UNIT- TWO

A WBS is an outcome-oriented analysis of the work involved in a project that defines the total scope of the project. It is often depicted as a tree-oriented family tree of activities that help people visualize the whole project & all of its main parts

WORK BREAKDOWN STRUCTURE

* A work breakdown structure is a method of representing, in a hierarchical manner, the part of a process or product. A project is made of various tasks with different functionalities. It may be performed by the org as a whole or by one group in the org. The tasks may be divided into subtasks if it can provide increased clarity & purpose to the project
* it can be used for representing a process, a product or both
* The WBS is a major system engineering tool and is considered one of the best project management tools * WBS forms the basis for planning & managing project schedules, costs & changes
* work breakdown structure is a document showing tasks associated with people and scheduled over time, where completion of all tasks leads to completion of the project
* A work package is a group of activities combined together under a single organizational unit

TYPES OF WBS

* There are 3 types of work Breakdown structure

① PROCESS WBS

A WBS that partitions a large process into smaller and smaller processes. Each process is eventually decomposed into tasks that can be assigned to individuals for accomplishment

② PRODUCT WBS

A WBS that partitions a large entity into its components. Each component and its interfaces are identified, resulting in a clear identification of the larger system

③ Hybrid WBS

A WBS that include both process and product elements.

Two Methods of WBS Representation

There are two methods of WBS representation. They are explained below :

(I) Tree Structured (or hierarchical) graph.

(II) Indented list form.

Let us discuss these methods one-by-one.

Method-I : Tree Structured Graph

As shown in Fig. 2.11, a graphical/tree/hierarchical WBS is a set of activities or product elements that illustrates **"is contained in"** relationships between higher level activities and/or product elements and lower level activities and/or product elements.

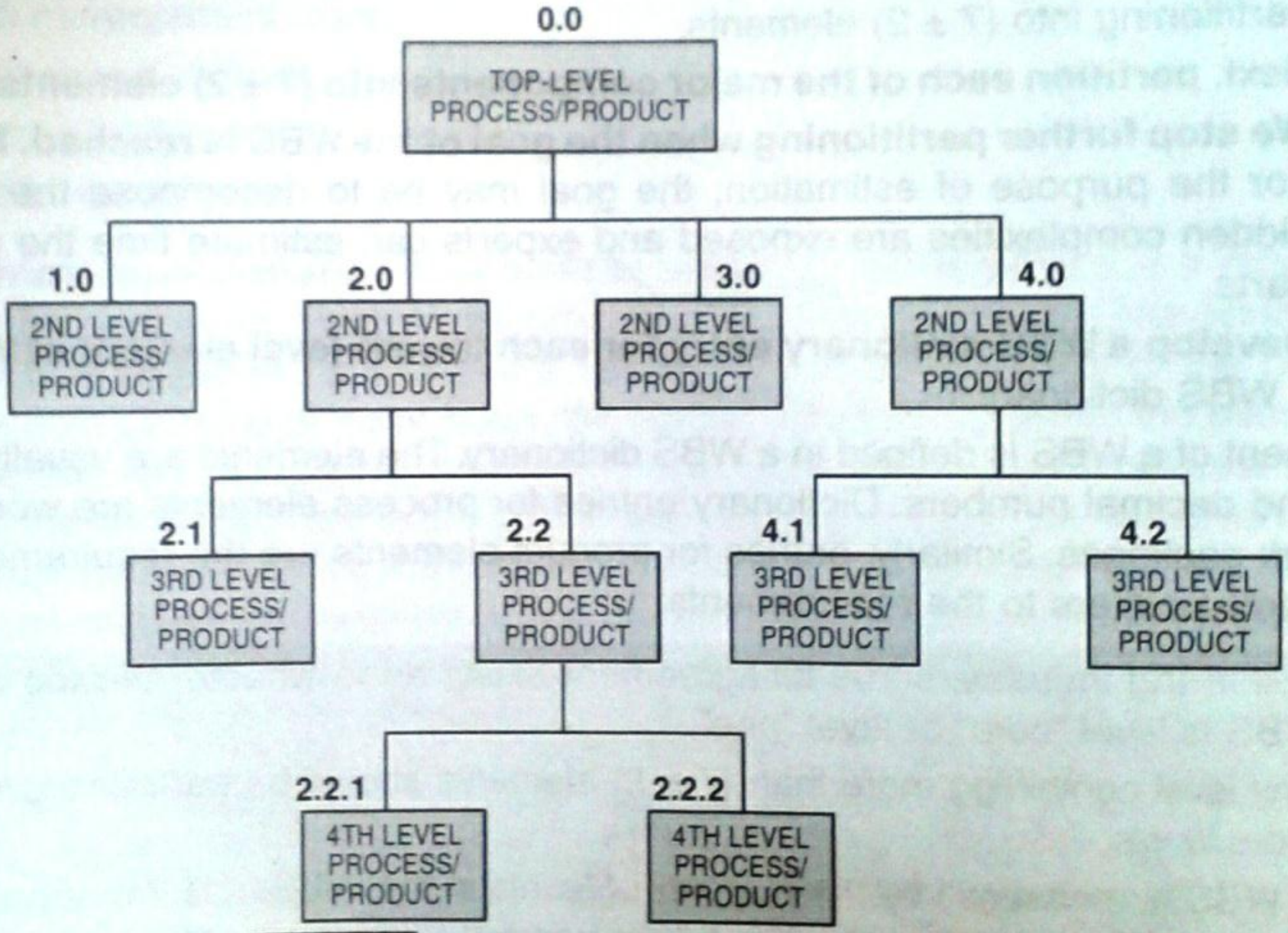


Fig. 2.11. Tree Structured/Hierarchical WBS

For example, an orgaizational chart will show a graphical WBS where in the smaller organization elements are contained in larger ones.

Method-II : Indented List Form

As shown in Fig. 2.12, in this form of WBS representation, indentations are used to show the relationships between higher-level product elements and/or processes and lower-level product elements and/or processes.

```
0.Top level process/product element (0th level).
   1.   1st level process or product elements.
   1.   1st level process or product element.
        2.1. 2nd level process or product element.
        2.2. 2nd level process or product element.
             2.2.1. 3rd level process or product element.
             2.2.2. 3rd level process or product element.
3.      1st level process or product element.
4.      1st level process or product element.
        4.1. 2nd level process or product element.
        4.2. 2nd level process or product element.
```

Fig. 2.12. Indented list form of WBS

This WBS is another form of the WBS discussed in Fig. 2.11. The elements with greater indentations are contained in the elements with the lesser indentations.

Types of WBS

There are three types of work breakdown structures. They are as follows :

(a) Process WBS.

(b) Product WBS.

(c) Hybrid WBS.

We shall discuss them one by one.

(a) Process WBS : It is a WBS-form that partitions a large process into smaller and smaller processes. Each process is eventually decomposed into tasks that can be assigned to individuals for accomplishment. It is used by project managers to manage their projects.

(b) Product WBS : It is a WBS-form that partitions a large entity into its components. Each component and its interfaces are identified, resulting in a clearer identification of the larger system. It is the primary tool of systems engineers and software engineers.

(c) Hybrid WBS : A WBS that includes both process and product elements of a project into one WBS. It is used by managers who first want to determine and second want to control project cost.

Solved Examples (with Case Studies)

Example 1. Case Study on WBS of an Air Traffic Control System (ATC)

Problem Domain : An air traffic control software consists up of a radar segment—search radar and beacon radar. It also has a tower segment which helps in communications and displays. The processors are fitted for various tasks like flight plan, display, manual entries etc. The communication is from ground-to-air, digital and voice networks are also used. A control segment controls various activities. We need to draw it's WBS based on the **"process"** and the **"product"**.

Solution. The WBS, based on **process** for an ATC is as follows :

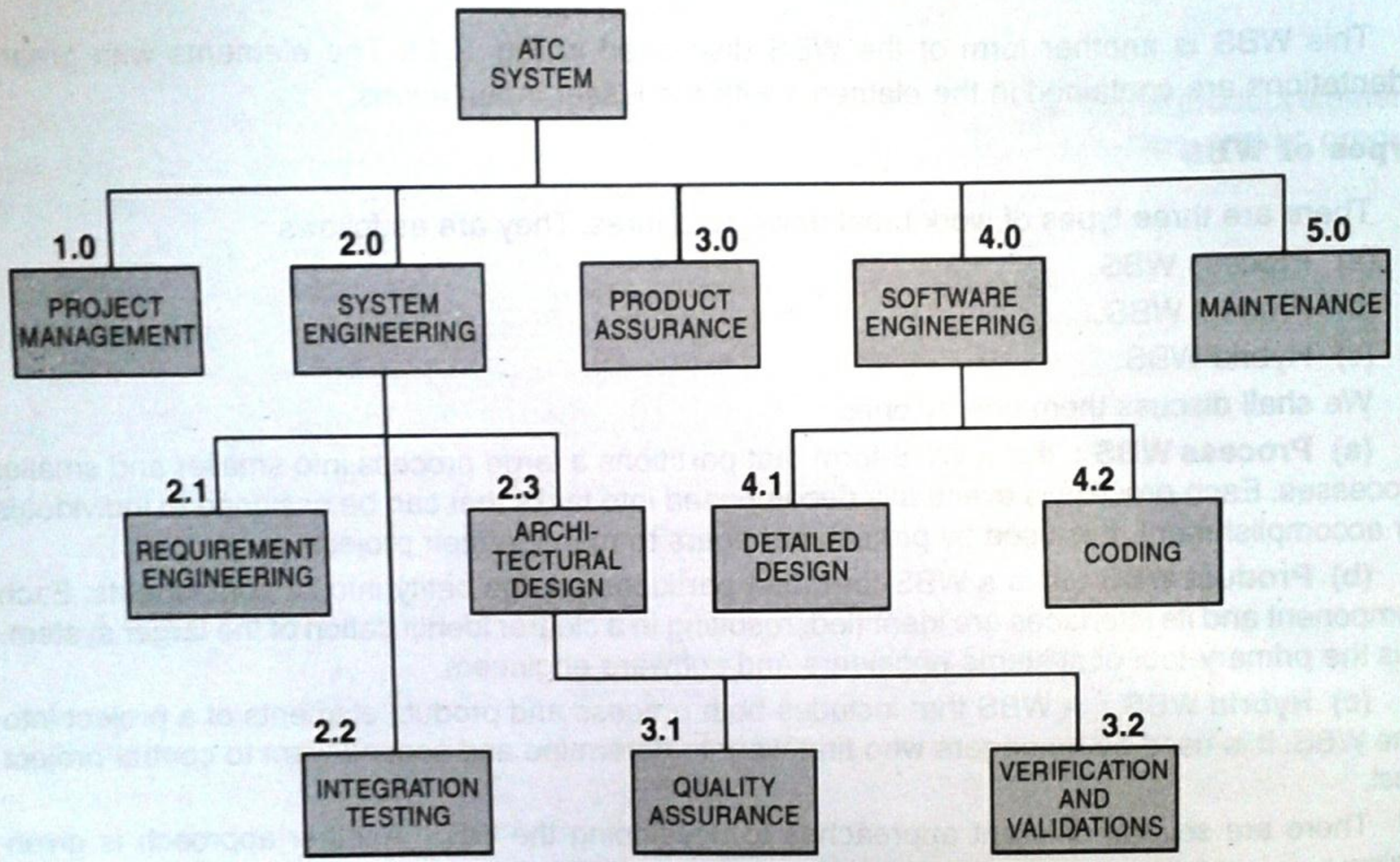


Fig. 2.13. WBS of ATC (Process Based)

Next, we draw its WBS, based on the product.

```
0.0.Air Traffic Control (ATC) System.
1.0.Radar Segment
    1.1.Search Radar
    1.2.Digitizer
    1.3.Beacon Radar
2.0.Terminal or Tower Segment
    2.1.Communications
    2.2.Display
3.0.Central Process Segment
    3.1.Radar Data Processing
    3.2.Flight Plan Processor
    3.3.Display Processor
    3.4.System Utilities
4.0 Communications Segment
    4.1.Ground-to-Air System
    4.2.Digital Network System
    4.3.Voice System
5.0.Area Control Segment
    5.1.Communications
    5.2.Display
```

Fig. 2.14. WBS of ATC Product Based

It is after planning that the project ...

Example 3. A new house is to be constructed. Activities like building its structure, installation of plumbing, heating and electric appliances is also to be done. Draw its WBS ?

Solution. We draw its WBS showing major tasks first.

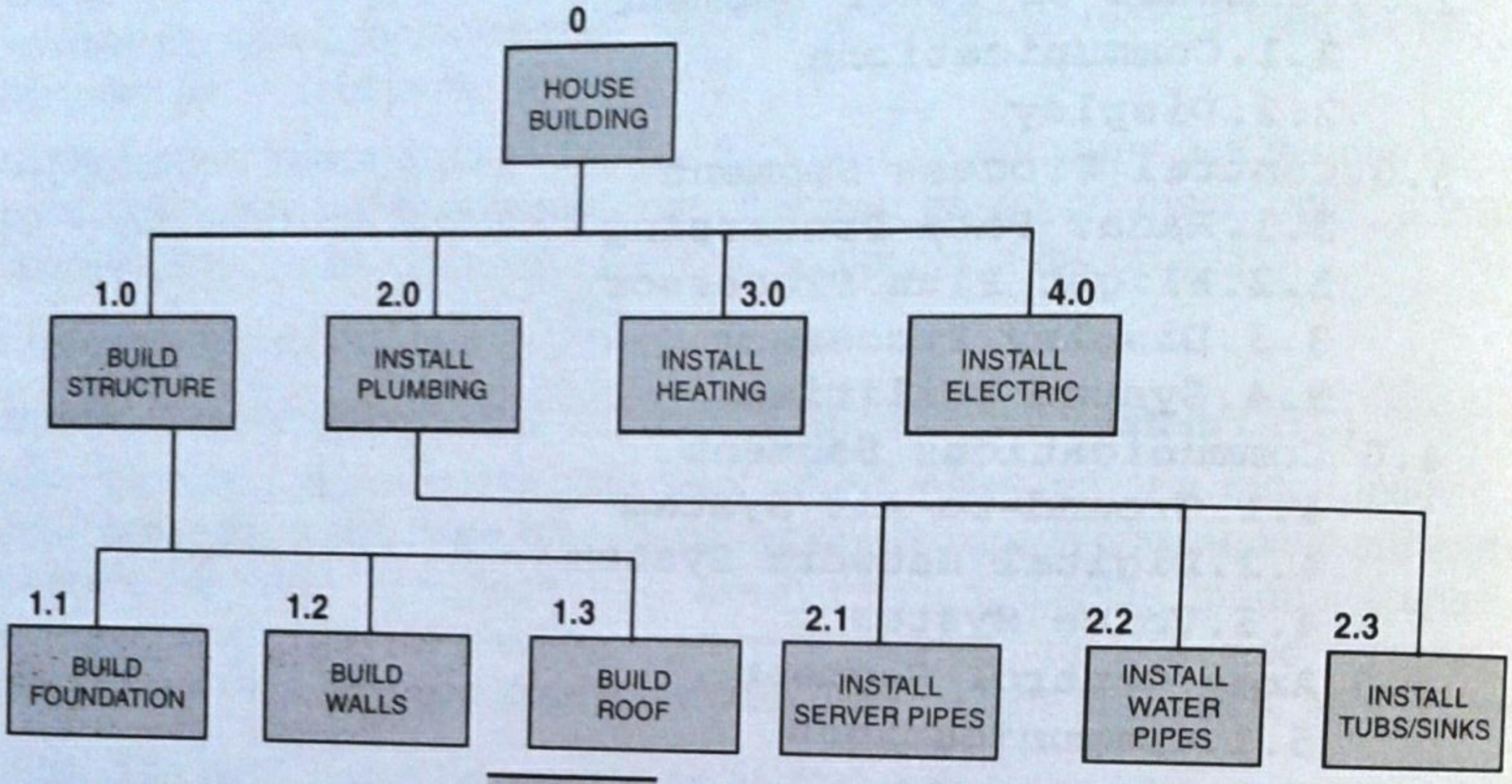


Fig. 2.15. WBS of a House

Herein, the cost of any level is to be computed by summing the cost of its siblings (children). Level-0 is the root node of this WBS-tree. It represents all work that is required to complete the project. The activities on the extreme right or at leaf (terminal) nodes can be assigned to different companies. **Please note that** a WBS does not show the sequencing of activities. Also note that tasks like installing water pipes can be done parallelly also alongwith the task of building house.

Example 4. Say, a compiler is to be developed for C++ language. Draw it's WBS using both tree method and using indented list method.

Solution. We, firstly draw its WBS using tree-method.

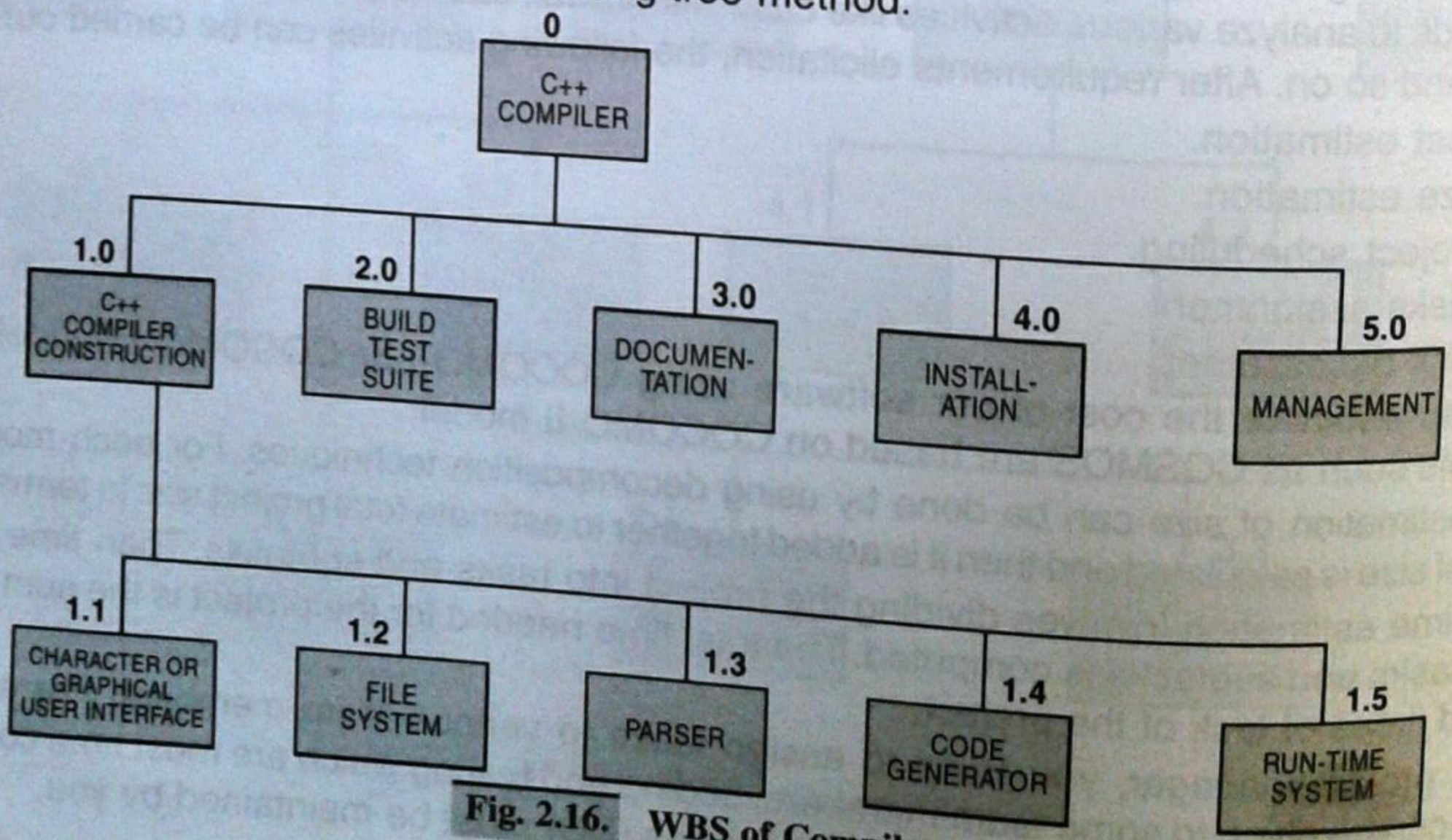


Fig. 2.16. WBS of Compiler

Another method to draw WBS for a software compiler is given below. This technique is called indented list representation.

```
1.0. C++ Compiler
1.1. Construct C++ Compiler
     1.1.1. Build User Interface (CUI/GUI)
            1.1.1.1.  Requirement Analysis
            1.1.1.2.  Design User Interface
            1.1.1.3.  Code User Interface
            1.1.1.4.  Test User Interface
     1.1.2. Build File System
     1.1.3. Build a Parser
     1.1.4. Build a Code Generator
     1.1.5. Build a Run Time System.
1.2.Build the Test Suite for C++ Compiler
1.3.Documentation Writing
1.4.Installation Software Writing
1.5.Management of Software
```

Fig. 2.17. WBS for Compiler

2.2. WAYS TO ORGANIZE PERSONNEL

Effective software project management focuses on 4 P's: people, product, process and project. Out of these four P's, people are the most important for the success of any project. Then, comes the product. Following the product is the process and finally the project.

I. The People

Every software project is populated by five-players:

1. **Senior Managers :** Who define the business issues that have significant influence on the project.
2. **Project Managers :** Who must plan, motivate, organize and control the practitioners who do software work.
3. **Practitioners :** Who deliver the technical skills that are necessary to engineer a product/ application.
4. **Customers :** Who specify the requirements for the software to be engineered.
5. **End-users :** Who interact with the software once it released for production use.

Team leaders : Weinberg suggests the following leadership skills [MOI]

(a) *Motivation :* The ability to encourage technical people to produce to their best ability.

(b) *Organization :* The ability to mold existing processes or invent new ones to get final product.

(c) *Ideas or Innovation :* The ability to encourage people to create and feel creative for software product.

Weinberg suggests that the software project Manager should concentrate on understanding the problem to be solved, managing the flow of ideas etc.

Other Characteristics of a Project Manager

1. Problem Solving : He/She should be able to diagnose the techical and organizational issues that are most relevant.

2. Managerical Identity : A good project manager must take charge of project. He/She must have the confidence to asssume control when necessary.

3. Achievement : He must reward initiatives (like bonus, gifts etc.) as this will optimize the productivity of a project team.

4. Influence and Team Building : He must be able to "read" people *i.e.*, he must be able to understand verbal and non-verbal signals and react to needs of people. The manager must remain under control in high-stress situations.

Software Team

The following options are available for applying human resources to a project that will require n-people working for k-years :

1. ***n* individuals are assigned to m different functional tasks :** Here, very little combined work occurs. Coordination is the responsibility of a software manager.
2. ***n* individuals are assigned to m different tasks where-in m < n :** Here, informal "terms" are established. An adhoc team leader may be appointed. Coordination among teams is the responsibility of a Software Manager again.
3. ***n* individuals are organized into t-teams :** Each team is assigned one or more functional tasks. Each team has a specific structure. Coordination is controlled by both team and software project manager. However, option-3 is most productive.

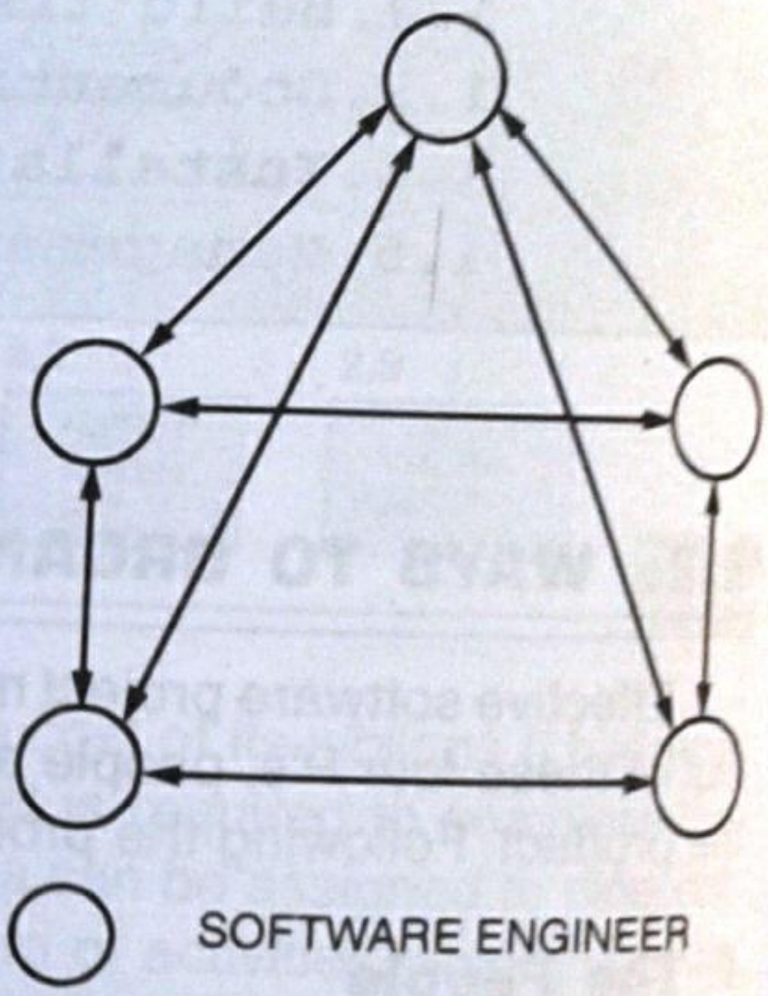


Fig. 2.18. Democratic Team Structure

Mantel describes 7 project factors that should be considered when planning the structure of software Engineering teams:

(a) The difficulty of problem to be solved.
(b) The size of resultant program in LOC.
(c) The time that the team will stay together.
(d) The degree to which the problem can be modularized.
(e) The required quality and reliability of system to be built.
(f) The rigidity of the delivery date.
(g) The degree of communication required for the project.

Mantei suggests 3 generic team organizations :

1. Democratic decentralized (DD) : This Software Engineering team has no permanent leader. Rather, "task coordinators" are appointed for short durations and then replaced by other who may coordinate different tasks. (See Fig. 2.18)

2. Controlled decentralized (CD) : This software Engineering team has a defined leader who coordinates specific tasks. Problem solving remains a group activity. Communications among subgroups and individuals is horizontal. Vertical communication along the control hierarchy also occurs. (See Fig. 2.19).

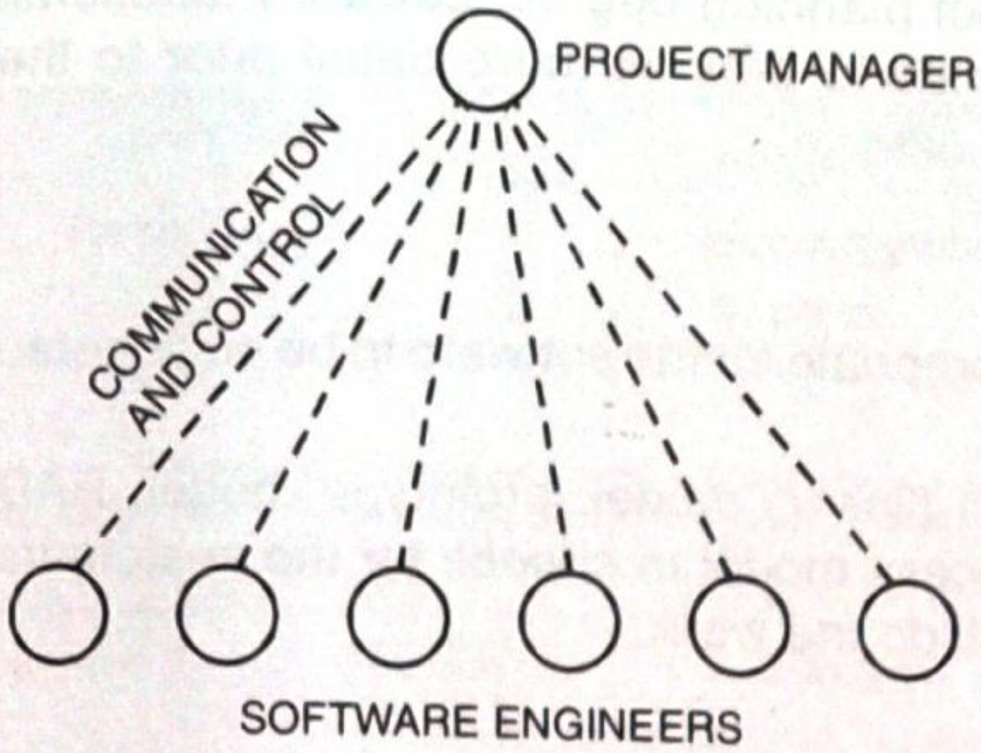


Fig. 2.19. Chief Programmer Team Structure

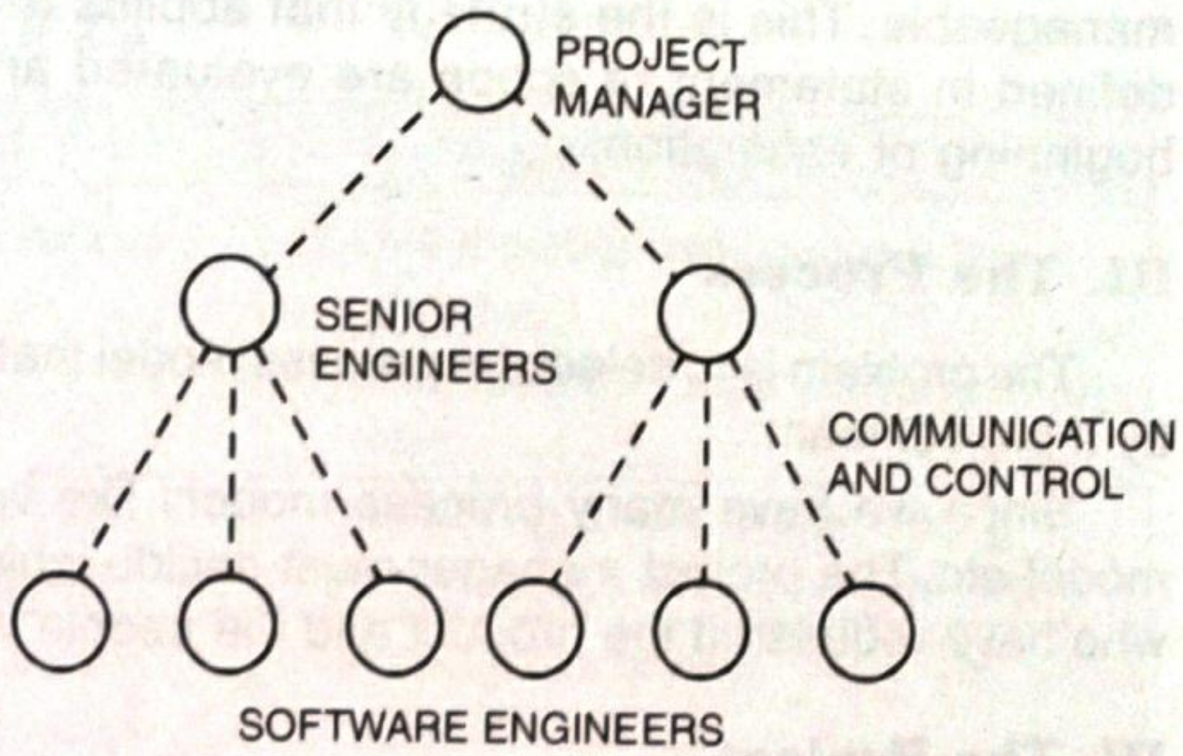


Fig. 2.20. Mixed Team Structure

3. Controlled Centralized (CC) : Top-level problem solving and internal team coordination are managed by a team leader. Communication between the leader and team member is vertical. (See Fig. 2.20).

Which one to select ? Because a centralized structure completes tasks faster, it is most suitable in handling simple problems. Decentralized teams generate more and better solutions than individuals.

So such teams are useful when difficult projects are to be done.

Since CD team is centralized for problem solving, either CD or CC team structure can be successfully applied to simple problems. A DD-structure is best for difficult problems.

Also, DD team structure is best applied to the problems with low modularity. When high modularity is possible then CC or CD structure will work well.

CC and CD teams have been found to produce fewer defects than DD teams. Decentralized teams generally require more time to complete a project than a centralized structure.

II. The Product

A software project manager is confronted with a dilemma at the very beginning of a software engineering project. Quantitative estimates and organized plans are required but solid information is unavailable. So, we must examine the product. This involves:

(a) **Software Scope :** It must be unambiguous and understandable at the management and technical level. A statement of software scope must be bounded *i.e.*, quantitative, data (*e.g.* no. of simultaneous users, size of mailing lists, inputs and outputs etc) are stated explicitly, constraints or limitations are noted (like memory size) and other factors like desired algorithms are well understood and are available.

(b) **Problem Decomposition :** Also called as partitioning or problem elaboration, is an activity that sits at the core of software requirement analysis. This decomposition is applied in 2 major areas :

1. The functionality that must be delivered, and
2. The process that will be used to deliver it.

Human beings tend to apply divide and conquer strategy when they are confronted with complex problems. A complex problem is partitioned into smaller problems that are more

manageable. This is the strategy that applies as project planning begins. Software functions, defined in statement of scope are evaluated and refined to provide more detail prior to the beginning of estimation.

III. The Process

The problem is to select the process model that is appropriate for the software to be engineered by a project team.

Since we have many process models like waterfall (linear) model, prototype model, RAD model etc. The project manager must decide which process model to choose for the customers who have requested the product and the people who will do the work.

IV. The Project

In order to manage a successful software project, we must understand what can go wrong and how to do it right. According to John Real, there are 10 signs that indicate that an information systems project is in jeopardy:

1. Software people do not understand their customer needs.
2. The product scope is poorly defined.
3. Changes are managed poorly.
4. The chosen technology changes.
5. Business needs change.
6. Deadlines are unrealistic.
7. Users are resistant.
8. Sponsorship is lost.
9. The project team lacks people with appropriate skills.
10. Managers and software Engineers (or practitioners) avoid best practices and lessons learned.

Software developers who will work on the project to deliver product can be assigned to the project in two ways

(I) Flat Staffing

(II) Gradual Staffing.

In flat staffing method, some of the developers can be assigned to the analysis activities with system analysts. While others may already start other activities such as CM, technology review, and trainings. This method has the advantage of establishing teams early and the environment necessary for speedy communication. With shorter projects and market deadlines, flat staffing is being preferred today. Developers are assigned all at once.

In gradual staffing method, the project work is gradually carried out by hiring people as required. It is motivated by saving resources in the early part of the project. Requirement analysis does not require as many people as coding and testing. Also note that the role of system analyst and system developer are different and need different skills. So they should be different personnel.

Now, what should be the team size ?

The table below [Kayser, 1990] shows various suggested team sizes and their positive and negative impacts :

Q. 4. What are the principles of WBS ? Discuss in detail.

Ans. WBS principles are as follows :

1. The WBS covers the total scope of the project. Work not in the WBS is not in the project.
2. All deliverables or output products are represented in the WBS.
3. The sum of the elements at each level represents 100 percent of the work of the next higher level. (The sum of the Level 2 items is 100 percent of the project work or cost.)
4. Work in each element is equivalent to the sum of the work in the subordinate elements.
5. The subdivisions should be logical and reflect the nature of the product, service, or result.
6. Each WBS element should represent a discrete element of work that can be described in the WBS dictionary.
7. Each WBS element should have a unique identifier.

8. WBS element descriptors preferably should be nouns, with adjective modifiers if necessary. For clarity or for cultural reasons, WBS descriptors may include verbs and modifiers. However, they should not be considered activities since activities are by definition the action elements that occur below the WBS.
9. The work in each WBS element may be described in detail in a WBS dictionary, which may become the basis for statements of work or work-authorizing documents.
10. Project management is a Level 2 element in all WBSs.
11. Stakeholders should participate in the development of the WBS.
12. The WBS should be base lined after approval by the stakeholders.
13. A formal change process should exist for base lined WBSs.
14. The WBS should focus on project output or deliverables; it is not an organization chart, a schedule, or a resource list.
15. The lowest level should be the level above the activities—the work package level.
16. The lowest level should permit adequate control and visibility for project management.
17. The lowest level need not be the same for all branches of the WBS.
18. The lowest level should not be so detailed as to create an administrative burden.
19. The WBS does not reflect time relationships or horizontal relationships between elements; all structural relationships are vertical.

Major Features of WBS :

(*i*) **Structure :** WBS diagram is drawn like the organization chart. Different desktop applications offer functionalities to easily create this kind of diagrams.

(*ii*) **Description :** Each WBS element should be described with a title. The meaning of each title should be clear.

(*iii*) **Coding :** One of the main feature of WBS is the ability to uniquely code the different elements of the work. The coding system can be alphabetic, numeric or alphanumeric.

(*iv*) **Depth :** The recommended depth of a WBS diagram is three to four levels. If deeper hierarchies are required the division into subprojects can be used and one element would then present one subproject. This can be useful, for example, in a situation where a subcontractor handles some part of the project. Each project manager could then have his/her project presented in one diagram. The downside of adding too many levels is firstly the readability of the diagram and secondly the fact that the larger the diagram, the more troublesome it is to update when major changes occur in the project.

(*v*) **Level of detail :** A rule of thumb is creating a WBS diagram is to make the lowest level element (often called work package) small enough to be considered a separate work element when estimating the amount of work in a project. This allows the work package later to be divided into a list of work activities and tasks.

Uses of WBS :

(*i*) For dividing the project into phases.

(*ii*) For dividing the project into responsibility areas within the organization.

(*iii*) For dividing the schedule of the project into sub-schedules whose interrelations are known.

(*iv*) For giving grounds to following the cost of the project by defining clear targets to it.
(*v*) For giving hierarchical outlining and coding for the work to be done.
(*vi*) For enabling integrating planning and managing of the project from both financial and scheduling perspective.

APPLICATION OF The WBS

① Process WBS

- The process WBS is used by project managers to manage their software engineering project
- The WBS presents a "picture" of activities that have to be accomplished to ensure a successful s/w project
- The top level of the WBS identifies the project by name. The second level of the WBS identifies the major work elements to de done, such as planning, organising, requirements analysis, design, coding, testing and so forth. The third level describes the more detailed activities that must be Completed in order to accomplish the second-level activities
- The lowest-lever process element in a WBS represent task
- The task is the smallest unit of management accountability are specified in "work packages".

② Product WBS

- The product WBS is a primary tool of system engineers and s/w engineers. A product WBS illustrates the components and interfaces of the product to be developed or produced and relates the elements of the product to each other and to the end product.
- The top level of the product WBS identifies the product by name. other elements of a product WBS are discrete, identifiable items of hardware, software and data.
- The product WBS specifies the hardware, software, and data that together completely define a project deliverable

③ Hybrid WBS

- we can combine the product and process elements of a project into one WBS

- A process-product WBS begins with a process, alternates process and productelement and terminates with the product elements. The rationale behind this approach is that processes produce products.

* WBS DICTIONARY

- Every element of a WBS is defined in a WBS dictionary. The elements are usually identified by their names and decimal number.
- Dictionary entries for process element are work package or pointer to work package.
- Entries for product elements are the requirements allocated to those elements or pointers to the requirements

* Developing a WBS

For Developing a WBS, a rolling wave approach is used. The top levels of the WBS are developed down to the second or third level. Analysis is done to determine which processes or product will be done first. The corresponding top-level elements are then partitioned down to their lowest levels in only those areas that are needed in the near future. WBS element are continuously being rolled into the future and decomposed when necessary.

STEPS

1) Determine the purpose of WBS
2) Identify the top of the WBS
3) PArtition the WBS into its major components
4) partition each of the major component into 7 ± 2 elements and so forth

5) Terminate the partitioning when the goal of WBS is reached
6) Develop a WBS dictionary entry for each lowest-level element of the WBS
7) Document the result.

* Specifying Tasks in S/W project work package.

A work package specification should specify the following for each task.:

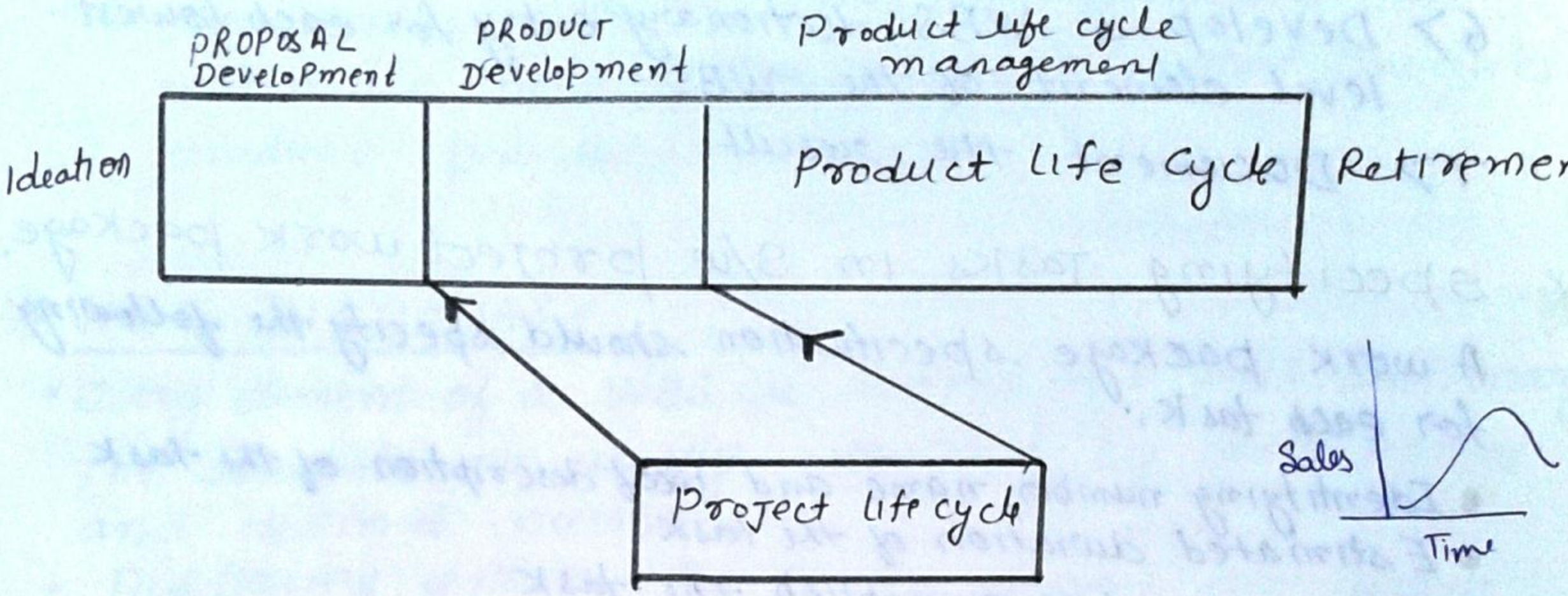
- Identifying number, name and brief description of the task
- Estimated duration of the task
- Resources need to accomplish the task
- Predecessor and successor task
- work products to be produced
- completion criteria for the task
- Risks associated with successful completion of the task.

A collection of work package can be analysed for the following characteristic

- Completeness
- consistency
- cost by task and "Roll-up"
- Duration by task and by Roll up
- personnel by type, number & need date
- other resources by type, number & need date
- Personnel and resource conflicts
- Activity network
- Risk by task and by roll-up

WBS Functions—1) break without compromising with the goals & objectives of the project 2) provides problem-free breakage of project 3) able to utilise their existing resources

THE PROJECT LIFE CYCLE AND PRODUCT LIFE CYCIE



* The product life cycle and project life cycle are important concepts of defining project.
* A life cycle composes the beginning and end of something.
* The product life cycle is the period from the concept to the end of a product.
* The project life cycle is a part of product life cycle covering the period from project initiation (also known as project authorization) to project closure (or termination)
* The above figure shows the product life cycle and where one project life cycle could fit in.
* Understanding each of these life cycles and their relationships can help us to better define the start and finish of a project. In addition, we will gain a better understanding of how people measures product and project performance.

* The product life cycle starts with an idea and ends with retirement of the product

* Eg: Suppose that a sales representative for a S/W company calls on the Human Resources department of a large company and finds that there is a need for a new way of tracking employees contributions to their pensions. This finding gives the idea to develop an application for that client and sell it to them. The product is launched, and it proves to provide value, it may enjoy a long period of demand. It is possible that underfurnished product technology become old, and the company decides to no longer support the product; this marks the end of that product's life and the end of its life cycle

PROJECT SCHEDULE

* The project schedule is the organisation of all project activities by time and by their logical dependencies and each with a start date and a finish date.

* The schedule is created after the work breakdown structure has been defined and all activities identified

* one of the main uses of the schedule is to set the start and end dates of the project and track when each activity should begin and finish

* The creation of the project schedule requires the team to define the condition that will lead to the development of schedule. The first piece of information needed for this step comes from the WBS that has all the activities identified for the project.

* The quality and completness of the WBS will determine the quality of the schedule

* Building the schedule is actually an easy part but once a project is published and issues and changes start to creep, the schedule become difficult to manage since it's resource with the less flexibility

* A schedule communicates the length of time a team has to complete project. it also advertises to stakeholders and others what the team has done, is doing and plans on doing in the future. This include tasks, deliverables, milestones and meeting.

* A schedule supports visibility into project progress, risk ~~Mar~~ assessment, identification of critical events and rescheduling

* A schedule contain many commitments b/w team members, b/w the team and support staff and b/w stakeholders and the team

* The scheduling of work elements is the most important step in planning because it is the basis for allocating resources, estimating costs and tracking project management

2.4. PROJECT SCHEDULING—PLANNED AND UNPLANNED EVENTS

Planned events are the schduled points in time during which participants exchange information on a specific topic or review a work product. Such events are formalized and structured to maximize the amount of information communicated and to minimize the time participants spend on communication. **Some examples** include problem presentation, client reviews, project reviews, Brainstorming etc. In an ideal project, all communications take place during planned communication events.

Unplanned events occur due to certain crises like issues resulting from a combination of isolated facts. They include

(a) Requests for clarification.

(b) Requests for changes.

(c) Issue resolution.

Note that the requests for clarification are unplanned. A participant may request clarification about any aspect of the system that seems ambiguous.

KINDS OF SCHEDULES

1) Project Schedules
→ It is used by project managers and upper management for planning and reviewing the entire project.
It shows the major project without too much detail.

2) Task Schedules
→ These shows the specific activities necessary to complete a task. They permit lower-level managers and supervisors to focus on tasks without being distracted by other areas that they have no interaction with.
Task schedules are prepared by functional managers and incorporate interface and milestone events.

3) Gantt charts, Milestone charts, Networks and Time-based networks.

Techniques for shortening a project schedule

By knowing the critical path, the project manager & the team can use several duration compression techniques to shorten the project schedule.

1) Reduce the duration of activities on the critical path by allocating more resources to those activities or by changing their scope.

2) Crashing is used for making cost & schedule trade-offs to obtain the greatest amount of schedule compression for the least incremental cost.
Advantage - shortening the time it takes to finish a project
Disadvantage - it often increases total project costs

3) Fast tracking involves doing activities in parallel that you would normally do in sequence or in slightly overlapping time frames.
Advantage - it can shorten time it takes to finish a project
Disadvantage - it can end up lengthening the project schedule since starting some tasks too soon often increases project risk & results in rework.

SCHEDULING OBJECTIVES

1> The goal of defining the schedule is for the project team to have a complete understanding of all the work that needs they must accomplish.

2> By defining the schedule of the project also develops an understanding of the

ⓐ Constraints of the activity
ⓑ Dependencies of the activity
ⓒ Sequence of the activity

COORDINATION

3> Scheduling enables us to integrate the activites of various project participant, show interface responsibility and secure, record and communicate commitment to tasks

4> Analysis and forecasting

Scheduling enable us to show priorities for procuring equipment, materials, labor and services. It enable us to analyze complex work areas with many interrelated activites and facilitate long range planning. Through analysis & forecast we can measure progress & performance

5> It enable to maintain control over time and cost of the project.

6> Reporting

scheduling enable us
- to provide a visible summary of important or major activites
- Report planned completion dates
- Report deviations from plan
- monitor cash flow - Record actual date.
- Provide an early warning system for delays

Q. 32. What are basic objectives of scheduling ?

Ans. The basic objectives of scheduling are as follows :

1. It is the basis for all planning and predicting and help management decide how to use its resources to achieve time and cost goals.
2. It provides visibility and enables management to control "one-of-a-kind" programs.
3. It helps management to evaluate alternatives by answering such questions as how time delays will influence project completion, where slack exists between elements, and what elements are crucial to meet the completion date.
4. It provides a basis for obtaining facts for decision-making.
5. It utilizes a so-called time network analysis as the basic method to determine manpower, material, and capital requirements, as well as to provide a means for checking progress.
6. It provides the basic structure for reporting information.
7. It reveals interdependencies of activities.
8. It facilitates "what if" exercises.
9. It identifies the longest path or critical paths.
10. It aids in scheduling risk analysis.

PROJECT SCHEDULE MANAGEMENT or BUILDING THE PROJECT SCHEDULE

* Schedule management includes the processes required to ensure timely completion of the project
* Before a project schedule is created, a project manager should typically have a WBS, an effort estimate for each task, and a resource list with availability for each resource.
* A schedule is created using a consensus-driven estimation method. The reason for this is that a schedule itself is an estimate: Each date in the schedule is estimated.
* The project manager assists by assimilating information about scope, budget, resources and estimating times for completion of project tasks.
* Once an overall schedule is set, the project manager is responsible for monitoring the progress of the project and revising the schedule if needed.
* It is essential for the project manager to keep all participants informed as to current schedule status.
* The schedule development process should generate a project schedule that meets the following criteria
  1. Complete → The schedule must represent all the work to be done
  2. Realistic → The schedule must be realistic with regard to time expectations and the availability of beneficiaries to participate.

(3) Accepted → The schedule must have "buy-in" from team members and stakeholders, specially the beneficiaries.

Steps: 1) Define the tasks 2) relate dependencies 3) Assign owners 4) Estimate effort/duration

STEPS FOR SCHEDULING

* Schedule management consists of a series of task and steps designed to help manage the time constraints of the project. The step are

1> Defining the schedule 2> Publishing schedule
3> Monitoring the schedule 4> updating the scheduling

*Inputs of scheduling
- (a) The WBS which contains a detailed list of all project activity and task
- (b) Historical information from similar project & their lessons learned
- (c) Expert advice from subject matter experts on a specific technical area of the project
- (d) information from project beneficiaries about their own time commitments
- (e) Information on calendar event, holidays
- (f) Resource planning, the no. of people available to the project
- (g) Milestones or agreed on dates for the delivery of specific output

* output of Scheduling
- (a) The project schedule
- (b) The schedule variance Report
- (c) The schedule updates.

17 Defining the schedule

The First piece of information needed for this step comes from the WBS that has all activities identified for the project. The quality and completeness of the WBS will determine the quality of the schedule

✡ Pls refer previous topic "Project schedule". we have to write the same thing here "

@ Activity sequence

* The first step in the creation of the project schedule is to define the sequence of the activities on a list. The sequence follows the natural progress the project will follow in the project cycle. The act of identifying which activity comes before or after another is the process of identifying dependency relationships b/w the activities
There are 3 types of activity dependencies

(i) Technical or mandatory dependencies is defined by the type of work or activity.

(ii) Discretionary dependencies are selected by the product manager to accommodate organisational or resource constraints, there are also based on educate guesses the project makes in order to circumvent other constraints,

(iii) External dependencies that comes from external factor imposed to the project

* The next step is to determine the type of relationship among all activities.
There are 4 types of relationship

(i) Finish to start

Successor activity cannot begin until the predecessor task has completed

(ii) Start to start

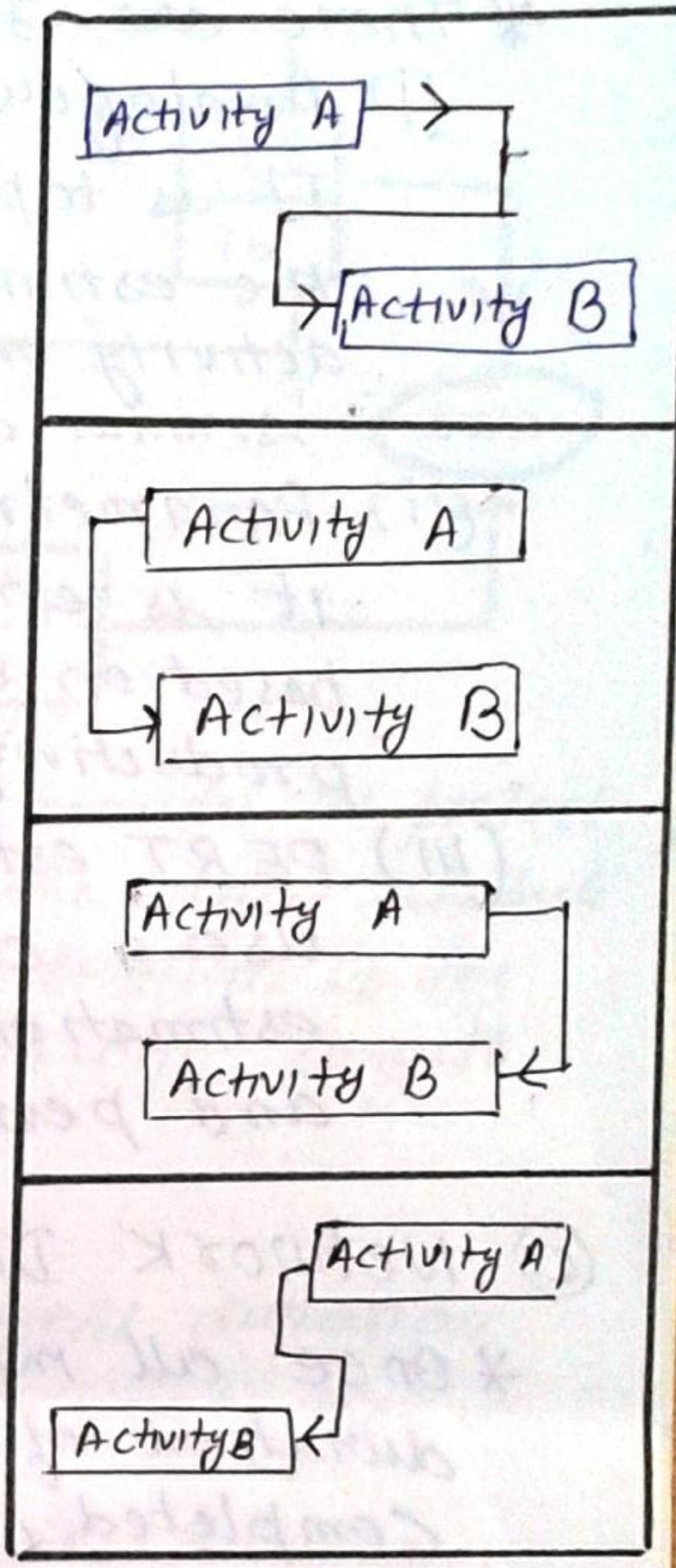
Successor activity depends on the start of the predecessor activity, used for starting activities in parallel.

(III) finish to finish

finish of the successor activity dependent on the finish of the predecessor

(IV) Start to finish

the finish of the successor activity is dependent on the start of its predecessor.



(b) Activity Duration

* The Team will construct a list of all activities and assign an estimate of the duration of each activity. It will use historical information from similar projects and Consult with experts. Duration includes the actual amount of time worked on an activity
* There are 3 schedule constraints that govern when an activity start or finish
  (i) An activity must be completed by no earlier than a specific date
  (II) An activity must be completed no later than a given date
  (III) an activity must be completed on a given date, no earlier or later.

* There are 3 types of activity estimation

(i) Analogous estimation

It is top down technique that involves basing the estimate of the duration of a future activity on the actual duration of a previous, similar activity

(ii) Parametric estimating

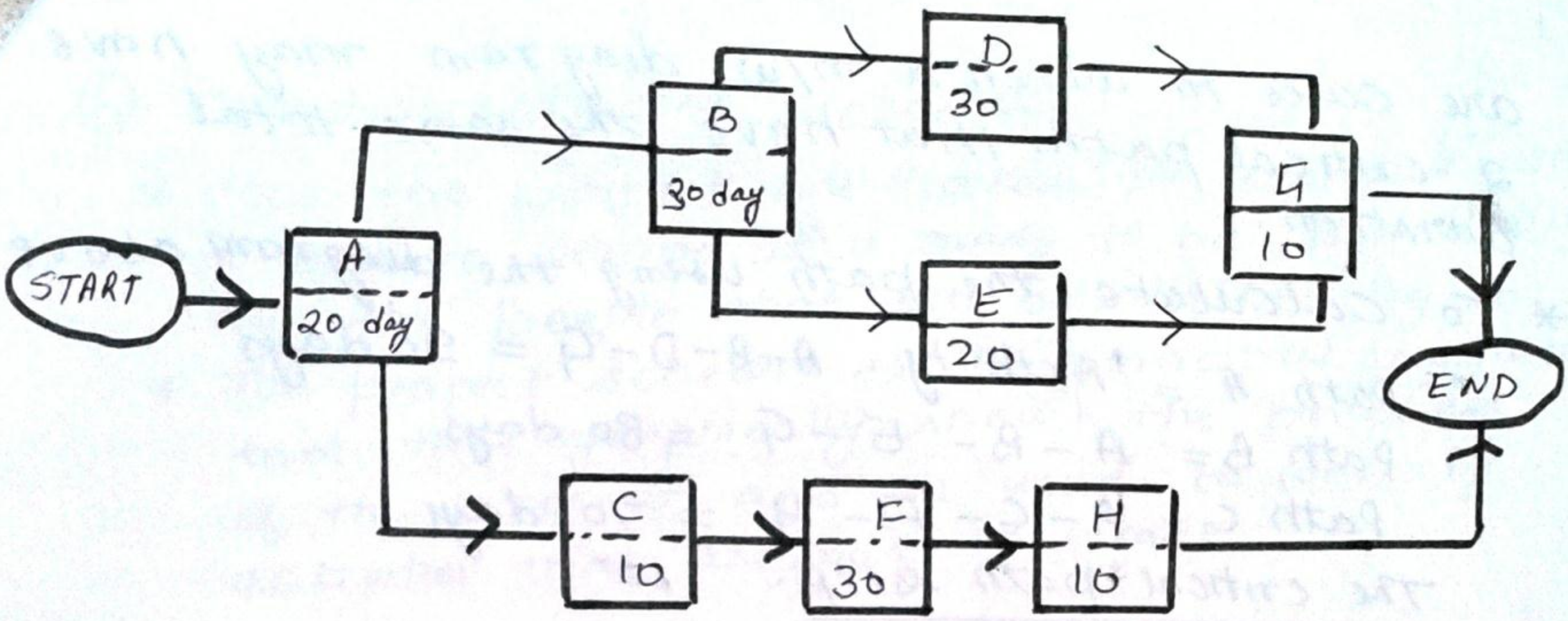
It is estimating the duration of an activity based on a rate or industry standard for productivity.

(iii) PERT estimating

uses a calculation to obtain a weighted avg. estimation using optimistic, most likely and pessimistic estimate

© Network Diagram

* Once all information on the sequence and duration of the project activities has been completed, the next step is a n/w diagram
* A N/W Diagram is a graphical representation of the sequence of project activities and the dependencies among them.
* The N/W diagram is read from left to right or Top to bottom.
* The n/w diagram use a diagram technique in which boxes represent activities, used by the project scheduling S/W.
* The complex and dynamic nature of development project make this tools especially valuable because it forces the project team to address the potential interactions of project activities that can be easily missed otherwise



* The value of the N/W diagram is that provides the project team with visibility and control over the project schedule
* it also helps to determine the total duration of the project and its critical path or path with longest duration.

(d) Critical path

* The critical path is the longest total duration
* Activities on the critical path cannot be delayed
* To find the critical path add up the duration of the activities for each possible path through the n/w, to determine which has the longest total duration
* The difference b/w the longest total duration and the shortest duration is the total amount of float or slack for the noncritical path activities
* The critical path is in essence the shortest time a project can be completed, even though the critical path is the longest path on the project. It is not the path with the most critical activities it is only concerned with the time dimension, it is not either the shortest path on a project n/w diagram. There

are cases in which a n/w diagram may have 2 critical paths that have the same total duration.

* To calculate the path using the diagram above

Path A = Activity A-B-D-G = 90 days

Path B = A - B - E - G = 80 days

Path C = A - C - F - H = 70 days

The critical path is A

2> Publish the schedule

@ Get schedule approval.

* This step also includes negotiations with project stakeholders. once all people has agreed, at least in principle to the schedule, it is ready to be published. These negotiations may include in changes to the schedule. The skills of the project manager in making negotiations will determine the amount of change on the schedule. The project team must learn to defend their estimates and learn to negotiate with these demand

* schedule baseline

once the team has completed the development of the project schedule they need to lock or set a baseline that will be used to monitor the schedule as the project makes progress. This baseline will be reviewed on a regular basis and all approved changes to the schedule will be updated against this baseline. This is the schedule that will be published to the team and stakeholders.

(b) Communicate the schedule.

* once the project has "locked" the schedule with a baseline version it is ready to be shared with all the people that will be affected by it.
* The project schedule is the principal communicate tool that graphically shows the progress of the project and is used to identify activities that are not on track

(c) Schedule update

* As the project starts to make progress, the project manager will use the activity status reports from the project team to update the schedule and update the information of progress
* Scheduling progress reporting include information such as the actual start and actual finish dates and any remaining duration for any unfinished scheduled activities.
* Project manager updates the schedule using 2 methods
  (a) by placing the percentage by which each activity has been completed during a reporting period
  (b) by placing the no. of days that have been worked on an activity.

37 MONITOR The Schedule

Monitor the project schedule is mainly focused on determining the current status of the project. On the project manager, based on the information then will determine what factors have influenced the changes in the schedule and these may be internal or external factors. The project manager then will determine the impact on the schedule and determine

Various actions to either bring the schedule back to the original status or accept that the changes will cause an effect on the schedule.

(a) Monitor schedule performance

Monitor performance basically results in deciding if the variation on the schedule requires any corrective action.

(b) Variance analysis

Variance analysis is performed to determine the degree of variance a schedule has from the baseline data. It compares target schedules dates with the actual start and completion dates of an activity. This helps detect variations and leads to the implementation of corrective actions in case of schedule delays.

(c) Propose schedule charge.

The project manager needs to evaluate the options available to bring the schedule back on track. This effort may include the use of additional resources and that can have an impact to the project budget. There are two simple corrective actions techniques to amend the schedule.

(1) Crashing is the technique for making budget and schedule

(2) trade off to obtain the greatest amount of schedule compression for the least amount of cost increase

4) UPDATE THE SCHEDULE

In order to properly update the project schedule the project needs to determine the process to make changes to the project schedule, this process includes:

* who has authority to make changes
* Version control
* Schedule change approval process
* How often the schedule is monitored and updated.

* How to analyze impact of schedule changes to other constraints such as scope, budget, and quality.

(a) update schedule.
updating the schedule requires modifications to the schedule baseline and new start dates or end dates are established on the project. All changes to the schedule must be approved as part of the change control procedures that defines the authorization levels for changes to the schedule.

(b) Document lessons Learned
Document the steps taken to make adjustment to the project schedule as part of the lessons learned process to build a historical database that will be compiled during the project close.

(c) communicate schedule updates
once the changes and been approved and the schedule has been updated, the project manager need to communicate the new schedule.

S/Net

2.4.2. Scheduling Terminology

Some basic terminology related to scheduling is given below :

1. **Schedule :** A schedule is the mapping of tasks onto time. Each task has a start and an end time. We can thus plan the deadlines for individual deliverables.
2. **Tasks :** A task is a well-defined work assignment for a role.
3. **Activities :** Group of related tasks are called as activities. A project manager assigns a task to a role.
4. **Work Product :** It is a tangible item that results from a task. For example, an object model, a class diagram, a piece of source code, a document etc.
5. **Work Package :** The specification of work to be accomplished in completing a task or activity is described in a work package.
6. **Event :** Something that causes a system or object to change state. For example, a message, the condition becoming time of completion of an activity.
7. **Synchronization Points :** The points in a project schedule that require the team to synchronize the contents of products, complete tasks and reduce defects.
8. **Thrashing :** The performing of unproductive work associated with a software project is known as thrashing.
9. **Task Staus :** The status of a specific task relative to the task goals and completion.
10. **Network :** A network is a graphical representation of a project plan, showing the inter-relationships of various activities.

2.4.3. Scheduling Techniques

Scheduling can be done using 2 methods :

(a) **Network Diagrams**—PERT and CPM.

(b) **Bar Charts**—Milestone Charts and Gantt Charts.

We shall now discuss all these techniques one by one.

2.4.3.1. Project Evaluation and Review Technique (PERT) History

PERT was originally developed in 1958 and 1959 to meet the needs of the "Age of Massive Engineering" where techniques of Taylor and Gantt were inapplicable. The Special Project Office (SPO) of the U.S. Navy introduced PERT. They used this technique on its polaris weapon system in 1958.

What is PERT ?

It is a technique of representing activities of projects in its proper sequence and timing.

A **PERT Chart** represents a schedule as an acyclic graph of tasks. It is used to schedule, organize and coordinate tasks within a project. PERT charts are often constructed from back to front because for many projects the end date is fixed and the contractor has front-end flexibility.

PERT is basically a management planning and control tool. It is just like a road map for a particular project in which all of the major elements (events) have been completely identified. These events in the PERT charts should be broken down to at least the same reporting levels as defined in Work Breakdown Structure (WBS).

Main Characteristics of PERT

1. It forms the basis for all planning—management can decide for best possible resource (cost, time, hardware, manpower) utilization.
2. It provides a basis for obtaining the necessary facts for decision-making.
3. It utilizes time network analysis technique as explained earlier also.
4. It provides the basic structure for reporting information.
5. It helps the management to understand as to what elements are crucial to meet the completion date.

Why This Method is Used ?

Some of the reasons are as follows :

1. To estimate the completion time of the project.
2. To find out if the project is behind, a head of or on schedule.
3. To compare the actual resources spent with the planned resources at any stage of the project.
4. To study activities that are critical for project completion.
5. To study activities that can be delayed without delaying the project completion date.

Rules Followed in Drawing PERT

Rule 1 : Always draw arrows in straight lines. Avoid curved lines.

Rule 2 : Always draw arrows from left to right. Avoid looping.

Rule 3 : Always number the events in ascending order from left to right.

Rule 4 : Always use alphabets to denote an activity drawn by arrows. The duration in days/ weak/months etc. are indicated as numbers that are written under them.

Rule 5 : Do not scale the length of arrow with respect to duration. This rule-5 is necessary to avoid looping and back-tracking.

How to Number the Events (Fulkerson's Rule)

After the network is drawn in a logical sequence, every event is assigned a number which is placed inside the node circle. The number sequence should be such as to reflect the flow of the network. These rules were given by **D.R. Fulkerson** that are used to number the events. They are as follows :

(i) The **initial event** (or node) is numbered as '1'. **Note that** this initial event will have outdegree only but its indegree (*i.e.*, incoming arrows) will be zero.

(ii) Delete all arrows going out from this node '1'. This will convert some more nodes, (at least one), into initial events. We number these events as 2, 3, ...

(iii) Delete all arrows going out from these numbered events to create more initial events. Assign the next numbers to these events.

(iv) Continue until the **final (terminal) node** is numbered.

NOTE **A terminal node has some indegree (arrows coming in) and zero outdegree whereas an initial or start node has zero indegree but has some outdegree.**

Let us consider an example to explain this **Fulkerson's Rule**. Consider the network as shown in Fig. 2.23.

Now, event-A is the initial event (start node) and is numbered as '1'. Now, we delete arrows a and b. This will create two more (B and C) initial events. We number these as 2 and 3. Now, delete arrows coming out from nodes 2 and 3. That is, arrows c, d and e. This converts D and E into initial events. Number these nodes as 4 and 5. Then delete arrows f and g. Then the last or terminal event is numbered as 6.

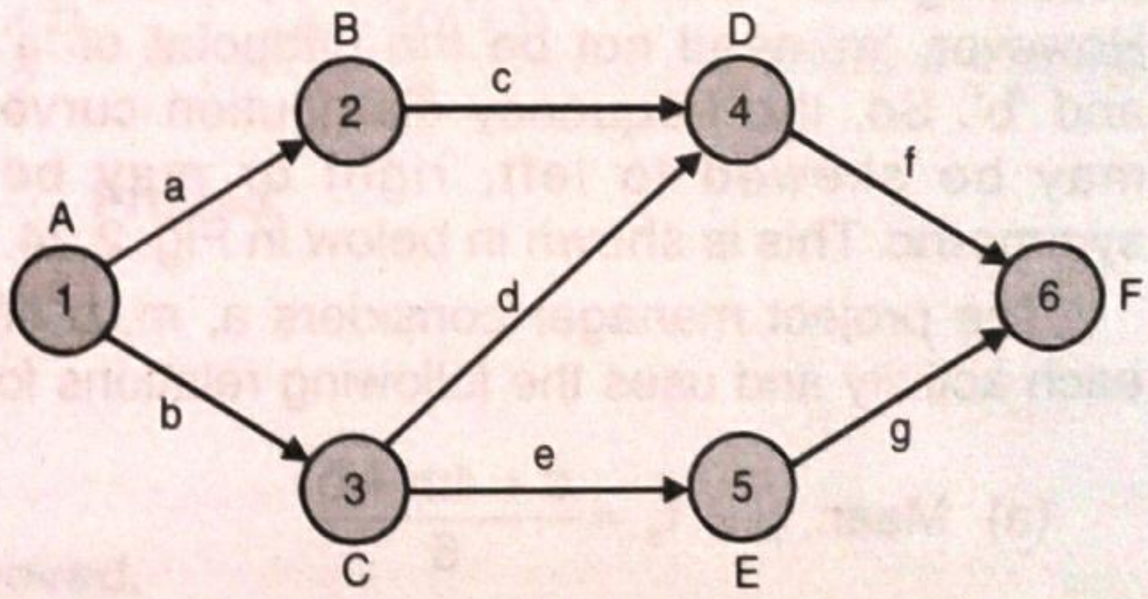


Fig. 2.23. To Illustrate Fulkerson's Rule

How This Technique (PERT) Works ?

PERT is concerned with the time estimate. PERT assumes the activities to be deterministic and is based on a "Three time estimate" of the average time required to execute the activity. These three time estimates are as follows :

1. *The Optimistic Time Estimate (a or t_o)*

It is defined as the shortest possible time required for the completion of an activity, if all goes extremely well. But this seldom happens.

2. *The Pessimistic Time Estimate (b or t_p)*

It is defined as the maximum time required to complete the activity assuming everything goes wrong.

OR

It is the longest time that an activity may require for completion.

Please note that it does not take earthquakes, floods, storms and labour problems into consideration while estimating the time.

3. *The Most Likely Time Estimate (m or t_m)*

It is defined as the time an activity will take if executed under normal conditions.

OR

It is the completion time having the highest probability.

This time falls in between two extremes (as mentioned above). Here, we estimate time under practical situations in which certain things go wrong and some go as per the plan.

Why is this done ? This is done as no two experts give same time estimations for a similar type of activity. So, we take three time estimates and average them.

How This Technique is Used ? Statistically, all time estimations in PERT are a prediction of probability. We have three time estimates for PERT activity, the optimistic (a), the pessimistic (b) and the most likely time (m). In the range from optimistic to pessimistic, there can be a number of time estimates for the activity. If a frequency distribution curve for the activity time is plotted, we will get a β-distribution curve with a unimodal point occurring at 'm' and its endpoints at 'a' and 'b'. However, 'm' need not be the midpoint of 'a' and 'b'. So, the frequency distribution curve may be skewed to left, right or may be symmetric. This is shown in below in Fig. 2.24.

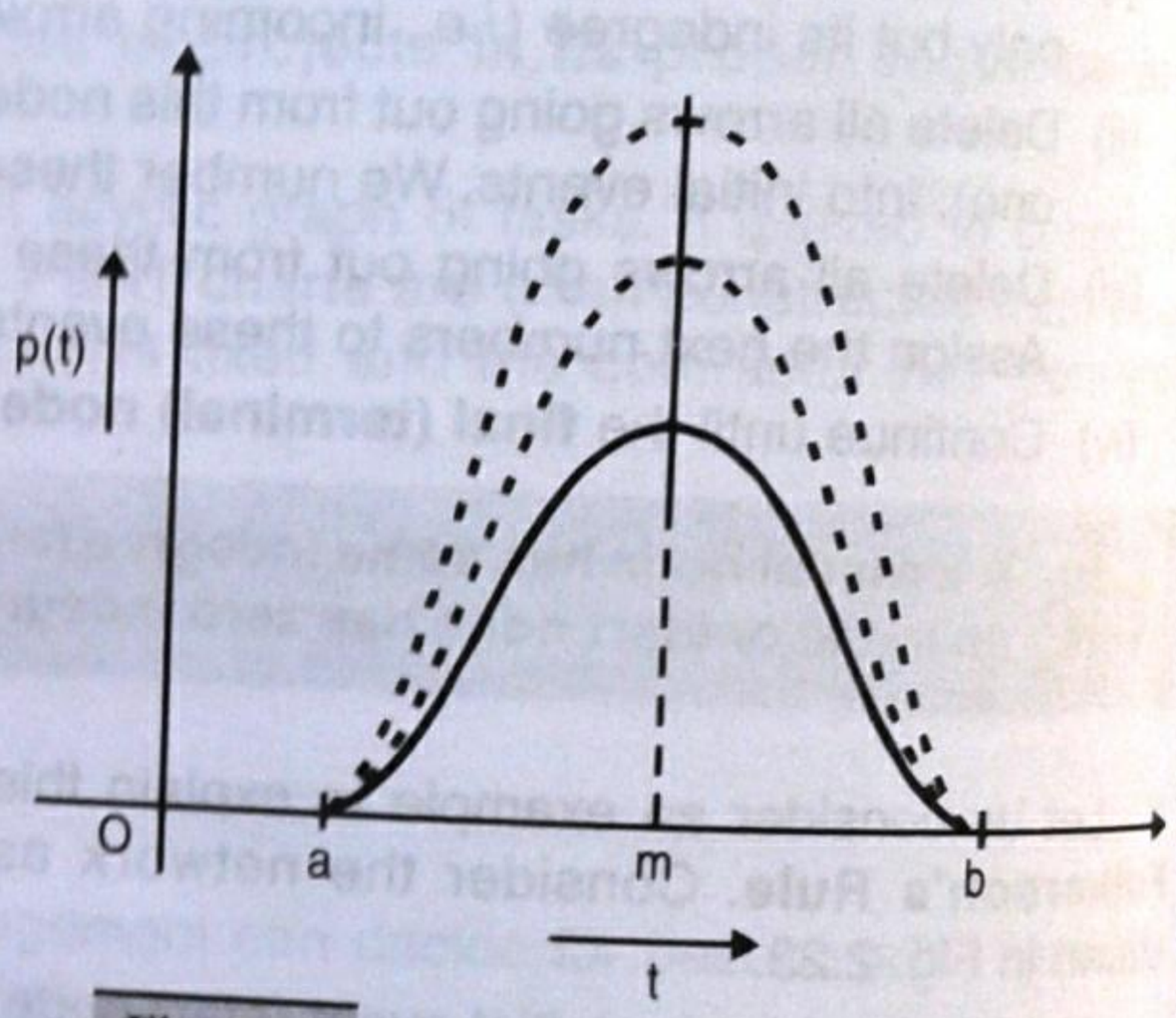


Fig. 2.24. Frequency Distribution Curve

The project manager considers a, m, b of each activity and uses the following relations for estimations.

(a) Mean, $\mu = t_e = \dfrac{a + 4m + b}{6}$ ...(i)

(b) Standard deviation, $\sigma = \dfrac{b - a}{6}$ ...(ii)

(c) Variance, $V = \left(\dfrac{b - a}{6}\right)^2$ ...(iii)

Steps to be Followed in PERT Planning Process

PERT planning involves the following steps :

Step 1. Identify the Specific Activities and Milestones : The activities are the tasks required to complete the project. The milestones represent the beginning and end of one or more activities. It is helpful to list the tasks in the table that in later steps can be expanded to include information on sequence and duration.

Step 2. Determine the Proper Sequence of the Activities : This step is used to determine the sequence of activities. The sequence describes the dependency of one activity on another. Activities may be serial or parallel activities. The relationships among activities need to be identified. This step may be combined with the activity identification step since the activity sequence is evident for some tasks. Other tasks may require more analysis to determine the exact order in which they must be performed.

Step 3. Construct a Network Diagram : We use the activity sequence information and draw a network diagram. It shows the sequence of the serial and parallel activities. For activity-on-arc (AOA) method, the activities are depicted by arrowed lines and milestones are depicted by circles or **"bubbles"**. Many CASE tools like MS-PROJECT simplify this step by automatically converting tabular activity information into a network diagram.

Step 4. Estimate the Time Required for Each Activity : Each and every completion of an activity is represented by some consistent unit of time. Most common unit used is weeks. PERT has an ability to deal with uncertainties in activity completion times. As explained earlier also, PERT uses three model equations

1. $$t_e = \frac{a + 4m + b}{6} \quad (\text{where } a < m < b)$$

2. $$\sigma = \frac{b - a}{6}$$

3. $$V = \left(\frac{b - a}{6}\right)^2.$$

So, t_e is the weighted average. This expected time may be displayed on the network diagram.

Step 5. Determine the Critical Path : What is a Critical Path ? In a network there are many paths indicating the start and end events of the project.

The path which takes the maximum amount of time is called as the critical path. The activities which lie on the critical path are called as critical activities. The critical path is determined by adding the times for the activities in each sequence and determining the longest path in the project. The critical path determines the total calender time required for the project. If the activities outside the critical path speed up or slow down within the limits, the total project time does not change. **The amount of time that a non-critical path activity can be delayed without delaying the project is called as the slack time.** If it cannot be found immediately as to which path is critical then we may take the help of four time estimate for each activity :

(a) **Earliest Start Time (ES) :** It is defined as the earliest start time when an activity can begin. It is assumed that the previous activities on which the activity depends are complete.

(b) **Earliest Finish Time (EF) :** It is equal to the earliest start time for the activity alongwith the time required to complete the activity.

(c) **Latest Finish Time (LF) :** It is the latest time at which the activity can be completed without delaying the project.

(d) **Latest Start Time (LS) :** It is equal to the difference of latest finish time with the time required to complete the activity.

These times are calculated using the expected time for the relevant activities.

How ES and EF are Determined ?

The ES and EF of each activity are determined by **working forward** through the network and determining the earliest time at which at activity can start and finish.

How LS and LF are Determined ?

The LS and LF of each activity are determined by **working backward** through the network.

What is an Activity Slack ?

The difference in the latest and earliest finish of each activity is an activity **slack.** A path through the network in which none of the activities have slack is known as the **critical path.**

The **variance** in the project completion time can be calculated by summing the variances in the completion times of the activities in the critical path. With this variance as input, we can calculate the probability that the project will be completed by a certain date. Since the **critical path will find out the completion date of the project, the project can be accelerated by adding the resources required to decrease the time for the activities in the critical path.** This process of shortening of the project is called as project **crashing.**

How Critical Path Calculations are Done ?

The critical path calculation involves two phases :

I. The forward pass.

II. The backward pass.

We shall discuss these passes one-by-one.

In forward pass, all calculations begin at the starting event and move toward the end event.

Consider the following network :

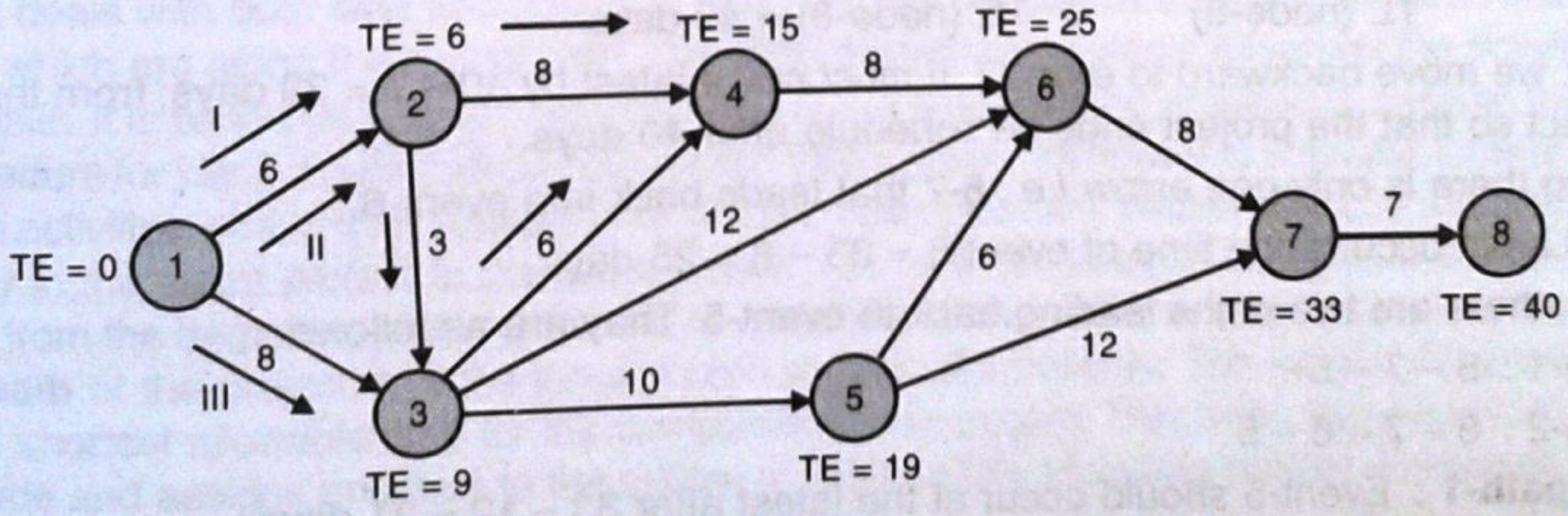


Fig. 2.26. Forward Pass Network

Herein, event-1 is the starting event and occurs at zero time. The event-2 can occur only after 6 days, when the activity 1-2 is over.

∴ Earliest occurrence time (TE) of event-2 is 6.

Now, there are two chains leading into event-3. Event-3 can occur only after activities, 1-3 and 2-3 are completed which is possible only after 9 days, *i.e.*, through the longest path 1-2-3.

Similarly, the earliest occurrence time of activity-4 will be 15. How ?

This is because there are three paths from node-1 to node-4 (or event-1 to event-4). They are shown in graph also as I, II and III. So, the paths from node-1 to node-4 are as follows :

Path 1 : 1 – 2 – 4

Path 2 : 1 – 2 – 3 – 4

Path 3 : 1 – 3 – 4

Now, total cost along path-1 is 6 + 8 = 14 days

Total cost along path is 6 + 3 + 6 = 15 days

and total cost along path-3 is 8 + 6 = 14 days.

And the maximum of (14, 15, 14) is 15 days.

∴ Earliest occurrence time (TE) of activity-4 is 15 days.

Note that this process can be continued till the terminal node. All these computations can be done on the network itself.

In backward pass, all calculations start at the end event and proceed towards the starting node. Consider the same network now :

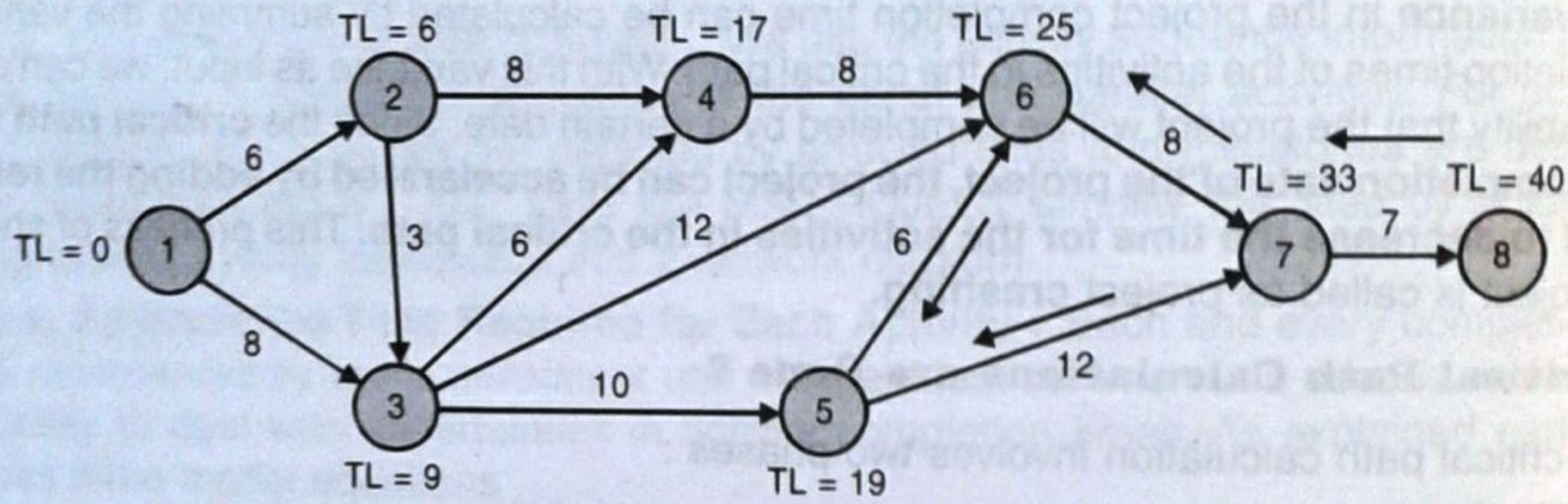


Fig. 2.27. Backward Pass Network

Herein, the latest allowable occurrence time (TL) of the end node-8 is equal to its earliest occurrence time (TE) as computed earlier in pass-1.

∵ TE (node-8) = 40 days

∴ TL (node-8) = TE (node-8) = 40 days

Now, we move backward to event-7. It must occur latest by 40 – 7 = 33 days; from the start of the project so that the project ends on schedule after 40 days.

Again there is only one arrow *i.e.*, 6-7 that leads back into event-6.

∴ Latest occurrence time of event-6 = 33 – 8 = 25 days

Now, there are two paths leading back to event-5. They are as follows :

Path-1 : 8 – 7 – 5

Path-2 : 8 – 7 – 6 – 5

For path-1 : Event-5 should occur at the latest after 33 – 12 = 21 days.

For path-2 : Event-5 should occur at the latest after 25 – 6 = 19 days.

Comparing the results of path-1 and path-2, we find that the latest allowable occurrence time (TL) of event-5 is 19 days. And this is shown as TL = 19 days in the network diagram also.

Thus, we find that the critical path is 1-2-3-5-6-7-8 and only event-4 has a slack of TL – TE = 17 – 15 = 2 days.

Step 6 : Update the PERT Chart as the Project Progresses

As the project work continues, we can make certain adjustments to our PERT chart. Adjustments can be like the estimated times can be replaced with the actual times. Another adjustment can be like some more resources may be added to stay on schedule. PERT chart can thus be modified.

Advantages of PERT :

(i) It helps us to estimate expected project completion time.

(ii) It helps us to identify the critical path activities that directly impact the completion time.

(iii) The start and end dates of the activities can be determined.

(iv) The activities with slack time can be identified.

(v) It allows a large amount of sophisticated data to be presented in a well-organized diagram from which both customer and the engineer can make joint decisions.

- PERT chart explicitly defines and makes visible dependencies (precedence relationships) between the WBS elements
- PERT facilitates identification of the critical path and makes this visible
- PERT facilitates identification of early start, late start, and slack for each activity,
- PERT provides for potentially reduced project duration due to better understanding of dependencies leading to improved overlapping of activities and tasks where feasible.

- PERT chart is useful for monitoring the timely progress of activ
- It allows scheduling & simulation of alternative schedules.
- It attempts to address the risk associated with dura estimates

Disadvantages of PERT :

(i) The acitvity time estimates are subjective. The numbers (time) may be guess also. This is true if there is little experience in performing an activity.

(ii) PERT assumes a beta distribution for the three time estimates, as discussed earlier. But the actual distribution may be different.

(iii) PERT assumes that probability distribution of the project completion time is the same as that of the critical path. Because other paths can become the critical path if their associated activities are delayed, PERT under-estimates the expected project completion time.

(iv) The complexity of PERT adds to the implementation problems.

(v) PERT is expensive to maintain and is utilized most often on large, complex programs.

- There can be potentially hundreds or thousands of activities and individual dependency relationships
- The network charts tend to be large and unwieldy requiring several pages to print and requiring special size paper
- The lack of a timeframe on most PERT/CPM charts makes it harder to show status although colours can help (e.g., specific colour for completed nodes)
- When the PERT/CPM charts become unwieldy, they are no longer used to manage the project.
- It involves more work since it requires several estimates

Critical Path Method (CPM)

What is CPM ?

Critical Path Method (CPM) is a network analysis technique used to predict the project duration by finding out which sequence of activities (critical path) has the least amount of scheduling flexibility. In this technique, the project manager identifies the critical activities of the project that constitute the critical path of the project.

CPM deals with both time and cost. it is essential that we concentrate our attention first to those activities which are along the critical path. The CPM system of networks assumes the activities to be deterministic. It is based on a single time estimate of the average time required to execute the activity. The procedure for idenfying the critical path in both PERT and CPM networks is similar. Critical activities are those activities whose total float value is '0'. This means that any delay in the critical activity results in a delay in the entire project to the same extent. The project manager identifies a series of critical activities from the beginning of the project to its completion. The series of critical activities is called the **critical path** of the project. It is the longest path through the network. The length of the critical path gives the shortest allowable time for the completion of the project. This helps the project manager to concentrate and assigns priorities to the critical activities while allocating project resources.

Steps in CPM Technique

The following steps are usually followed to draw CPM charts :

Step 1 : Specify the Individual Activities

A listing of all the activities in the project is made from the Work Breakdown Structure (WBS). This listing can be used as the basis for adding sequence and duration information in later steps.

Step 2 : Determine the Sequence of Those Activities

Some activities depend on others for their completion. They need to be identified. A listing of the immediate predecessors of each activity is useful for constructing the CPM network.

Step 3 : Draw a Network Diagram

Once the activities and their sequencing have been defined, the CPM diagram can be drawn. CPM was originally developed as an Activity-On-Node (AON) network diagram.

Step 4 : Estimate the Completion Time for Each Activity

For each activity the completion time need to be estimated. This can be done on the basis of past experience. CPM is deterministic, so only one number is used for an activity's time estimate. It does not take variations into completion time.

Step 5 : Identify the Critical Path

The critical path is the longest duration path through the network where **no activity is slack. The amount of time for which a non-critical path activity can be delayed without delaying the project is known as slack time.** The critical path can be identified by determining the following four parameters for each activity :

(a) Earliest Start Time (ES) : It is defined as the earliest time at which the activity can start given that it's previous activities must be completed first.

(b) Earliest Finish Time (EF) : It is equal to the earliest start time for the activity **plus** the time required to complete the activity.

(c) Latest Finish Time (LF) : It is defined as the latest time at which the activity can be completed without delaying the project.

(d) Latest Start Time (LS) : It is equal to the latest finish time **minus** the time required to complete the activity.

Please note that the **slack time** for an activity is the time between its earliest and latest start time or between its earliest and latest finish time. **Slack** is the amount of time that an activity can be delayed past its earliest start or earliest finish without delaying the project.

So, the path for which ES = LS and EF = LF (for all activities in the path) is the critical path. A delay in the critical path delays the project. Similarly, to accelerate the project it is necessary to reduce the total time required for the activities in the critical path.

Step 6 : Update the CPM Diagram as Project Progresses

As the project progresses, the actual task completion times will be known to us. So, the CPM diagram can be updated to include this information. A new critical path may emerge and structural changes may be made in the network if the project requirements change.

CPM network is now complete. It provides us vital information like :

(a) The total time to complete the project.
(b) The scheduled start and finish dates for each task pertaining to the projects completion.
(c) The tasks that are "critical" to the project and must be completed exactly as scheduled.
(d) The "slack" time available is non-critical tasks, as well as how long they can be delayed before they affect the project finish date.

Advantages of CPM

(1) It provides a realistic and disciplined basis for determining how to attain these objectives.
(2) It provides a clear, concise and unambiguous way of documenting and communicating project plans, schedules, time and cost performance.
(3) If properly developed and applied, CPM can encourage a team feeling.
(4) It facilitiates the application of the principle of "management by exception" by identifying most critical elements.
(5) They are useful in new project managers.
(6) The acitivities and their outcomes can be shown as a network.
(7) It displays dependencies to help scheduling.
(8) It evaluates which activities can run parallel to each other.
(9) It determines slack times.

(10) It is widely used in industry.

(11) It determines the project duration which optimizes both direct and indirect costs.

Disadvantages of CPM

(1) CPM networks can be complex too. This happens more for larger projects.

(2) It does not handle the scheduling of personnel (people) and the resource allocations.

(3) The critical path is not always clear and needs to be calculated carefully.

(4) Estimating the completion times of an activity can be difficult.

Conclusion : Both CPM and PERT provide the user with project management tools to plan, monitor and update the project as it progresses. They have some similarities and differences too. We tabulate both one by one.

TABLE 2.5. Similarities between PERT and CPM.

S. No.	PERT	CPM
1.	They use network diagrams.	They also use network diagrams.
2.	They are used to plan the scheduling of individual activities.	They are used to plan the scheduling of individual activities.
3.	It can be used to determine the earliest/latest start and finish times for each activity.	It can also be used to determine the earliest/ latest start and finish times for each activity.
4.	It has a single "start" and single "finish" activity.	It has a single "start" and single "finish" activity.
5.	It determines the critical path in the entire network.	It determines the critical path in the entire network.

We shall now tabulate the differences also. They are given below :

TABLE 2.6. Differences between PERT and CPM.

S. No.	PERT	CPM
1.	It basically deals with time estimate.	It deals with both time and cost.
2.	It is probabilistic.	It is deterministic.
3.	It takes into consideration three time estimates.	It is based on single time estimate.
4.	Estimates are based on past-experiences, most likely and not-sure timings.	Estimates of activity are based on historical data.
5.	Estimates are uncertain. It talks of ranges of duration (B-curve) and the probability that an activity will fall into that range.	Only one number is used for an activity's time estimate.

BAR CHARTS: MILESTONE CHARTS, GANTT CHARTS

* A BAR CHART or BAR Graph is a Chart with rectangular bars with lengths proportional to the values that they represent
* The bars can also be plotted horizontally
* BAR Chart are used for plotting discrete or discontinuous data i.e data which has discrete values and is not continuous.
* BAR Chart are the easiest and most widely used form of scheduling in construction management.

* A typical bar chart is a list of activities with the start, duration and finish of each activity shown as a bar plotted to a time scale. The level of detail of the activities depends on the intended use of the schedule.

* The bar charts are also useful for calculating the resources required for the project

The following steps are usually followed to draw the bar charts :

Step 1 : Analyze the project and specify the basic approach to be used.

Step 2 : Break the project down into a reasonable number of activities to be scheduled.

Step 3 : Estimate the time required to perform each activity.

Step 4 : Place the activities in sequence of time. Keep in mind the requirements that certain activities must be performed sequentially while others can be performed simultaneously.

Step 5 : If a completion date is specified, the diagram is adjusted until this constraint is satisfied.

Advantages of Bar Chart :

(i) The **main advantage** of the bar chart is that the plan, schedule and progress of the project can all be portrayed graphically together. As shown in the graph, there is a five activity plan and there is a 12 week schedule. The current status is end of 3rd week. Also it shows that the activity-B is slightly behind the schedule.

(ii) They are simple to understand and easy to change.

Disadvantages of Bar Charts :

(i) They do not show the interdependencies of the activities and therefore do not represent a "network" of activities.

(ii) Planning and scheduling are considered simultaneously.

(iii) Since bar graphs are simple so they do not show sufficient detail to enable us to detect schedule slippages on time.

(iv) The bar chart is essentially a manual graphical procedure. It is not suitable for large projects.

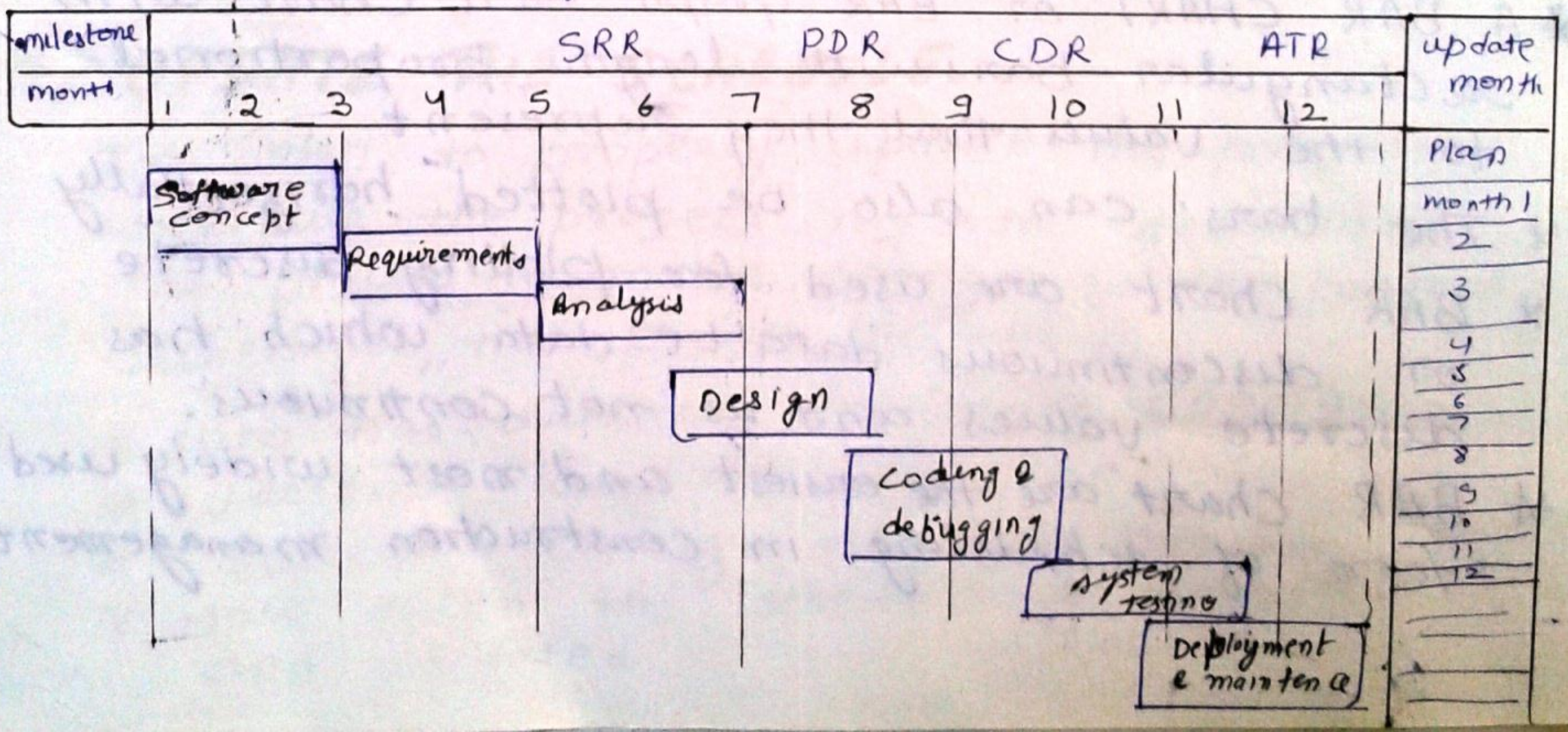
(v) Bar charts have tendency to quickly become outdated and to lose their usefulness.

(vi) Bar charts do not show uncertainty involved in performing an activity. They do not readily admit itself to sensitivity analysis. For example, what is the shortest time that an activity might take ? What is the average or expected time for an activity completion ?

MILESTONE CHART

* Milestone Chart are used to report when milestones have been, or will be, achieved. First, an initial estimate of each milestone date is made.
* This estimate is put in the schedules section of the software project management plan (SPMP) Then, at the end of every reporting period, the following data are collected:
    1. previous estimates of milestone achievement dates
    2. new estimate of milestone achievement dates

The date should be plotted in a milestone trend chart to illustrate the changes, if any, of the dates.



* A milestone chart is similar to a Gantt chart with the emphasis placed on task completion
* it embodies the same simplified techniques as does the Gantt chart. it does not portray the interrelationships b/w task and hence doesn't identify the critical path

GANTT CHART

→ A Gantt chart is a calender oriented bar chart with each bar representing an activity* Gantt charts are mainly used to allocate resources to activities. The resources allocated include staff, Machi
Gantt charts are useful for resource planning.
* The bars are drawn along a time line. The length of each bar is proportional to the duratio of the time planned for the corresponding activity.

* A Gantt chart is a type of bar chart that illustrates a project schedule. Gantt charts illustrates the start and finish dates of the terminal elements and summary elements of a project. Terminal elements and summary elements comprise the work breakdown structure of the project. Some Gantt charts are show the dependency relationships b/w activities.
* Gantt charts can be used to show current schedule status using percent-complete shading and a vertical "Today" line as
→ By Henry Gantt in 1910.
* Advantages
(i) Direct correlation with Time
(ii) straight forward relationship with projects involving a limited number of task
(iii) straight forward integration of subtask having seperate scheduling charts
(iv) Time scheduling is flexible and is expanded to show tasks of shorter nature
(v) Progress against the plan is easily reflected.
(vi) It gives pictorial model of the project
(vii) It is easy to construct & understand

(IV) For large projects it is not suitable as it is ~~[illegible]~~ manually.

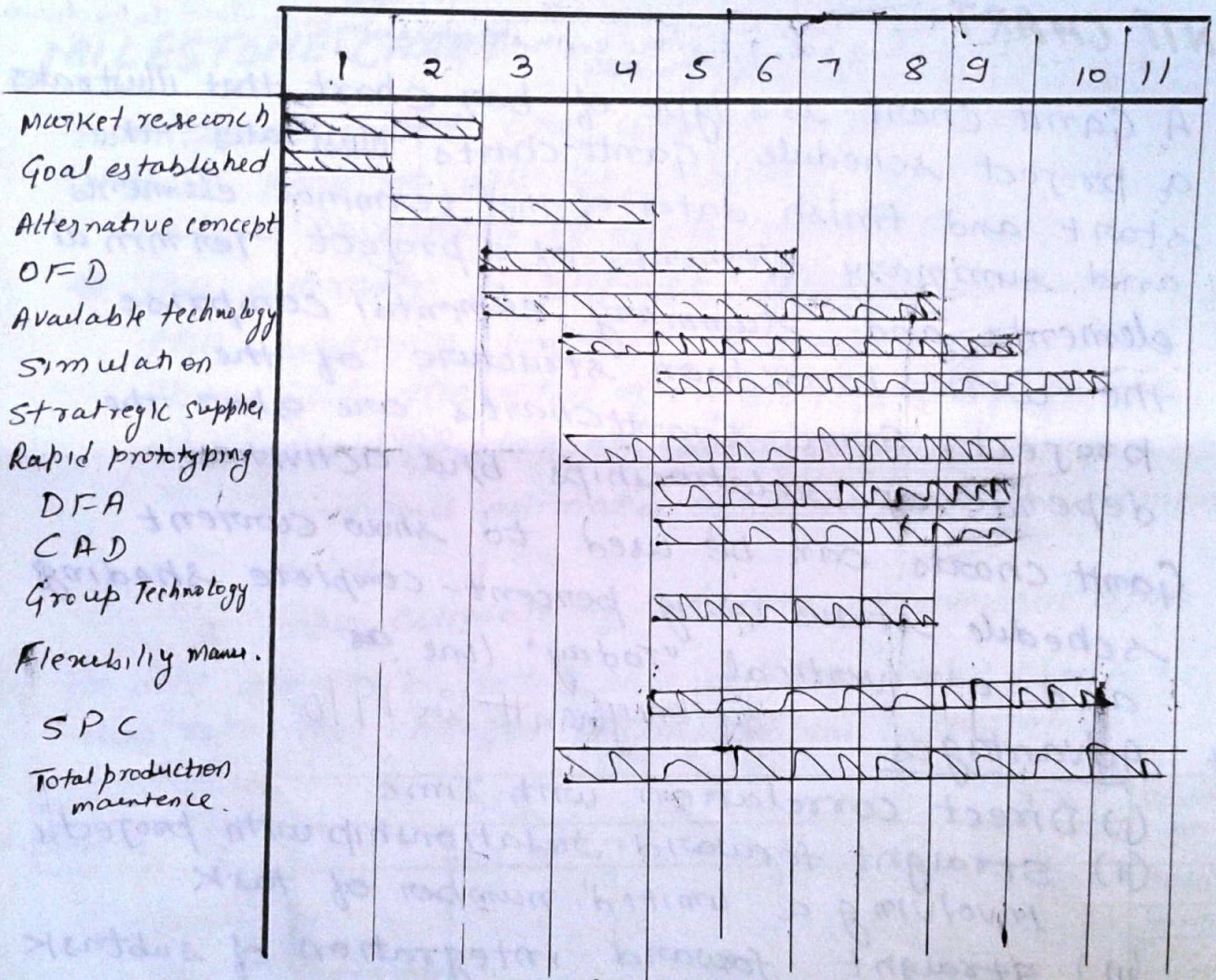
* Disadvantage

(I) ~~there~~ it ~~is~~ does not ~~convey the complex~~ explicitly show interrelationships that may occur b/w tasks or work elements.

(II) It does not reveal the effect of one work element falling behind schedule on other element

(III) They alone provide no way of distinguishing elements that can be delayed from those that cannot.

Time allocated (weeks)



— An activity n/w shows the different activities making up a project, their estimated durations and interdependencies. Each activity is represented by a rectangular node.

* The Gantt chart consists of a horizontal scale divided into time units days, weeks, or months and vertical scales showing project work elements tasks, activities, work packages & so forth. Work packages are listed on left hand side and work weeks are listed along the bottom. The starting and completion times of jobs are indicated by the beginning & ending of bar

Q. 8. What do you mean by activity? Explain.

Ans. Before we try to identify the activities that make up a project it is worth reviewing what we mean by a project and its activities and adding some assumptions that will be relevant when we start to produce an activity plan.

(*i*) A project is composed of a number of interrelated activities.

(*ii*) A project may start when at least one of its activities is ready to start.

(*iii*) A project will be completed when all of the activities it encompasses have been completed.

(*iv*) An activity must have a clearly defined start and a clearly defined endpoint, normally marked by the production of a tangible deliverable.

(*v*) If an activity requires a resource then that resource requirement must be forecastable and is assumed to be required at a constant level throughout the duration of the activity.

(*vi*) The duration of an activity must be forecastable-assuming normal circumstances, and the reasonable availability of resources.

(*viii*) Some activities might require that others are completed before they can begin (these are known as precedence requirements).

The activity-based approach consists of creating a list of all the activities that the project is thought to involve. This might involve a brainstorming session involving the whole project team or it might stem from an analysis of similar past projects. When listing activities, particularly for a large project, it might be helpful to subdivide the project into the main life-style stages and consider each of these separately.

Rather then doing this in an ad-hoc manner, with the obvious risks of omitting or double-counting tasks, a much favoured way of generating a task list is to create a Work Breakdown Structure (WBS). This involves identifying the main (or high-level) tasks required to complete a project and then breaking each of these down into a set of lower level tasks. Figure given below shows a fargment of a WBS where the design task has been broken down into three tasks and one of these has been further decomposed into two tasks.

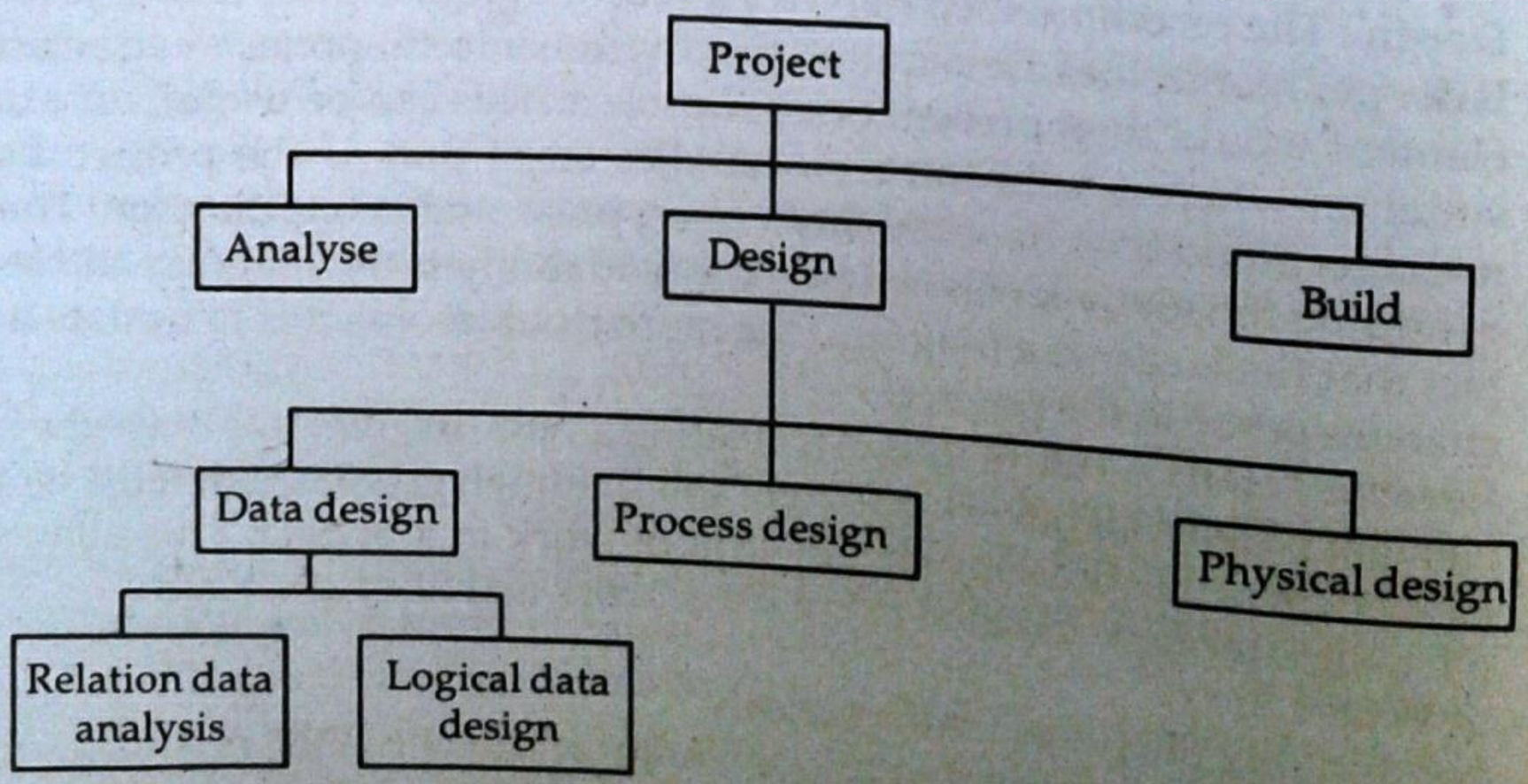


Fig. 2.6.

Activities are added to a branch in the structure if they directly contribute to the task immediately above - if they do not contribute to the parent task, then they should not be added to that branch. The tasks at each level in any branch should include everything that is required to complete the task at the higher level- if they are not a comprehensive definition of the parent task, then something is missing.
When preparing a WBS, consideration must be given to the final level of detail or depth of the structure. Too great a depth will result in a large number of small tasks that will be difficult to manage, whereas a too shallow structure will provide insufficient detail for project control. Each branch should, however, be broken down at least to a level where each leaf may be assigned to an individual or responsible section within the organization. Advantages claimed for the WBS approach include the belief that it is much more likely to result in a task catalogue that is complete and is composed of non-overlapping activities. Note that it is only the leaves of the structure that comprise the list of activities in the project, higher level nodes merely represent collections of activities.

Q. 9. What are different characteristics of activity? Explain.

Ans. The characteristics of activities are as follows :

1. Work is performed and described in terms of a verb, adjective, and noun, there is action performed.
2. A single person or organization is responsible for the work—more than one resource may be assigned to an activity, but one person is in charge of delivering the output. If this is not the case, the item needs further decomposition or joint responsibilities should be clarified.
3. It has defined start and finish points—there is either a specific predecessor activity or event that must be completed first or a specific date on which the activity is scheduled to start; the scheduled end date is based on the estimated duration, baseline duration, or scheduled duration of the activity.
4. Usually, there is a tangible output or product at completion—projects occasionally have level-of-effort activities or support activities without clearly defined outputs; however, the primary activities have defined and measurable outputs. The point at which an activity is completed is determined by the availability of an output product that is used as input by a successor activity.
5. It fits logically under an existing WBS element–if it does not, the activity is not part of the project, the WBS needs modification, or the activity is ambiguous and needs redefinition.
6. It is of a size and duration that is sufficient for control–activities that are too long do not provide sufficient time for corrective action if problems arise; activities that are too short make the control cost more expensive than a problem that may arise.
7. Actual schedule status data can be collected for the activity–for schedule control, the start and end points must be sufficiently defined so that the start and finish of the activity can be reported.
8. Actual cost (person-hour) data can be collected for the activity or work package that contains the activity—for cost or resource control, actual cost data or the actual expenditure of resources can be collected; obviously, if tracking actual expenditures is not required, this principle can be ignored.
9. The labor and costs necessary to perform the activity can be estimated—the resource requirements must be able to be determined in the planning phase.
10. The output of the activity is known or can be identified—outputs are frequently pieces of paper or other tangible proof of the activity being completed.
11. The activity represents a significant effort in support of project objectives—trivial or incidental activities need not be included.