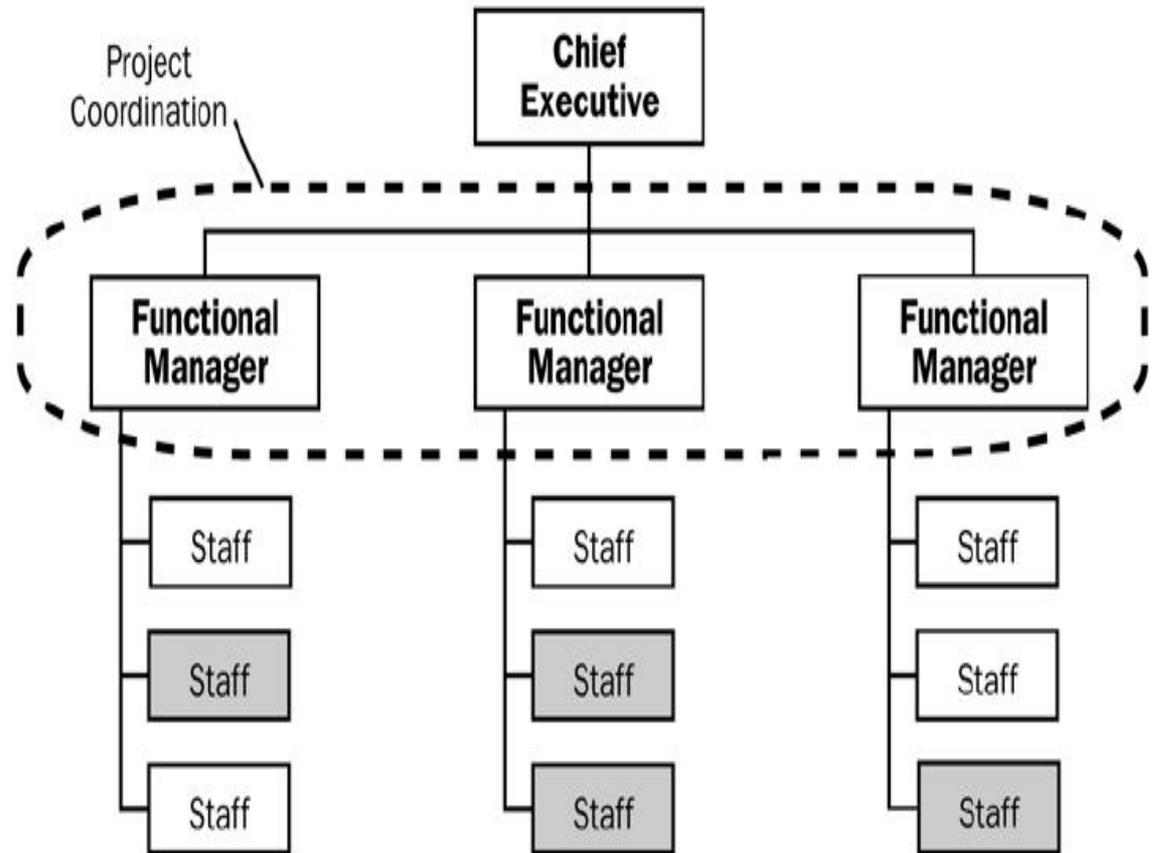
Forms of Organization

- **PMI talks about five types of organizational structure, based upon project manager's level of authority.**
- **Organizational structure can be characterized as scanning a spectrum from functional to projectized as follows:**
 - **Functional Organization .**
 - **Weak, balanced and strong Matrix Organization.**
 - **Project zed Organization.**



Functional Organization

This is the most common form of organization. The organization is grouped by areas of specialization within different functional areas (e.g. accounting, Marketing and manufacturing).



(Gray boxes represent staff engaged in project activities.)



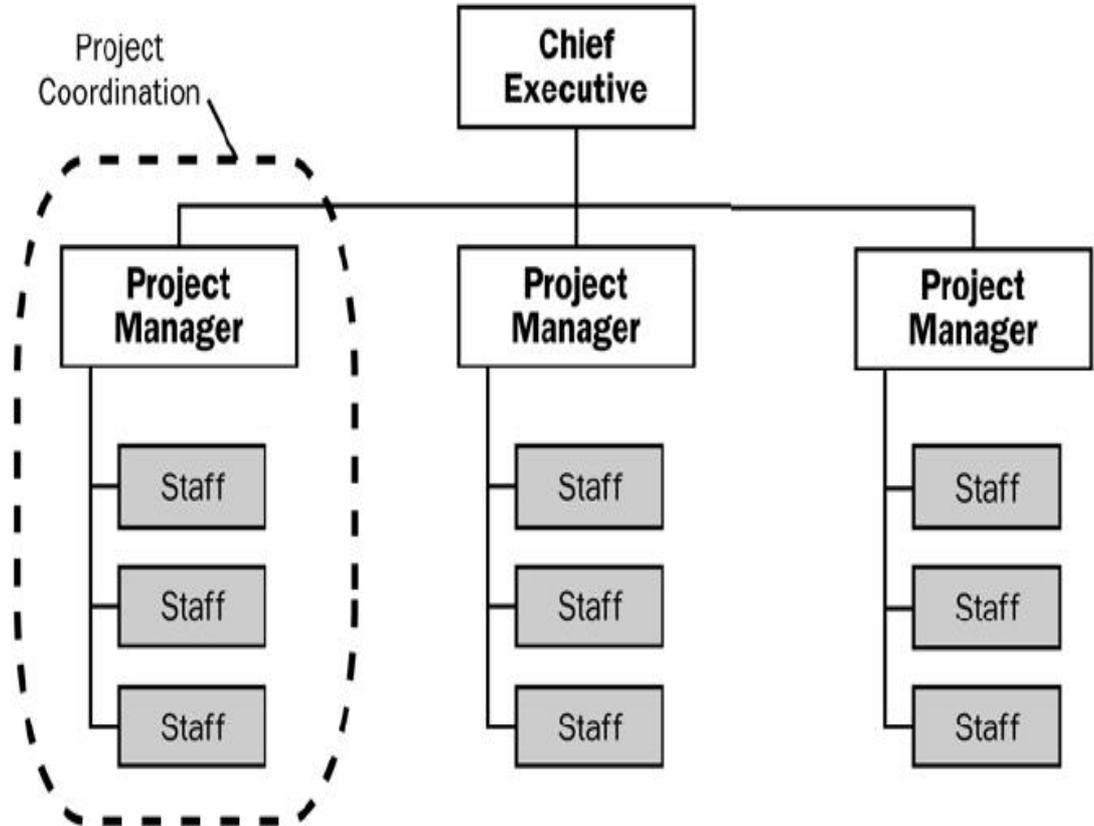
Advantages of Functional Organizations

- **Easier Management of specialists.**
- **Team reporting to 1 supervisor.**
- **Similar resources are centralized and grouped by specialty.**
- **Clear career path in areas of specialty.**
- **Job security is guaranteed.**
- **More focus on the specialty than over the concern for the project success.**
- **No career path in PM.**
- **PM has no authority.**



Project zed Organization

All organization is run by projects.
The Project Manager has total control of projects
Personnel are assigned and report to a Project Manager.



(Gray boxes represent staff engaged in project activities.)



Advantages & disadvantages of Project zed Organizations

- **Advantages:**
 1. Project Manager has the power and full authority over the project's resources.
 2. Communication are easier and faster.
- **Disadvantages:**
 1. No career path in areas of specialty.
 2. No job security.



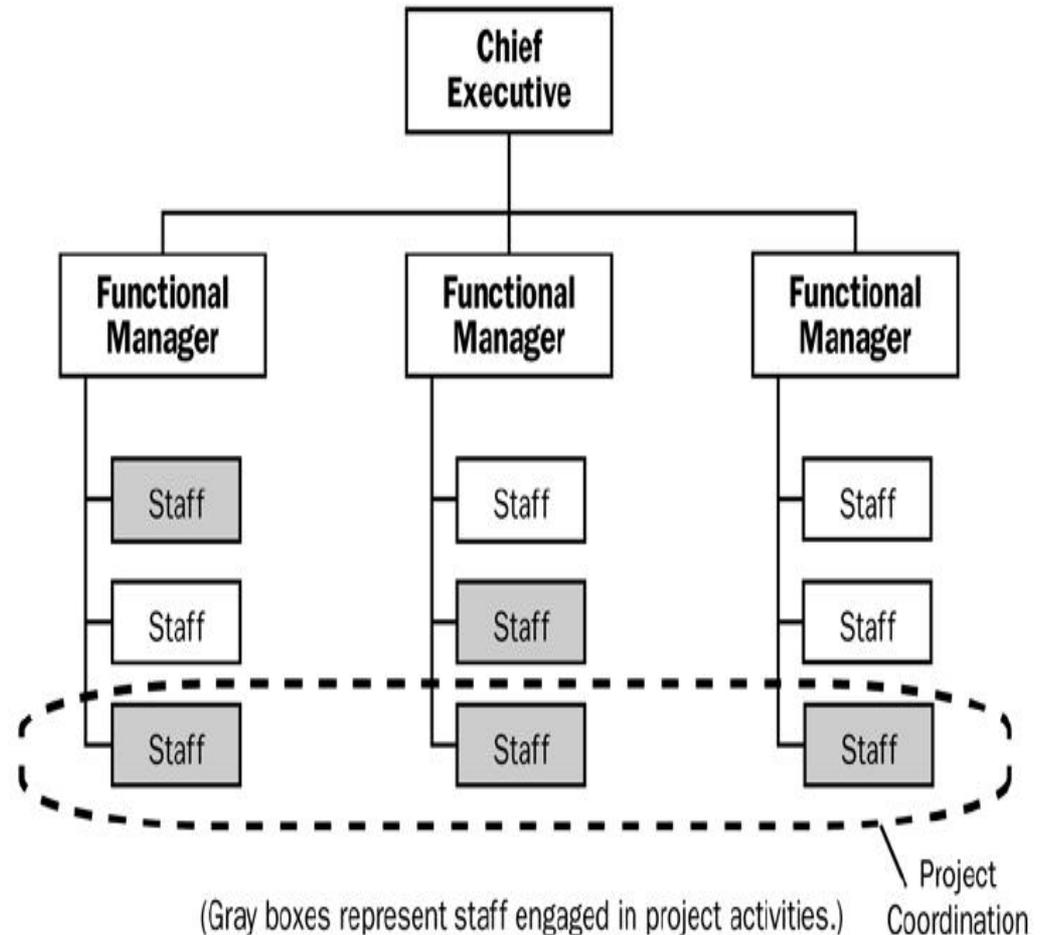
Matrix Organization

- This form is an attempt to maximize the strengths and weaknesses of both the functional and project forms.
- In a strong matrix, power rests with the project Manager. In a **weak matrix**, power rests with the functional manager.
- In a **balanced matrix**, the power is shared between the functional manager and the Project Manager.



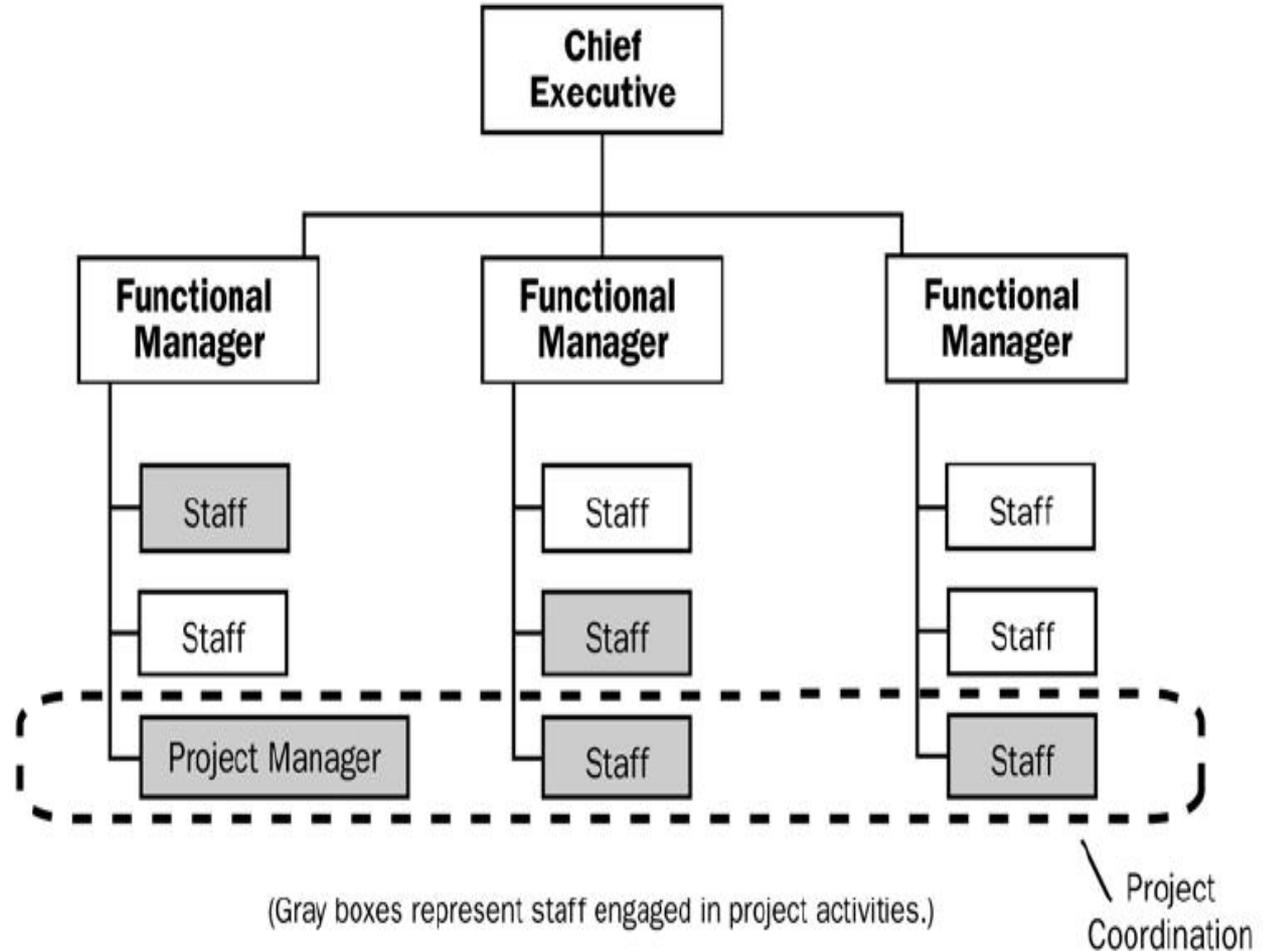
Weak matrix Organization

In this form of organization, the project expeditor acts primarily as a staff assistant and communications coordinator. The expeditor cannot personally make or enforce decisions

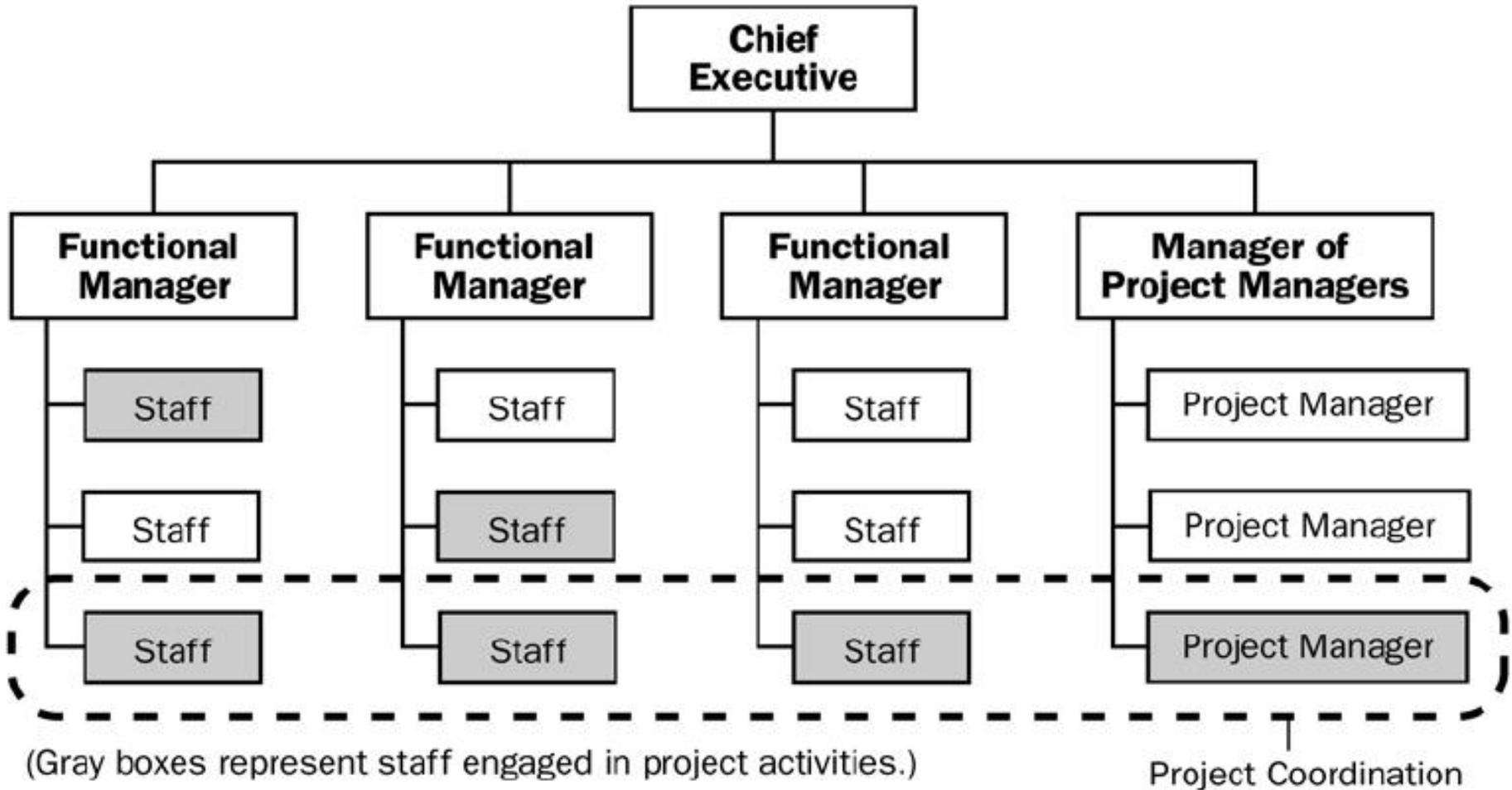


Balanced Matrix

This form of organization is similar to the Weak Matrix organization, except that the coordinator has some power to make decisions, some authority and reports to higher-level manager.



Strong Matrix



Advantages & disadvantages of matrix Organizations

- **Advantages:**

- Both Project Manager and functional managers share the responsibility of the project's resources.

- **Disadvantages:**

- There is more than one boss for the project team.
- Communications are complex as the team members should make dual reporting.



Organization Structure versus Project Characteristics

Organization Structure Project Characteristics	Functional	Matrix			Projectized
		Weak Matrix	Balanced Matrix	Strong Matrix	
Project Manager's Authority	Little or None	Limited	Low to Moderate	Moderate to High	High to Almost Total
Resource Availability	Little or None	Limited	Low to Moderate	Moderate to High	High to Almost Total
Who controls the project budget	Functional Manager	Functional Manager	Mixed	Project Manager	Project Manager
Project Manager's Role	Part-time	Part-time	Full-time	Full-time	Full-time
Project Management Administrative Staff	Part-time	Part-time	Part-time	Full-time	Full-time



Project planning

- Defining scope and terms of reference
- Work break down structure
- Basic scheduling
- Time cost tradeoffs
- Resources considerations

Project Planning

- Resource Availability and/or Limits
 - Due date, late penalties, early completion incentives
 - Budget
- Activity Information
 - Identify all required activities
 - Estimate the resources required (time) to complete each activity
 - Immediate predecessor(s) to each activity needed to create interrelationships

Work breakdown structure

- A method of breaking down a project into individual elements (components, subcomponents, activities and tasks) in a hierarchical structure which can be scheduled and cost
- It defines tasks that can be completed independently of other tasks, facilitating resource allocation, assignment of responsibilities and measurement and control of the project
- It is foundation of project planning
- It is developed before identification of dependencies and estimation of activity durations
- It can be used to identify the tasks in the CPM and PERT

Ways that WBS based on :

- Hard work orientation identification of basic work package
- Agency organization : Based on assignment of responsibility to different agencies (some subcontractors, agencies)
- Function oriented (e.g. design , Procurement , construction).

- WBS doesn't show sequence of work and breakdown a project only to levels sufficient to produce an estimate required accuracy (+ or -)10 % .

work breakdown structure

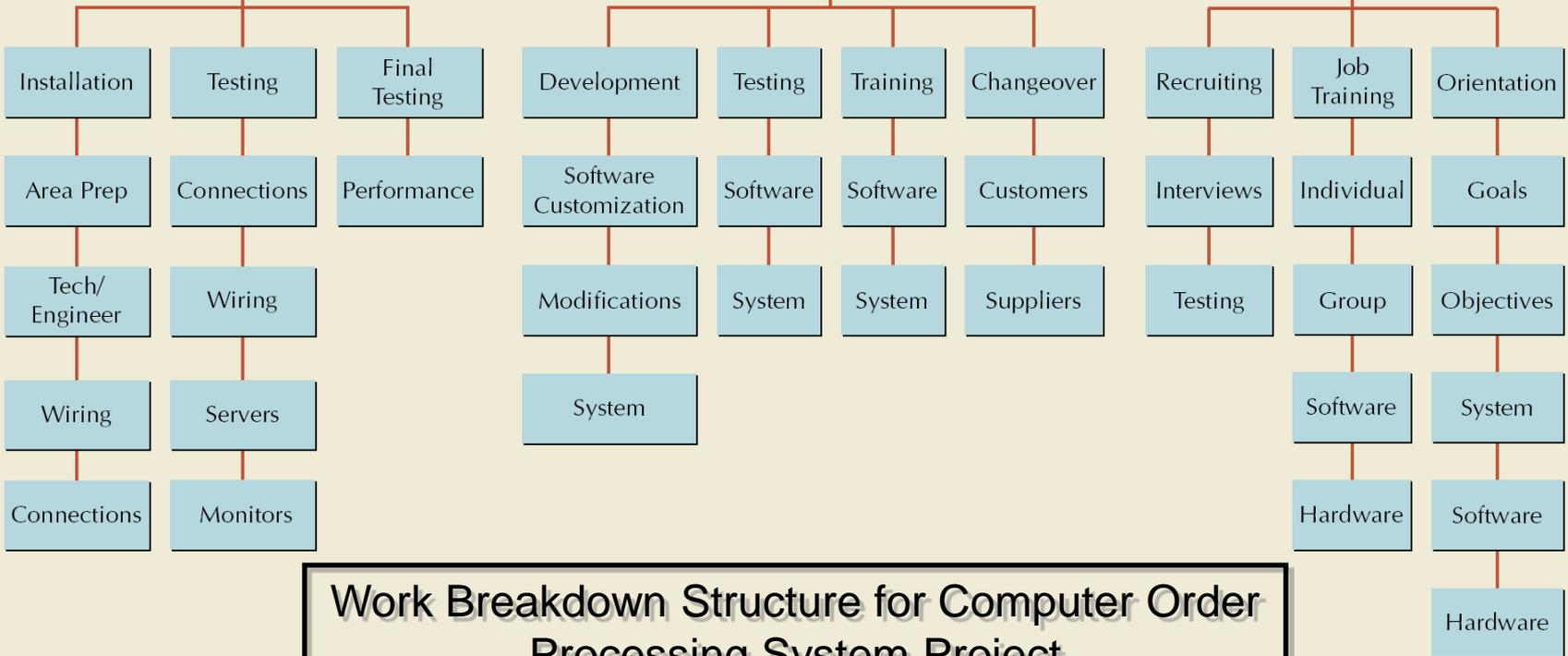
- 1-generally WBS includes 6-7 levels. more or less may be needed for a situation
- 2-all paths on a WBS do not go down to the same levels
- 3-WBS does not show the sequencing of work.
- 4-WBS should be developed before scheduling and resource allocation are done.

Computerized Order Processing System

Hardware

Software/System

Personnel



Work Breakdown Structure for Computer Order Processing System Project

Work breakdown structure

- Work breakdown structure should be developed by individuals knowledgeable about the work .
 - This means that levels will be developed by various groups of and the separate parts combined .
- . Outputs of WBS :-
- Detailed list of activity.
 - Easy to estimate cost and resource
 - Easy to estimate duration.

Project representation

- 1-project name and description .
- 2- list of activities that constitute the project .
- 3-Gantt or bar chart showing when activities take place .
- 4-project network showing activities, there dependencies and there relation to the whole activities.(AOA and AON)Representations.

Project Scheduling and Control Techniques

Gantt Chart

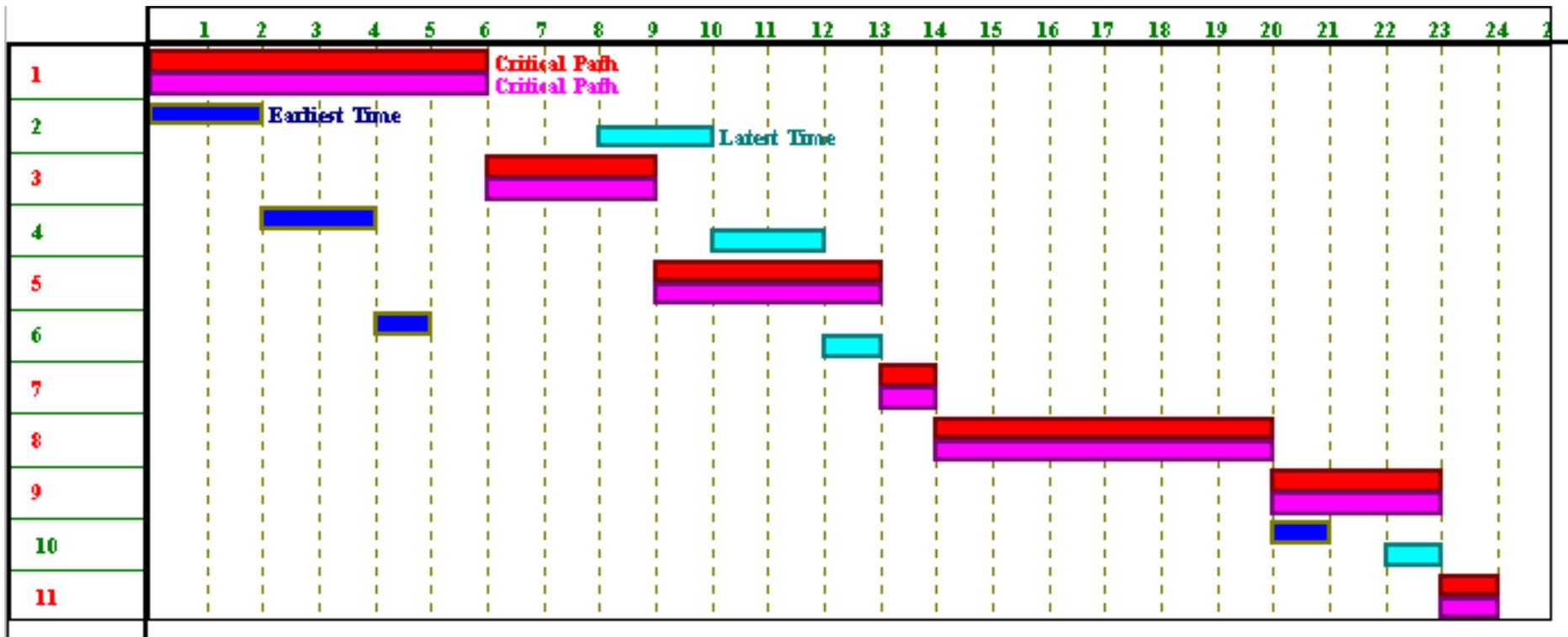
Critical Path Method (CPM)

Program Evaluation and Review Technique (PERT)

- Gantt bar chart : an old to prepare this chart we need to
- Carefully examine the scope of the project and then adopt a strategy for the performance (divide the project to units)
- Divide the project into units then to activities(by WBS :work break-down structure).the activity was divide into sub activities.
- Estimate time required to finishing these activities (duration) time
- Assign a priority of dependency for each activity
- Draw a bar chart according to the priority of dependency

Gantt Chart

- ◆ Graph or bar chart with a bar for each project activity that shows passage of time
- ◆ Provides visual display of project schedule



Gantt Charts

- The Gantt chart shows planned and actual progress for a number of tasks displayed against a horizontal time scale
- It is an effective and easy-to-read method of indicating the actual current status for each set of tasks compared to the planned progress for each item of the set
- It can be helpful in expediting, sequencing, and reallocating resources among tasks
- Gantt charts usually do not show technical dependencies

Disadvantages of Gantt bar chart :

- Doesn't show critical activities($T.F = 0$)
- Doesn't show floats
- Doesn't show the relationship between activities
- Not good for large scale project ,you can't trace the effect of delays

Project Network

- Why use project network?
- A convenient way to show activities and precedence in relation to the whole project.
- Basis of project planning:
- Responsibility allocation
- Definition of subcontracting unite
- Roles of different players.
- Basic scheduling and establishment of work time tables.
- Critical path determination and selective management control
- Alternatives of project representation:
 - 1- Activity on a node (AON)
 - 2- Activity on arc (AOA)

History of CPM/PERT

- Critical Path Method (CPM)
 - E I Du Pont de Nemours & Co. (1957) for construction of new chemical plant and maintenance shut-down
 - Deterministic task times
 - Activity-on-node network construction
 - Repetitive nature of jobs
- Project Evaluation and Review Technique (PERT)
 - U S Navy (1958) for the POLARIS missile program
 - Multiple task time estimates (probabilistic nature)
 - Activity-on-arrow network construction
 - Non-repetitive jobs (R & D work)

Scheduling 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. An identifiable end state occurring at a particular time. Events use no resources.
- **Network** - The combination of all activities and events define the project and the activity precedence relationships

Project Network

- Network analysis is the general name given to certain specific techniques which can be used for the planning, management and control of projects
- Use of nodes and arrows
 - Arrows → An arrow leads from tail to head directionally
 - Indicate ACTIVITY, a time consuming effort that is required to perform a part of the work.
 - Nodes ● A node is represented by a circle
 - Indicate EVENT, a point in time where one or more activities start and/or finish.
- 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

Project Network

- 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
- ◆ 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

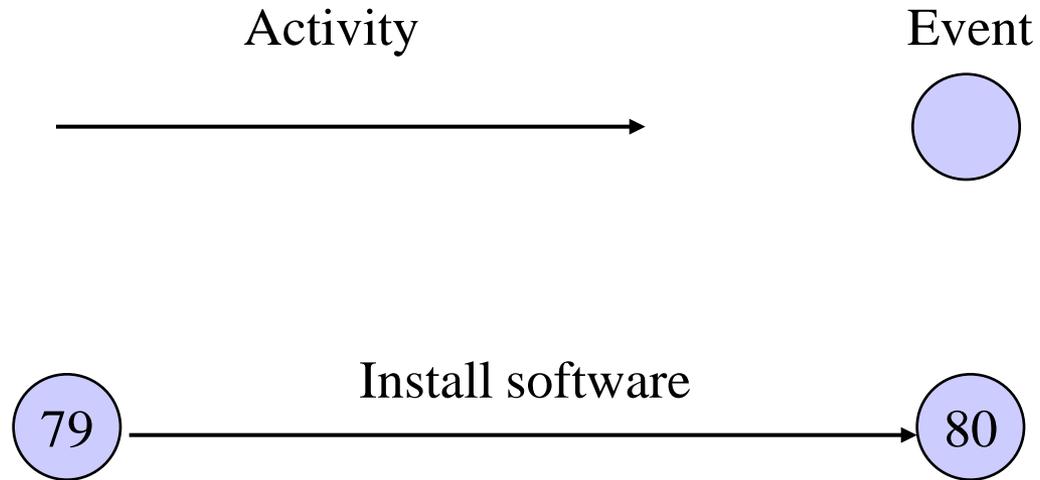
Scheduling Terminology

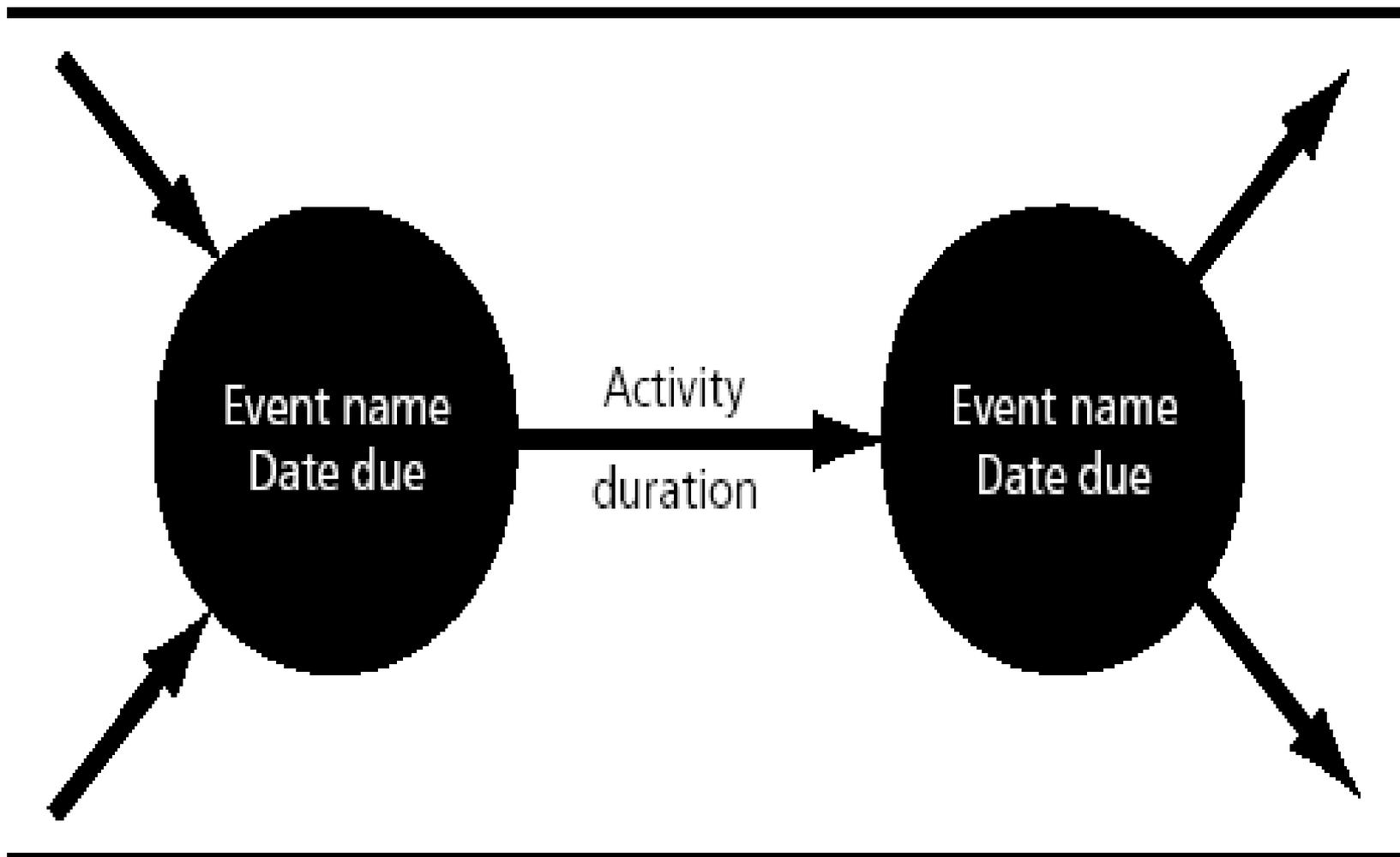
- **Path** - The series of connected activities (or intermediate events) between any two events in a network
- **Critical** - Activities, events, or paths which, if delayed, will delay the completion of the project. A project's critical path is understood to mean that sequence of critical activities that connect the project's start event to its finish event

Scheduling Terminology

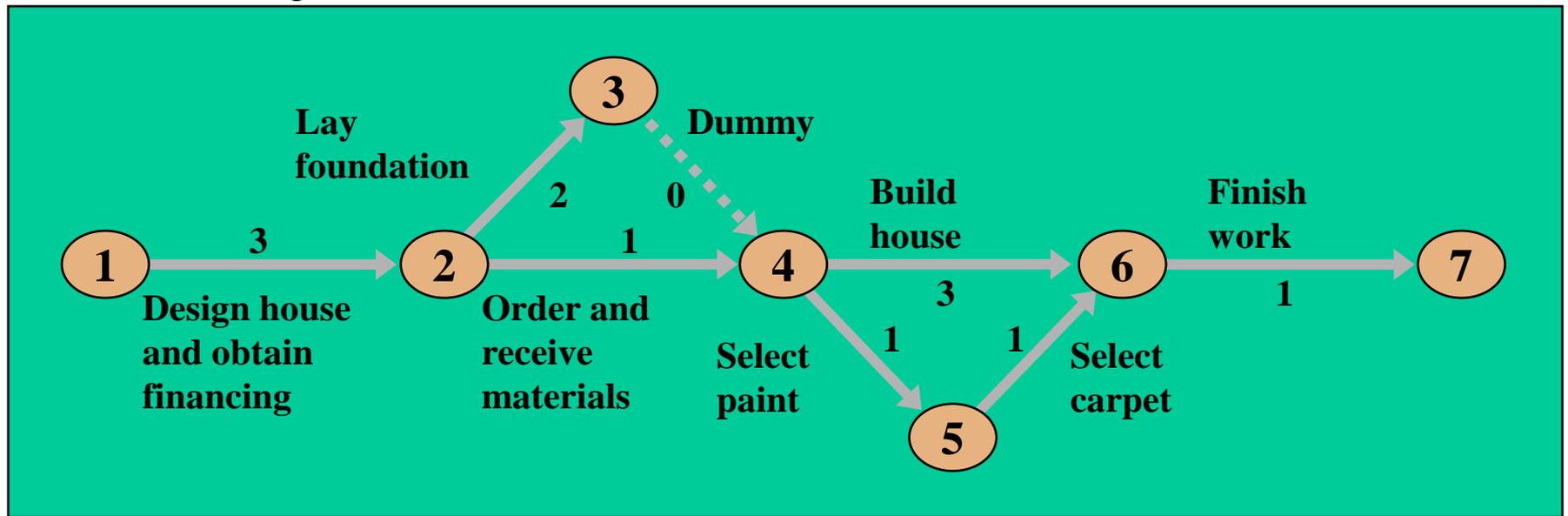
- An activity can be in any of these conditions:
 - It may have a successor(s) but no predecessor(s) - starts a network
 - It may have a predecessor(s) but no successor(s) - ends a network
 - It may have both predecessor(s) and successor(s) - in the middle of a network
- Interconnections from horizontal links in vertical WBS

AOA Network Building Blocks

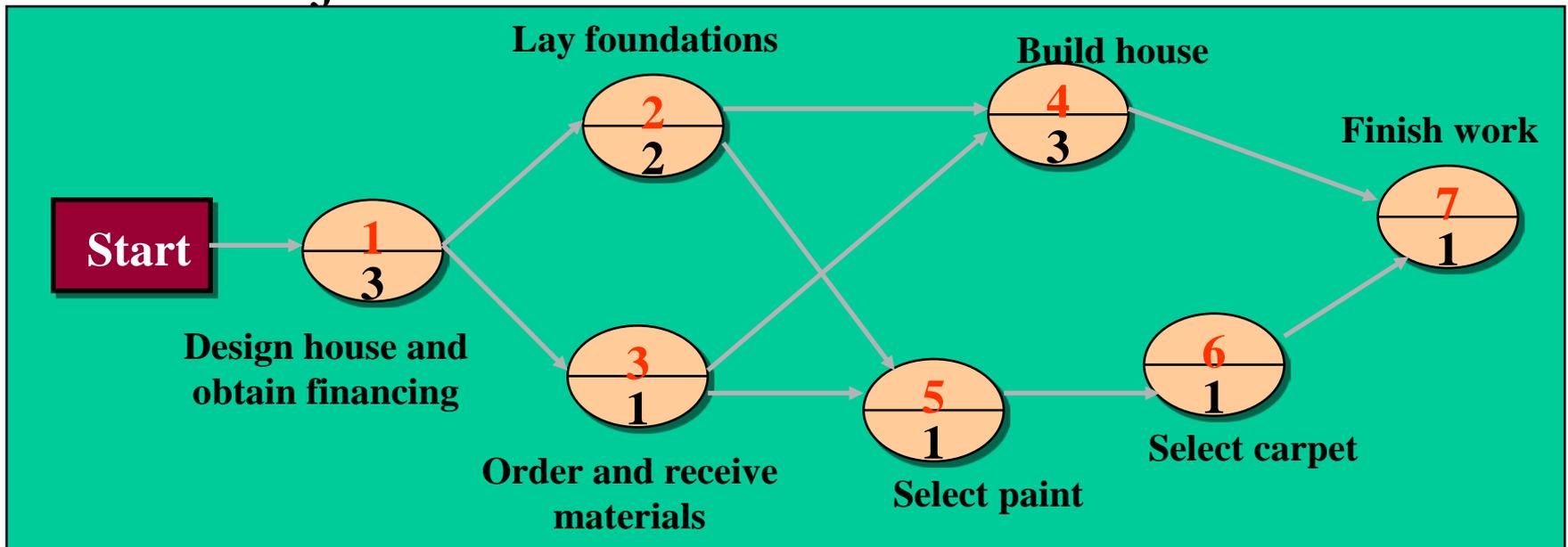




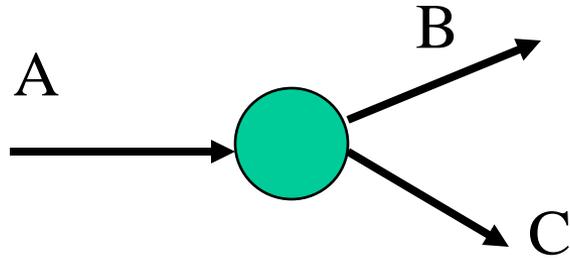
AOA Project Network for House



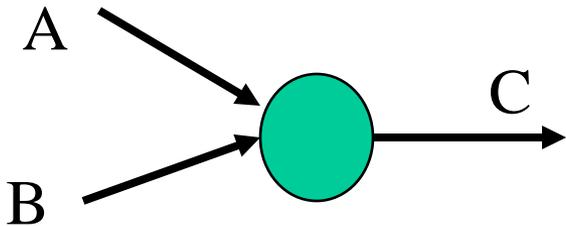
AON Project Network for House



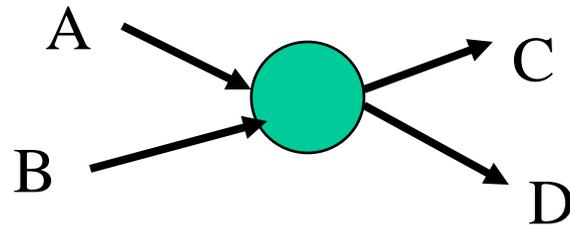
Situations in network diagram



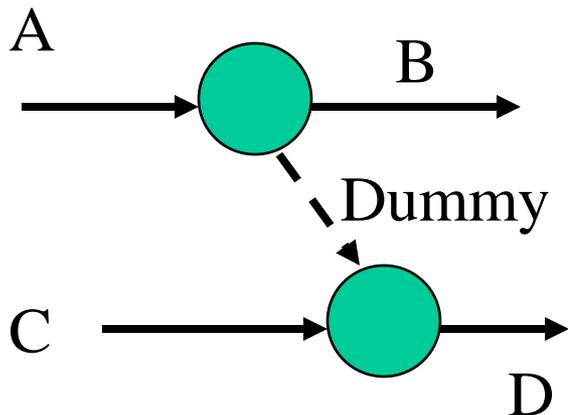
A must finish before either B or C can start



both A and B must finish before C can start



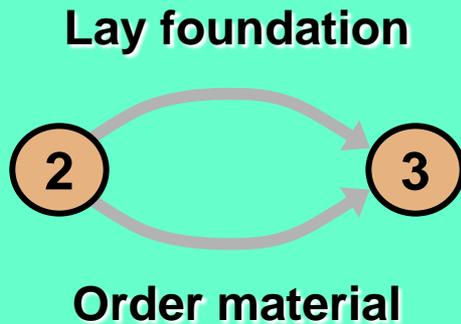
both A and B must finish before either of C or D can start



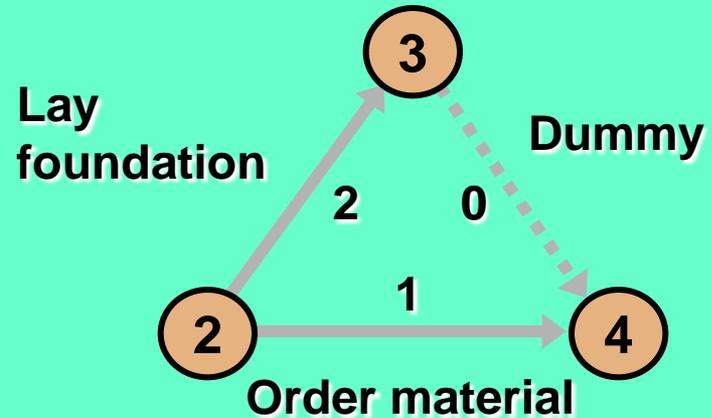
A must finish before B can start

both A and C must finish before D can start

Concurrent Activities



(a) Incorrect precedence relationship



(b) Correct precedence relationship

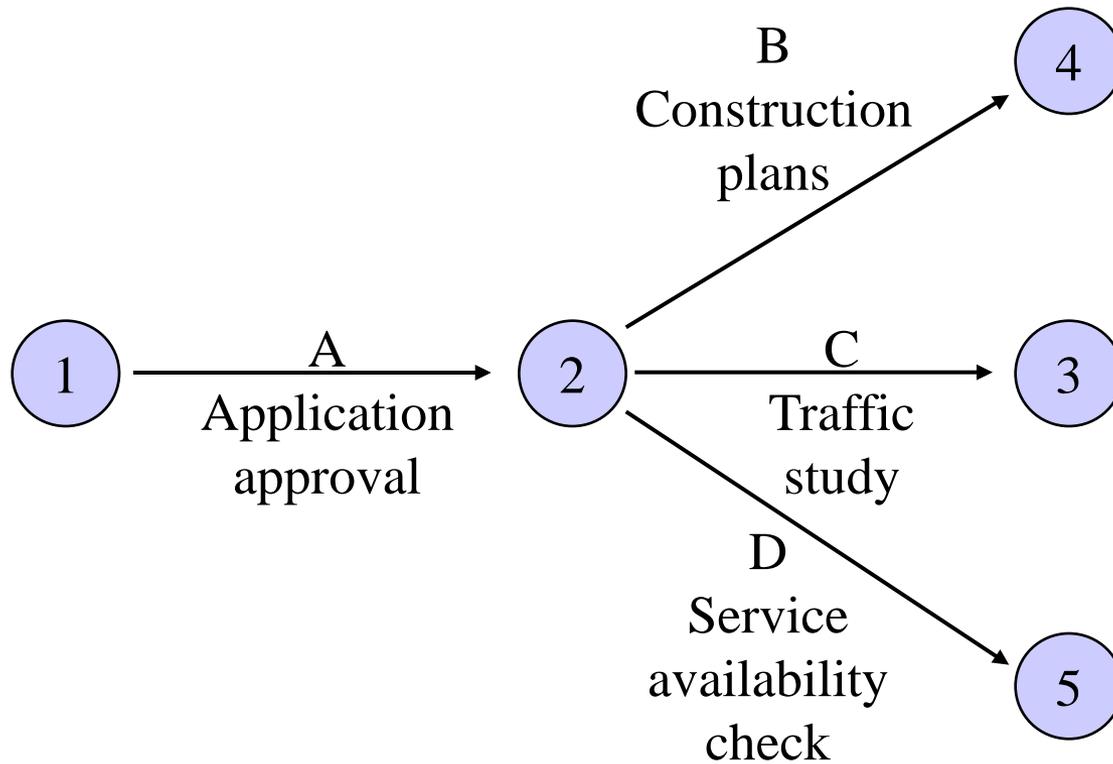
Drawing Networks

- Activity-on-Arrow (AOA) networks use arrows to represent activities while nodes stand for events
- Activity-on-Node (AON) networks use nodes to represent activities with arrows to show precedence relationships
- The choice between AOA and AON representation is largely a matter of personal preference

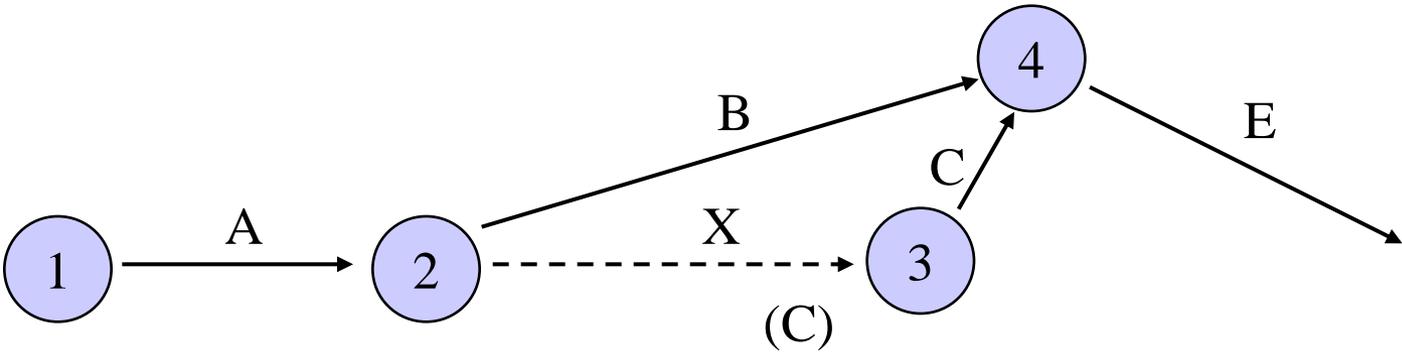
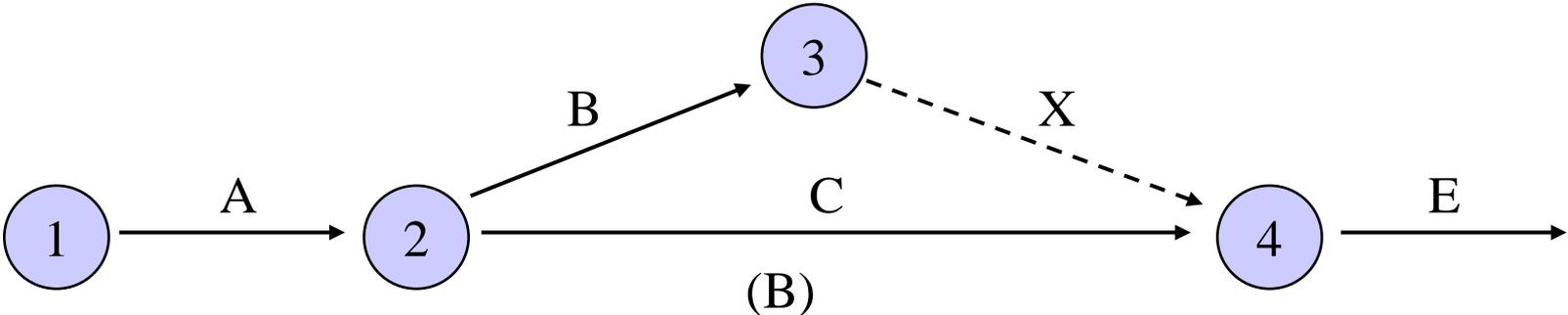
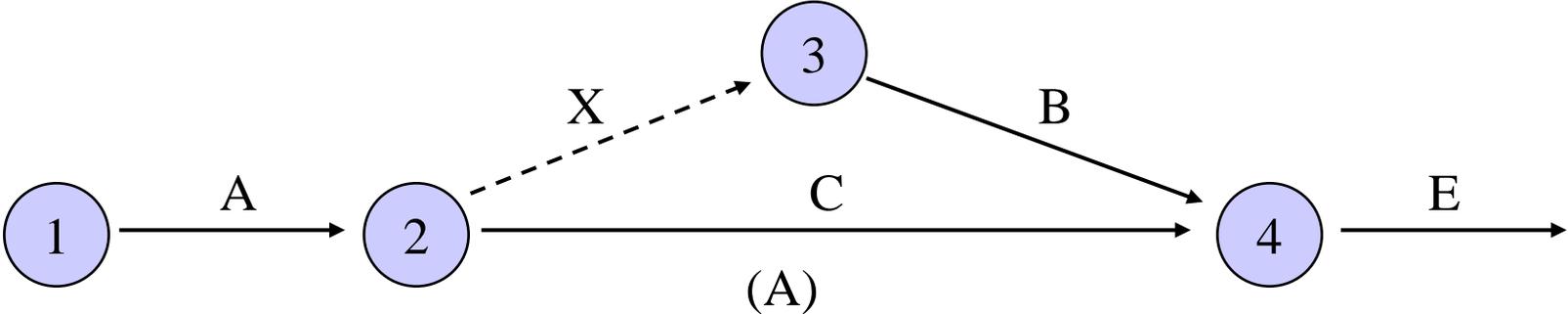
Drawing example

• Act.	Depend on
• A	--
• B	a
• C	a
• D	b,c
• E	c
• F	c

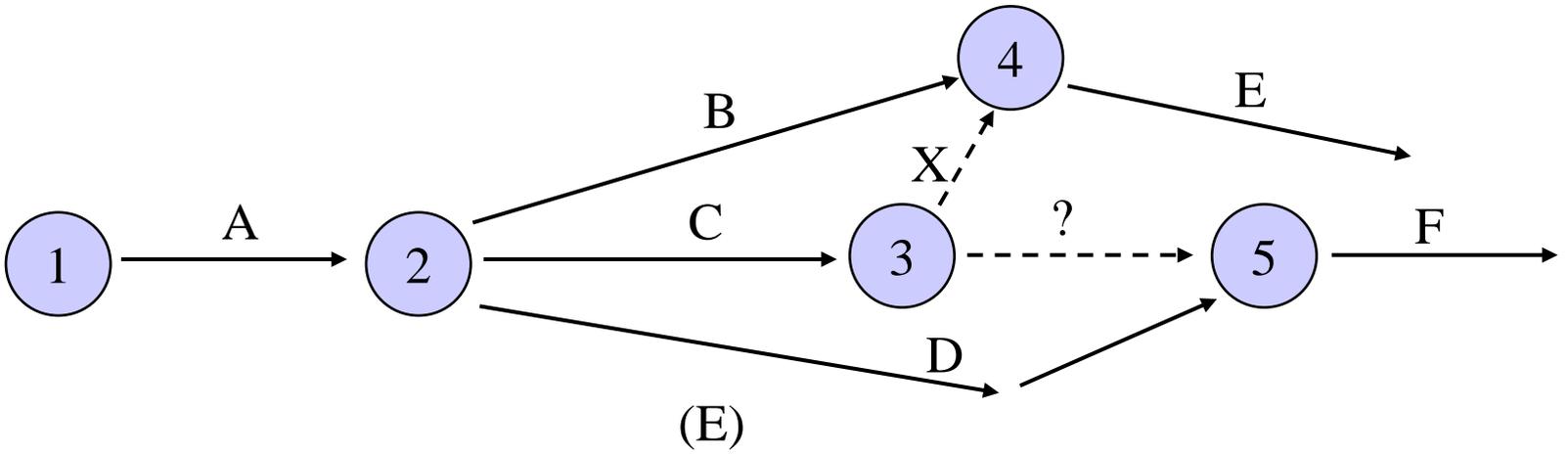
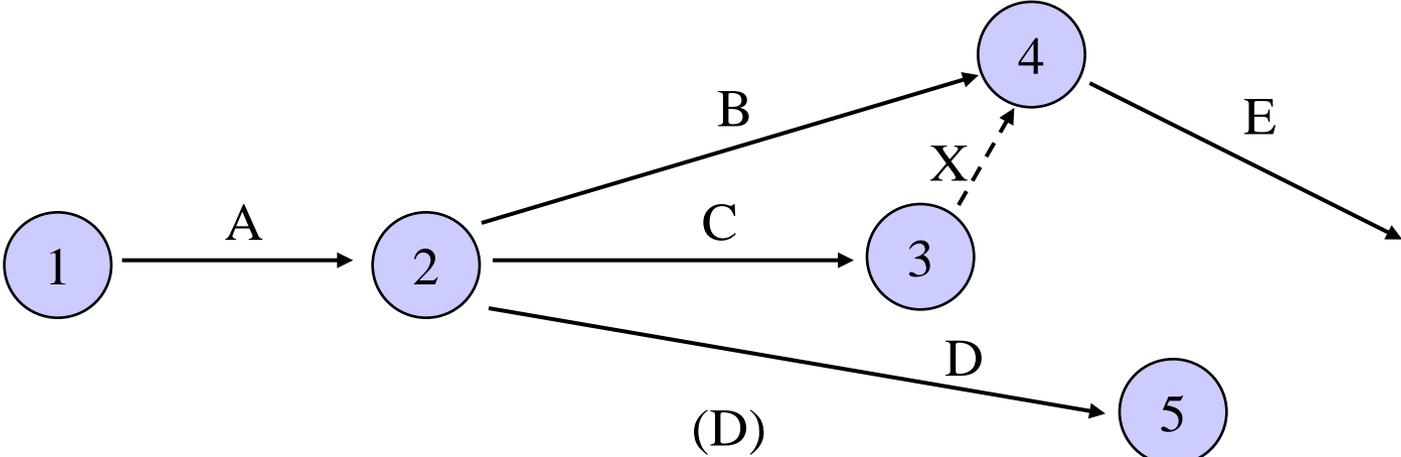
AOA



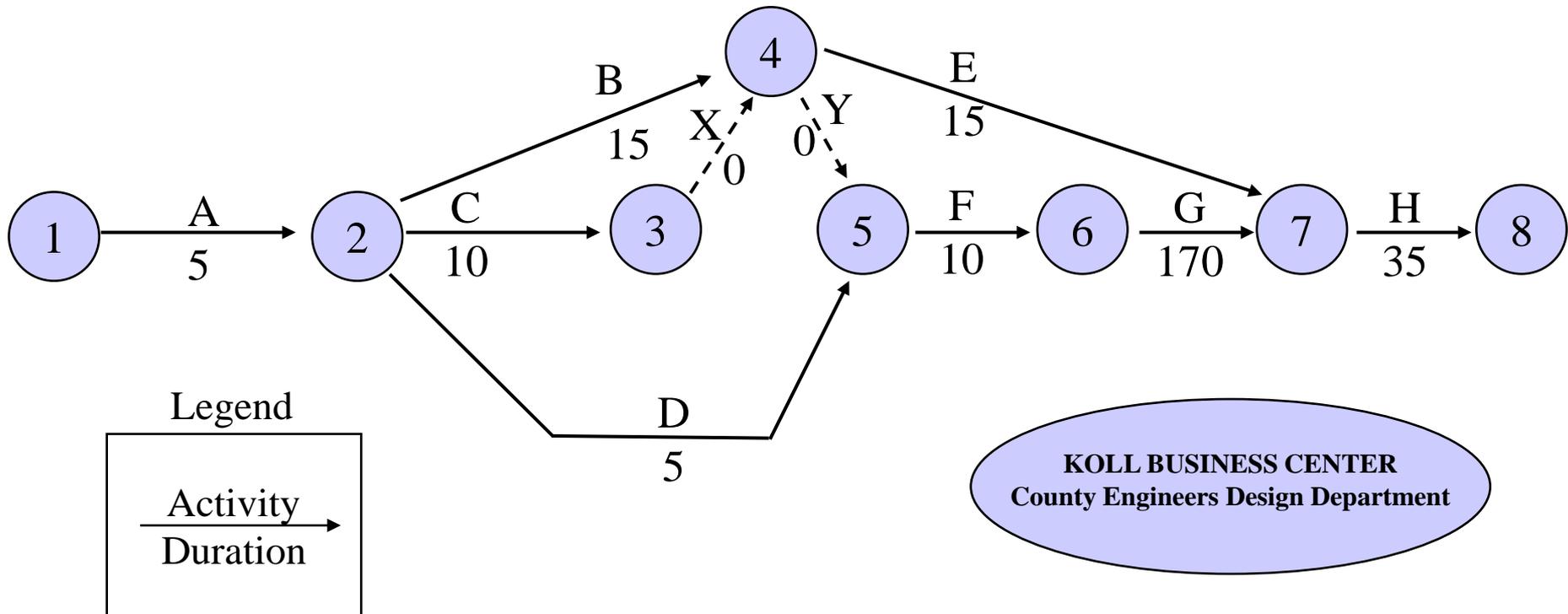
Partial AOA Network



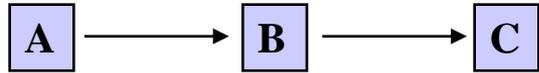
Partial AOA Network



Full AOA Network

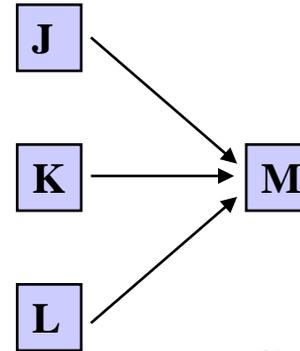


Activity-on-Node Network Fundamentals



A is preceded by nothing
B is preceded by A
C is preceded by B

(A)

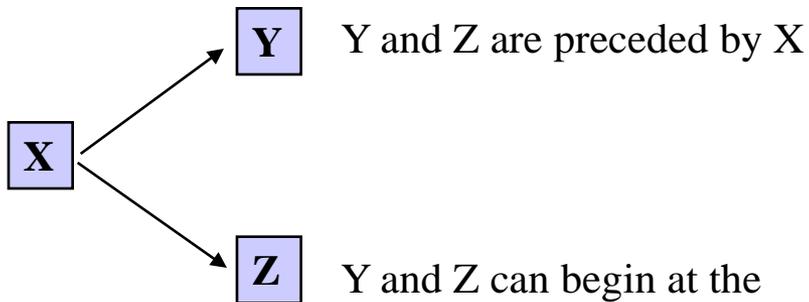


J, K, & L can all begin at the same time, if you wish (they need not occur simultaneously)

but

All (J, K, L) must be completed before M can begin

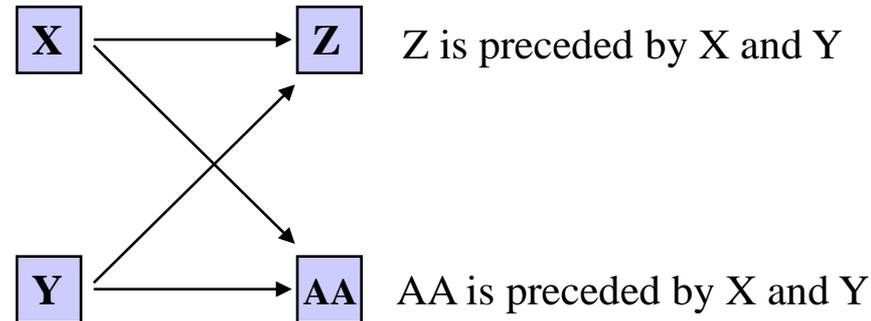
(C)



Y and Z are preceded by X

Y and Z can begin at the same time, if you wish

(B)



Z is preceded by X and Y

AA is preceded by X and Y

(D)

History of CPM/PERT

- Critical Path Method (CPM)
 - E I Du Pont de Nemours & Co. (1957) for construction of new chemical plant and maintenance shut-down
 - Deterministic task times
 - Activity-on-node network construction
 - Repetitive nature of jobs
- Project Evaluation and Review Technique (PERT)
 - U S Navy (1958) for the POLARIS missile program
 - Multiple task time estimates (probabilistic nature)
 - Activity-on-arrow network construction
 - Non-repetitive jobs

Network example 1

Activity	predecessors
A	---
B	---
C	---
D	a,b
E	b,c

Network example 2

Activity	predecessors
A	---
B	---
C	---
D	a,b
E	a,c
F	a,b,c

Network example 3

Dummies for uniqueness of activity representation

Activity	predecessors
----------	--------------

A	---
---	-----

B	a
---	---

C	a
---	---

D	a
---	---

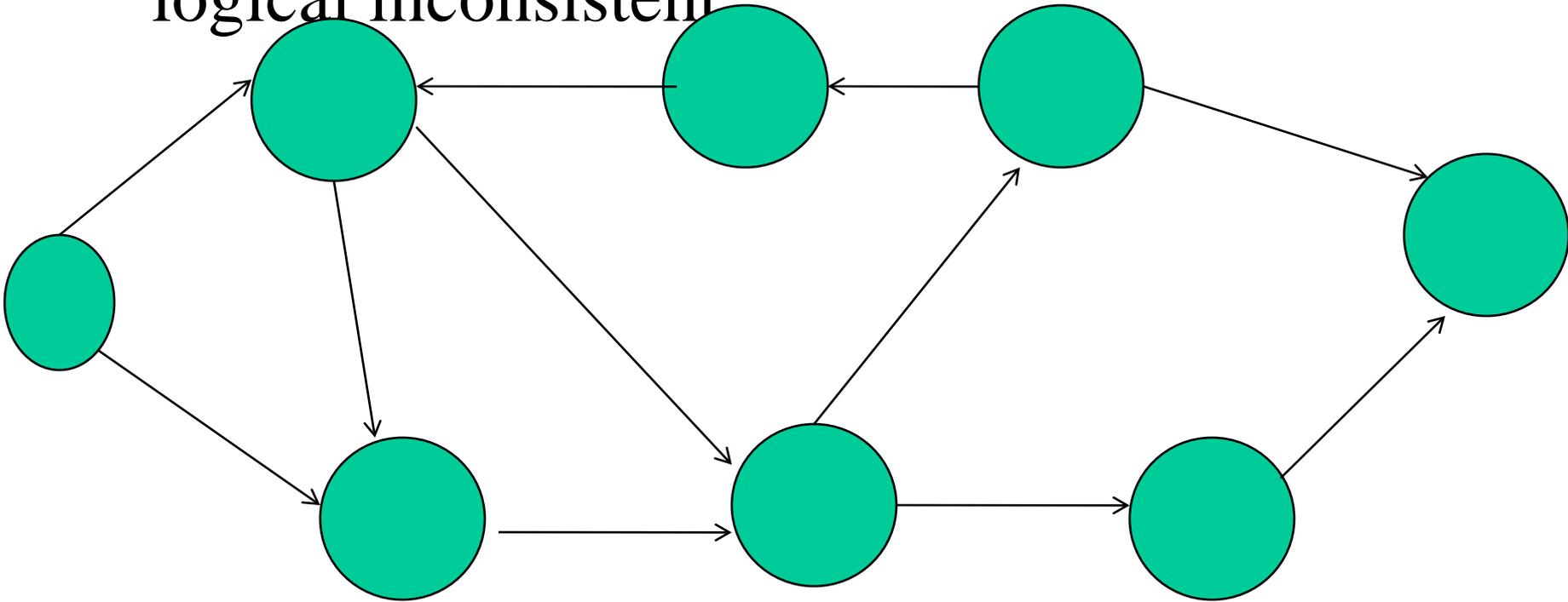
E	b,d,c
---	-------

The role of dummies in project networks

- 1 correct representation of precedence logic
- 2 uniqueness of activity representation
- 3-creation of single source and sink
- 1,2 and 3 is used in AOA network
- 3 only used in AON network

Inconsistent network

- A closed loop in a project network is a logical inconsistent



Prerequisites for a valid project network

- Necessary requirement :the project network must not have any cycles or loops ,since these represent logical inconsistencies in representation
- Desirable features: the project network should have the minimum numbers of dummies and on redundancies since these unnecessarily clutter the network

CPM calculation

- 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

Forward Pass

- Earliest Start Time (ES)
 - earliest time an activity can start
 - $ES = \text{maximum EF of immediate predecessors}$
- Earliest finish time (EF)
 - earliest time an activity can finish
 - earliest start time plus activity time

$$EF = ES + t$$

Backward Pass

◆ 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

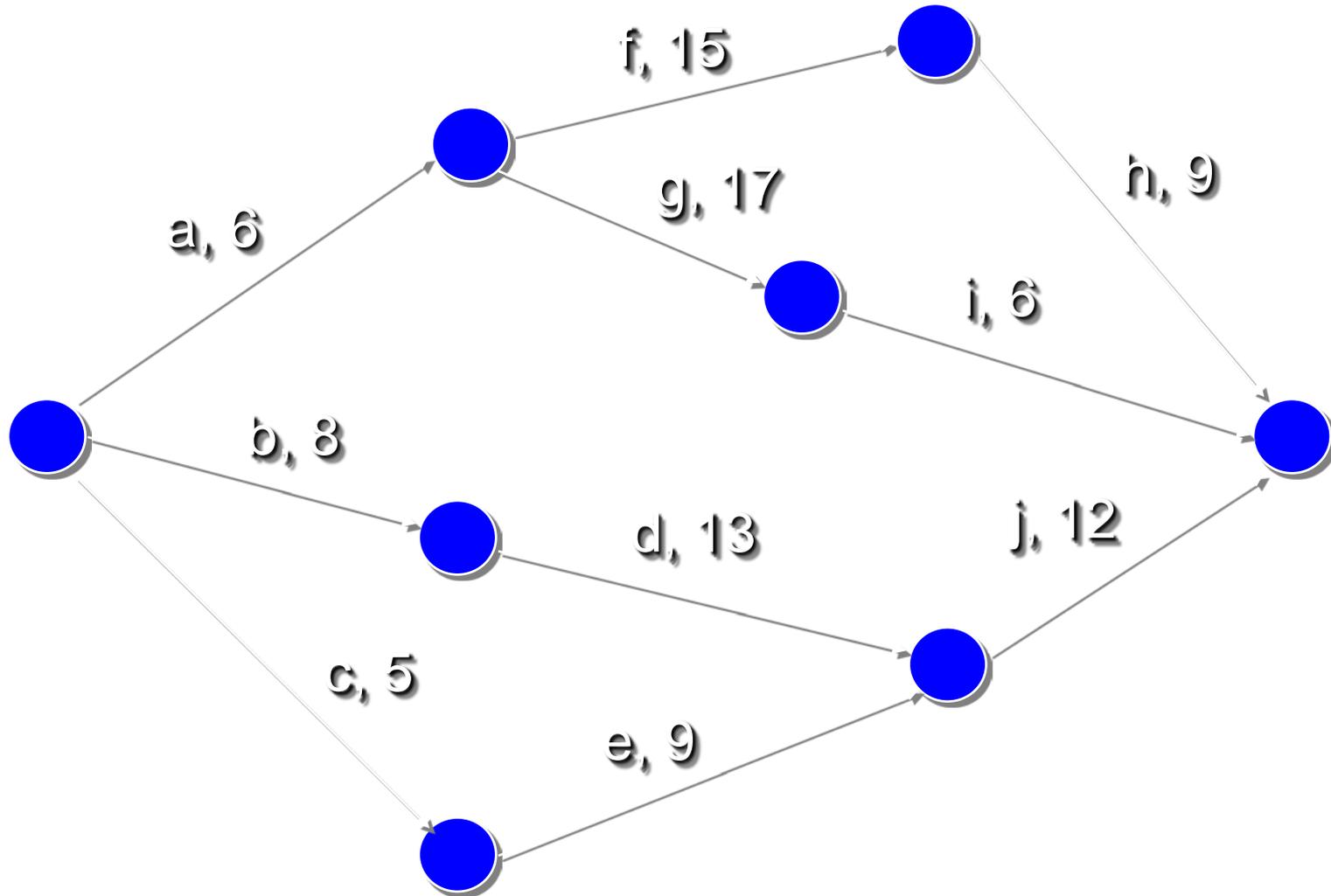
$LS = \text{minimum LS of immediate predecessors}$

CPM analysis

- Draw the CPM network
- Analyze the paths through the network
- Determine the float for each activity
 - Compute the activity's float
$$\text{float} = \text{LS} - \text{ES} = \text{LF} - \text{EF}$$
 - Float 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
- Find the critical path is that the sequence of activities and events where there is no “slack” i.e.. Zero slack
 - Longest path through a network
- Find the project duration is minimum project completion time

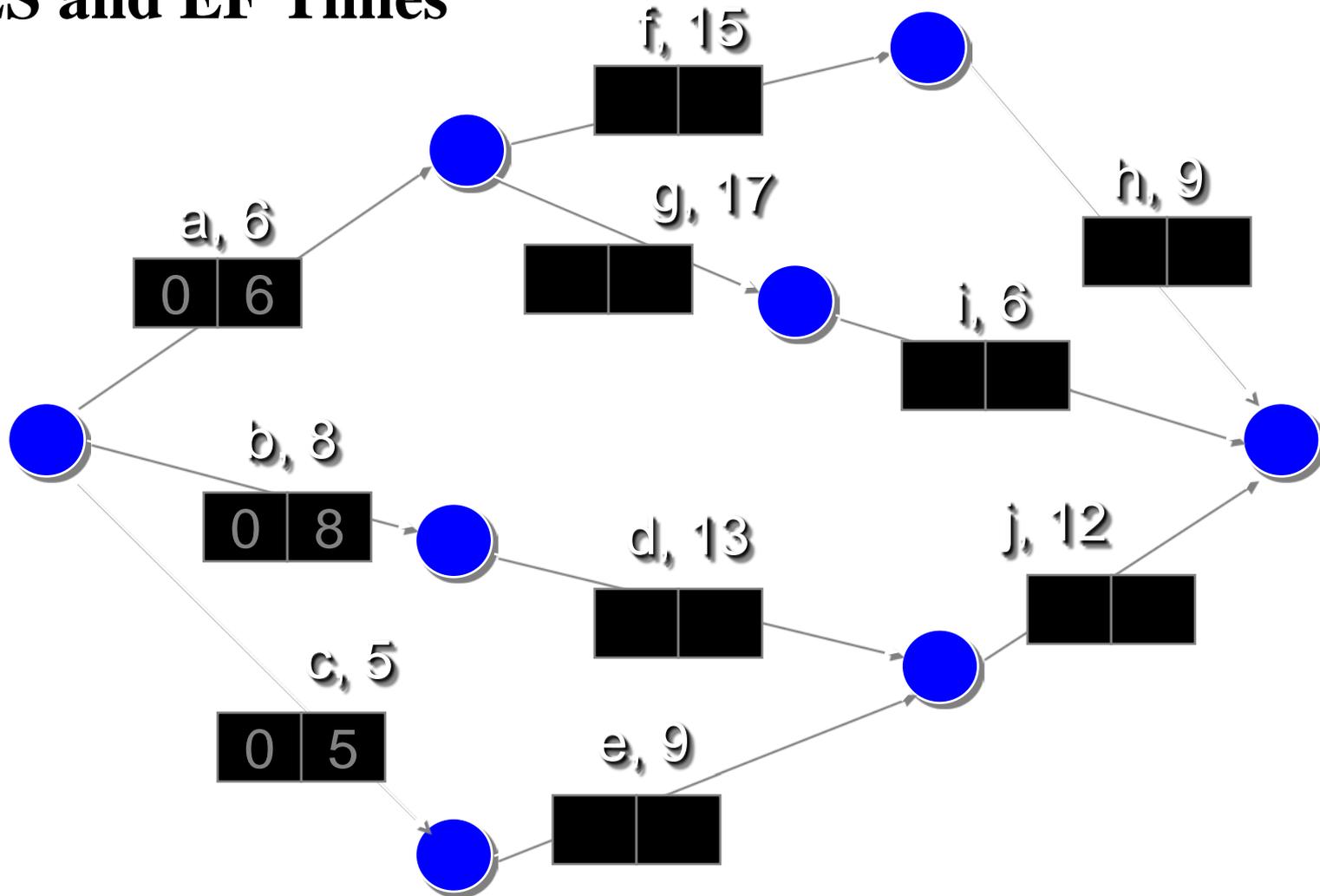
CPM Example:

- **CPM Network**



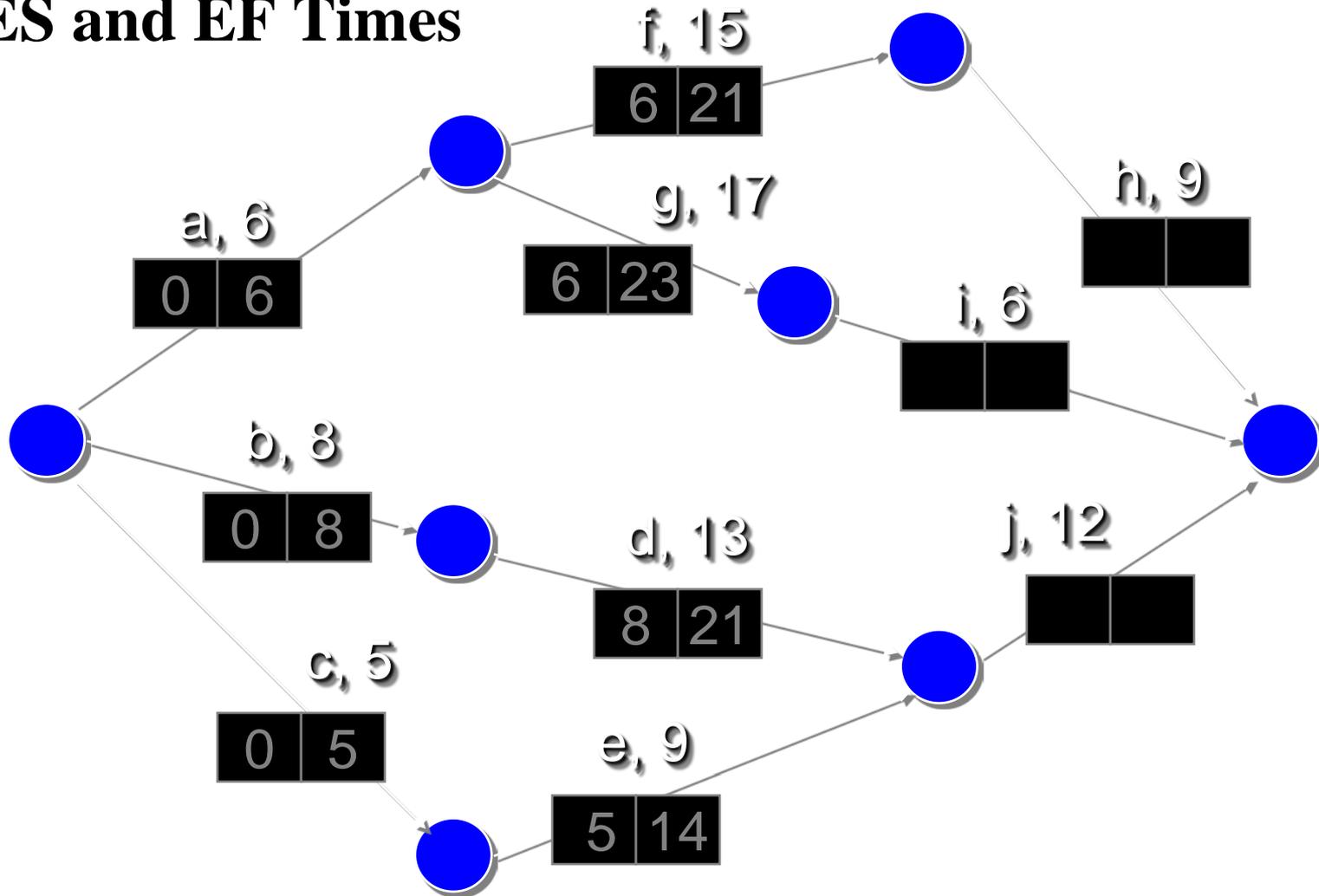
CPM Example

- **ES and EF Times**



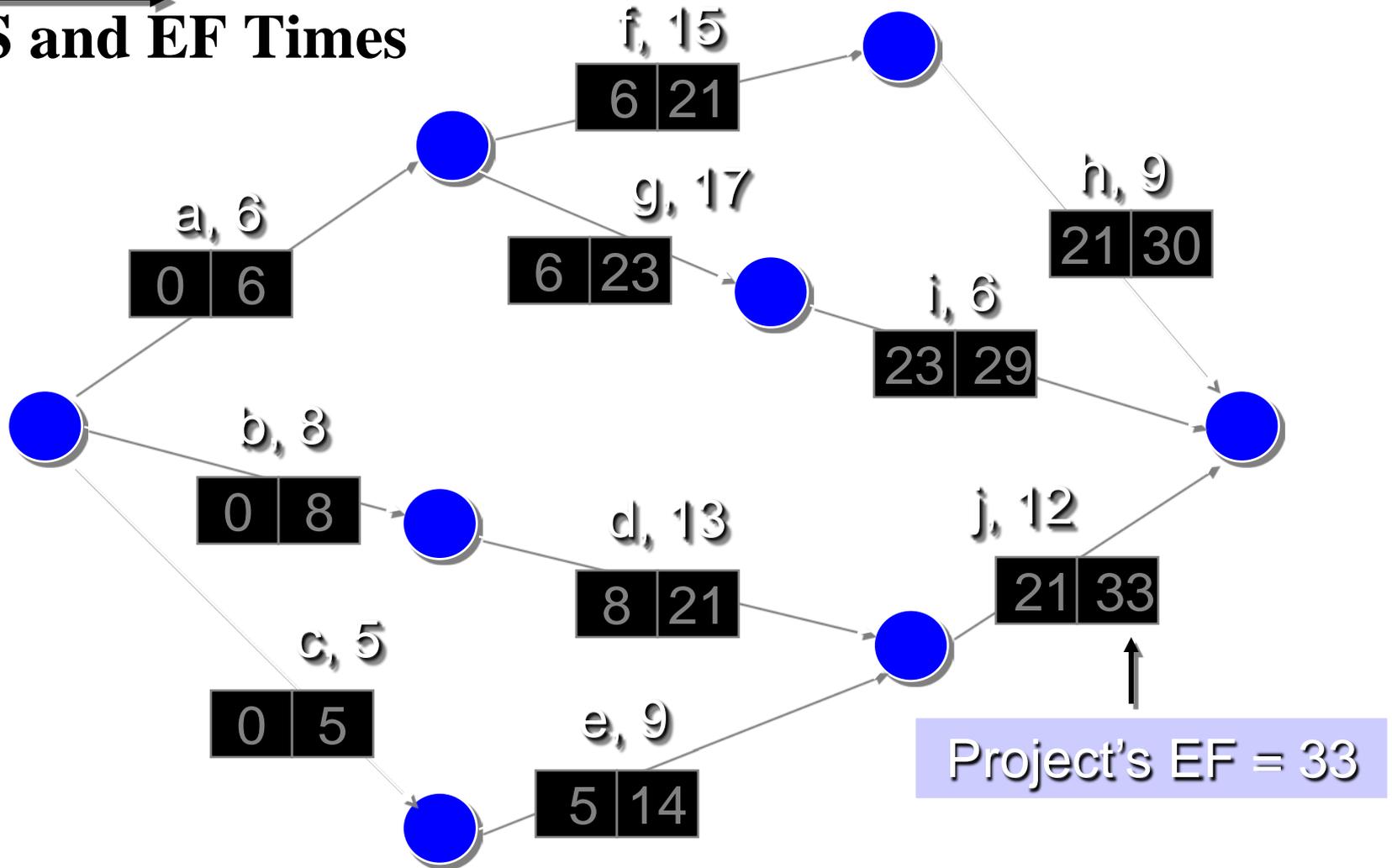
CPM Example

- • **ES and EF Times**



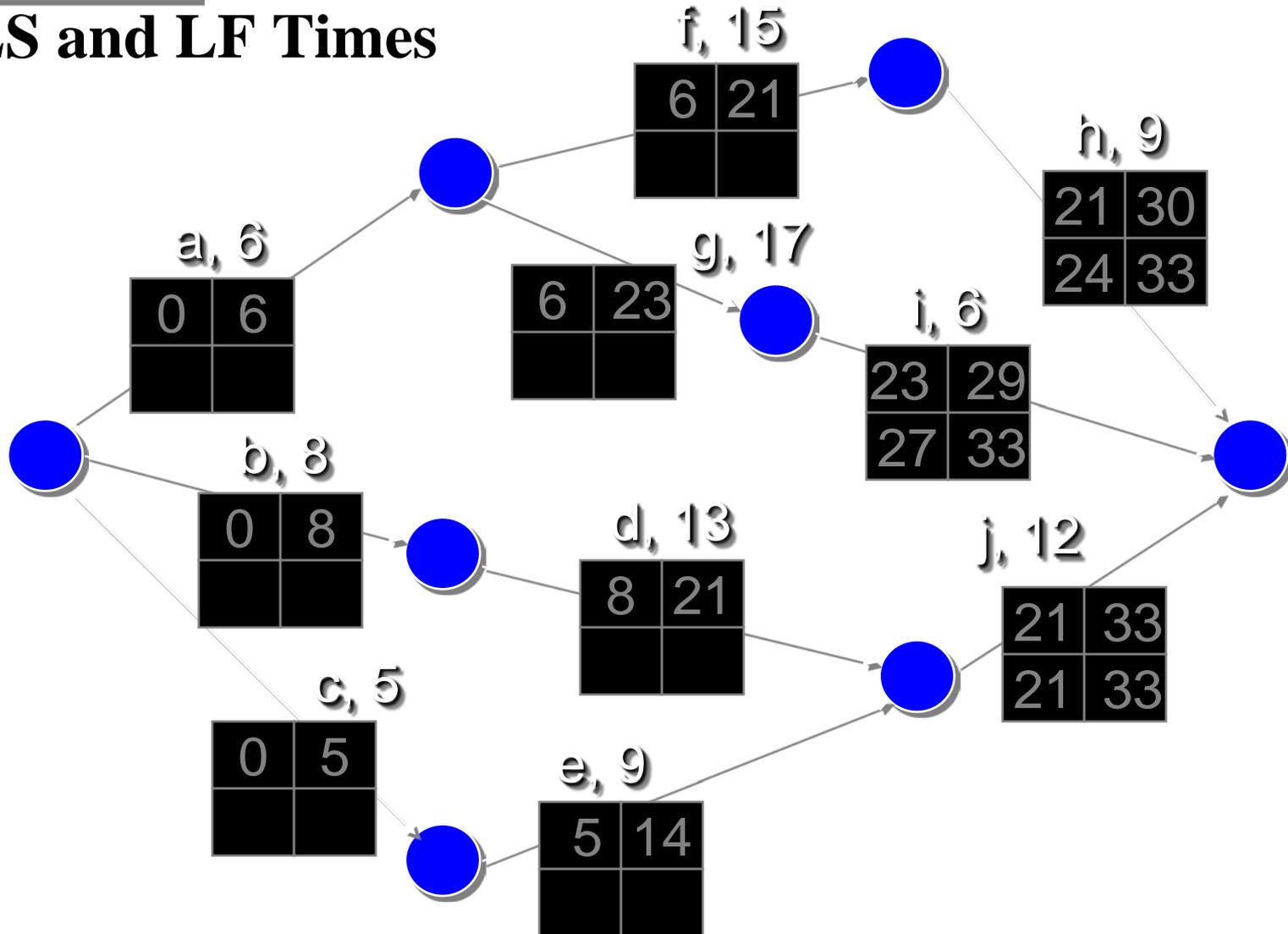
CPM Example

- **ES and EF Times**



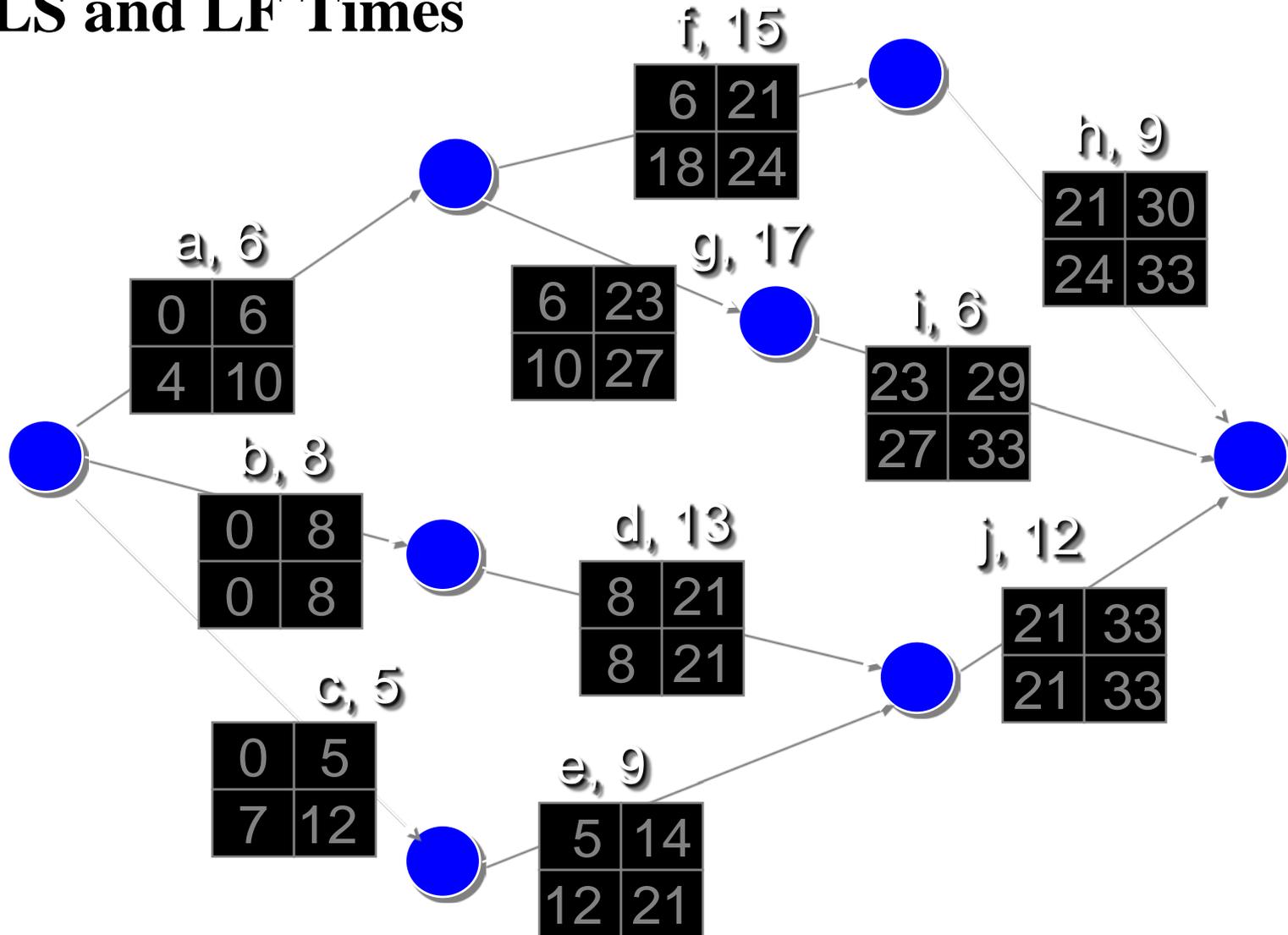
CPM Example

- ← **LS and LF Times**



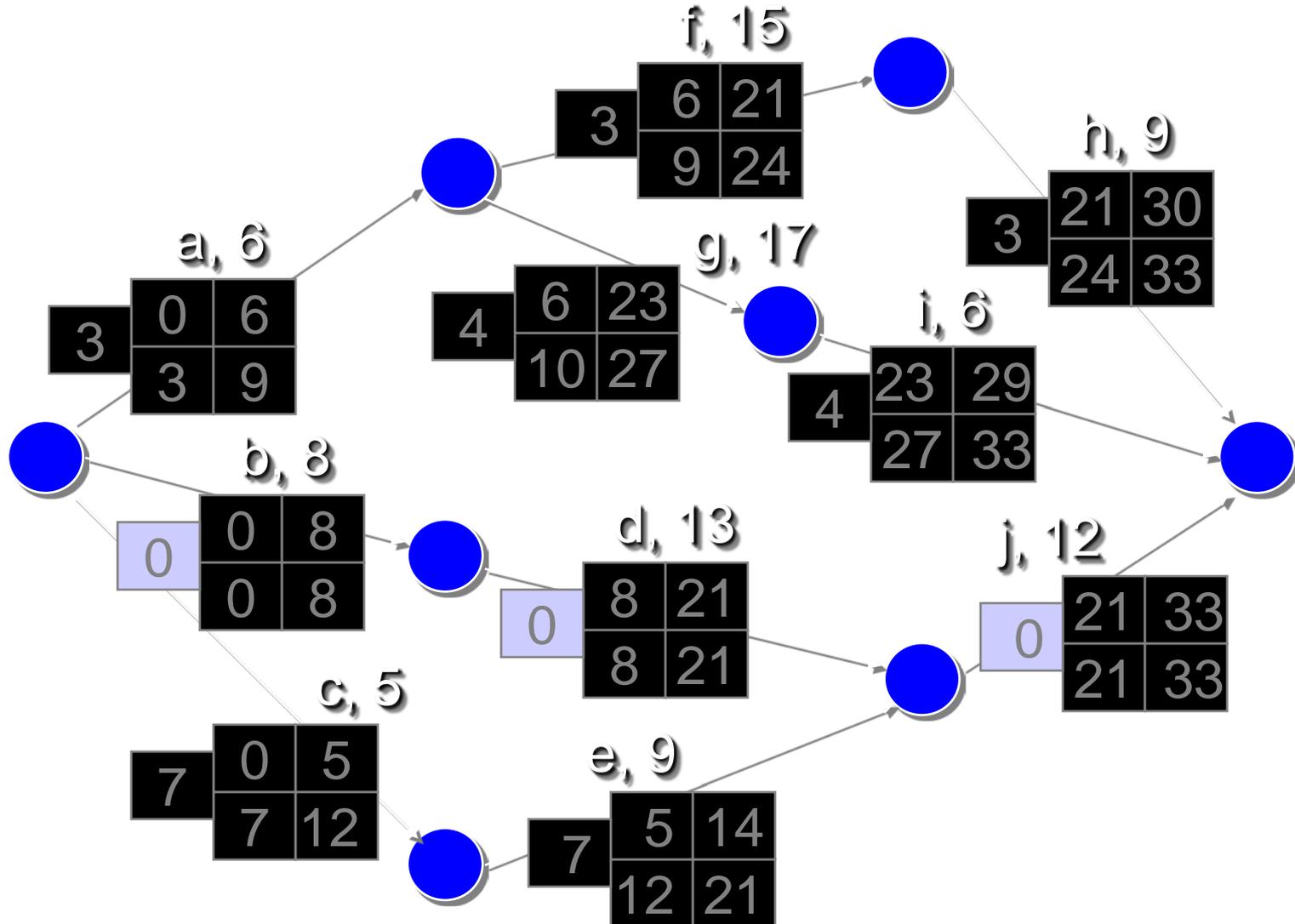
CPM Example

- ← **LS and LF Times**



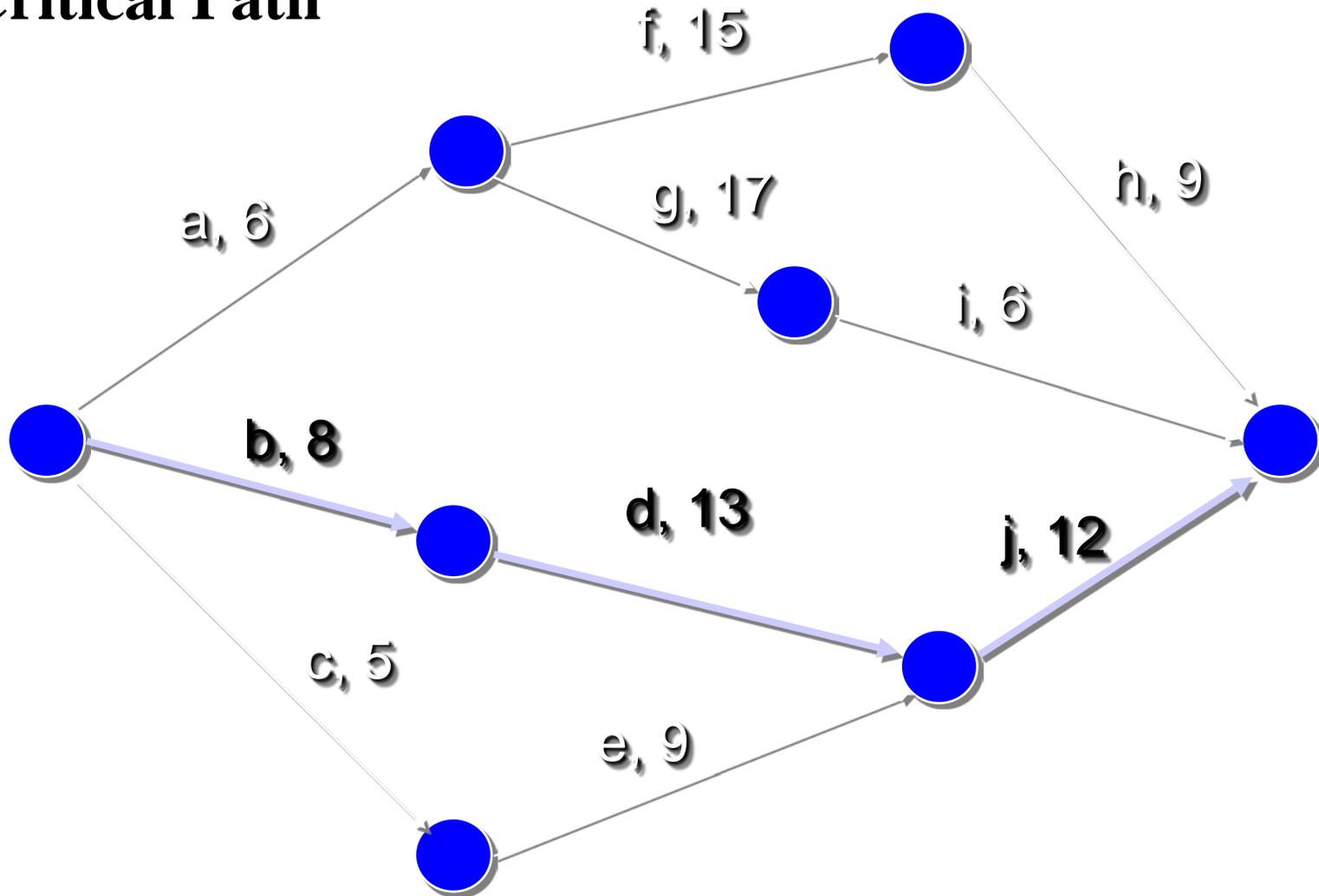
CPM Example

- **Float**



CPM Example

- **Critical Path**



PERT

- PERT is based on the assumption that an activity's duration follows a probability distribution instead of being a single value
- 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

Mean (expected time): $t_e = \frac{t_p + 4 t_m + t_o}{6}$

Variance: $V_t = \sigma^2 = \left(\frac{t_p - t_o}{6} \right)^2$

Methods of inconsistency checking

- Topological ordering of activities
- Fulkerson's numbering rules
- Squaring adjacency matrix

Network example

Illustration of network analysis of a minor redesign of a product and its associated packaging.

The key question is: How long will it take to complete this project ?

Activity number		Completion time (weeks)
1	Redesign product	6
2	Redesign packaging	2
3	Order and receive components for redesigned product	3
4	Order and receive material for redesigned packaging	2
5	Assemble products	4
6	Make up packaging	1
7	Package redesigned product	1
8	Test market redesigned product	6
9	Revise redesigned product	3
10	Revise redesigned packaging	1
11	Present results to the Board	1

For clarity, this list is kept to a minimum by specifying only immediate relationships, that is relationships involving activities that "occur near to each other in time".

Activity number		Activity number
1	must be finished before	3
2		4
3		5
4		6
5, 6		7
7		8
8		9
8		10
9, 10		11

Questions to prepare activity network

- Is this a Start Activity?
- Is this a Finish Activity?
- What Activity Precedes this?
- What Activity Follows this?
- What Activity is Concurrent with this?

