Learning Resource
On
Software Project Management

SPM_Unit-4
Activity Planning

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Talkflow

- Introduction to Scheduling
- Define Activities
- Approaches to identify activities
  - Work based approach
  - Product based approach
  - Hybrid approach
- Final Outcome of Activity Planning
- Network Planning Model
- PERT vs CPM
- CPM calculations

Introduction to Scheduling

- **Scheduling** in activity planning refers to the process of organizing, estimating, and allocating resources and time to different tasks and activities within a software project.
- It ensures that all project activities are completed in a structured and timely manner to meet project deadlines and objectives.
- **Key Aspects of Scheduling in SPM:**
  - **Task Breakdown** : Dividing the project into smaller, manageable tasks (Work Breakdown Structure - WBS).
  - **Task Dependencies:** Identifying relationships between tasks
  - **Time Estimation:** Assigning realistic time durations to tasks using estimation techniques like PERT or Function Point Analysis.
  - **Resource Allocation:** Assigning personnel, tools, and budget to each activity.

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- **Critical Path Method (CPM) & PERT** – Identifying the longest sequence of dependent tasks to determine the shortest possible project duration.
- **Gantt Charts & Milestones** – Visual representation of the project timeline with important deadlines.
- **Risk Buffering** – Adding contingency time to manage risks and uncertainties.
- **Monitoring & Adjustments** – Continuously tracking progress and making necessary adjustments.

Note: Scheduling helps in avoiding delays, optimizing resource utilization, and ensuring smooth project execution in software development.

Defining activities

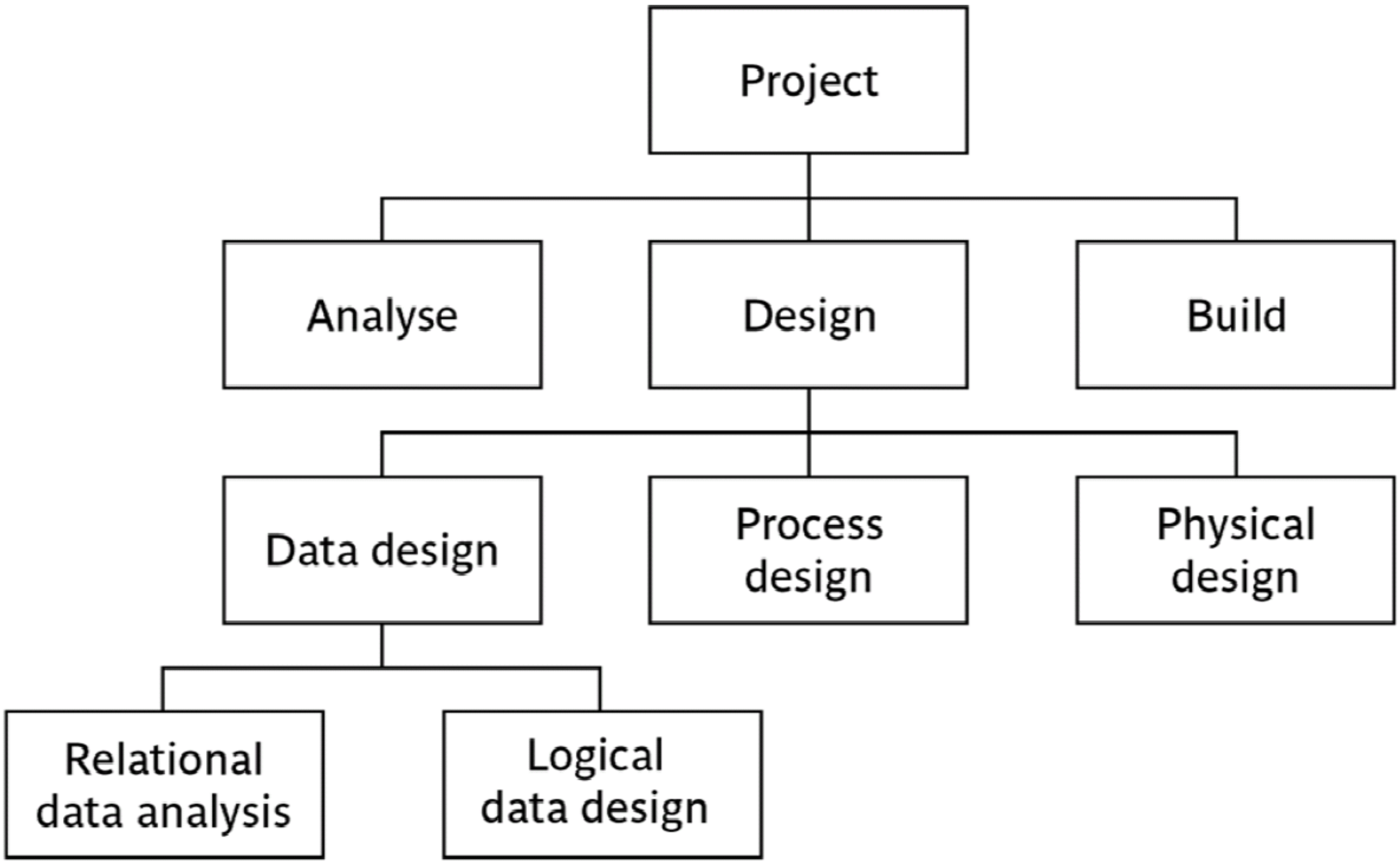
- A **project** is:
  - Composed of a number of **activities**
  - May start when at least one of its activities is ready to start
  - Completed when all its activities are completed

- An **activity**
  - Must have clearly defined start and end-points
  - Must have resource requirements that can be forecast: these are assumed to be constant throughout the project
  - Must have a duration that can be forecast
  - May be dependent on other activities being completed first (precedence networks)

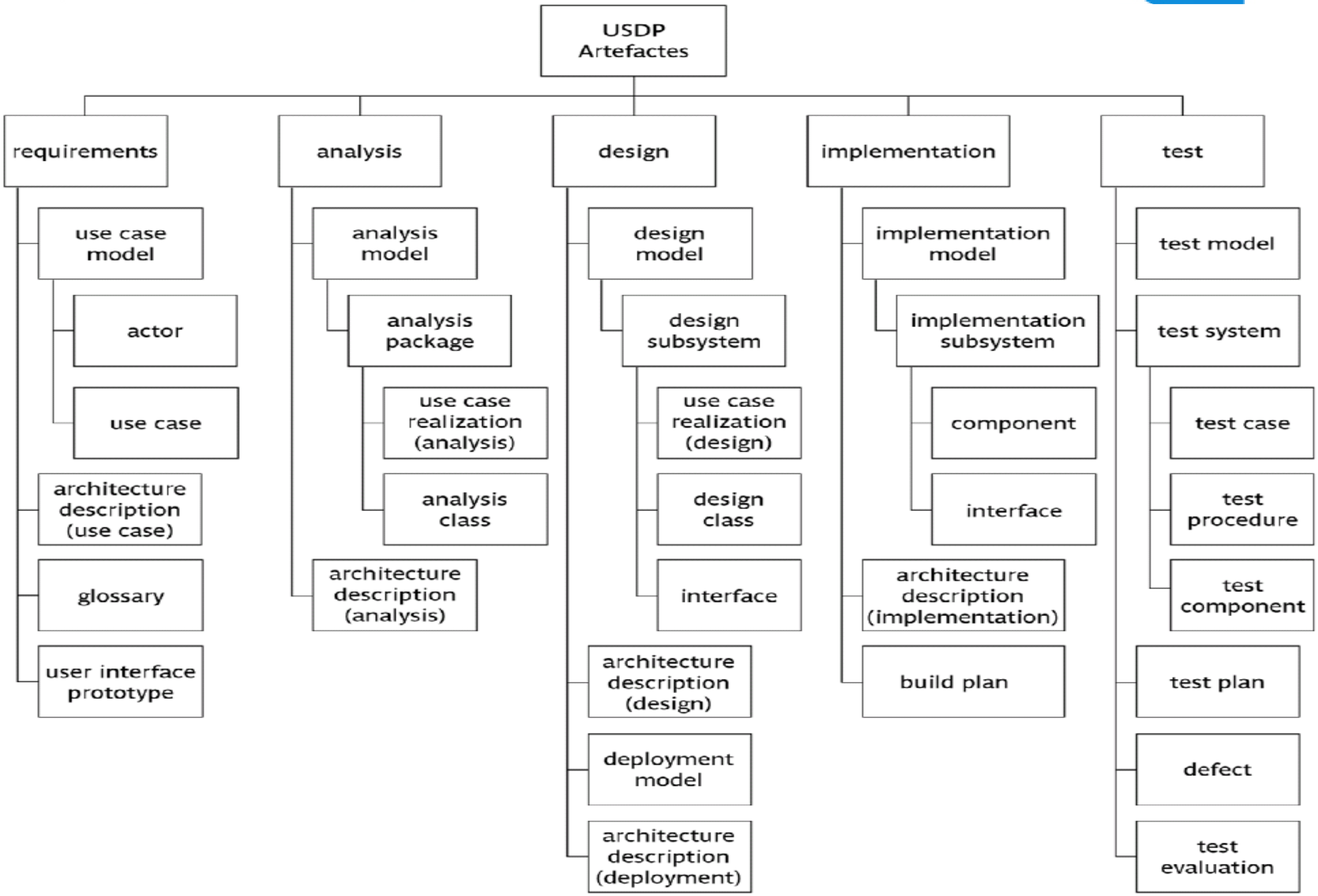
Approaches to identify Activities

- **Work-based approach:**
  - draw-up a **Work Breakdown Structure (WBS)** listing the work items needed.
  - In a WBS, a given task set is decomposed recursively into small activities. Root of the tree is labelled by the problem name.
  - Each node of the tree is broken down into smaller activities that are made the children of the node.
  - Each activity is recursively decomposed into smaller sub-activities until at the leaf level.
- **Product-based approach:**
  - list the deliverable and intermediate products of project – **product breakdown structure (PBS)**
  - Identify the order in which products have to be created
  - work out the activities needed to create the products

Work based approach

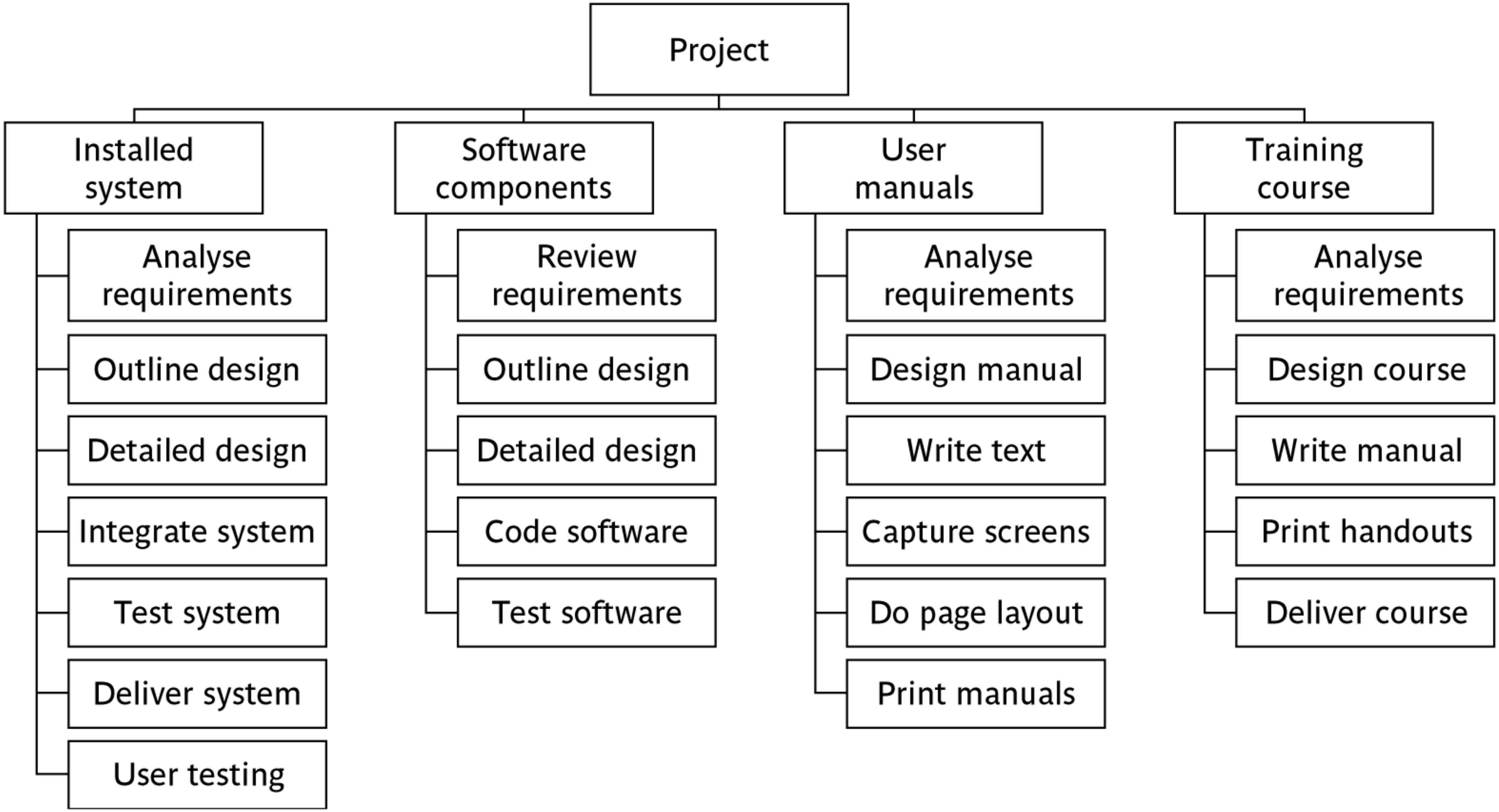


Product based approach



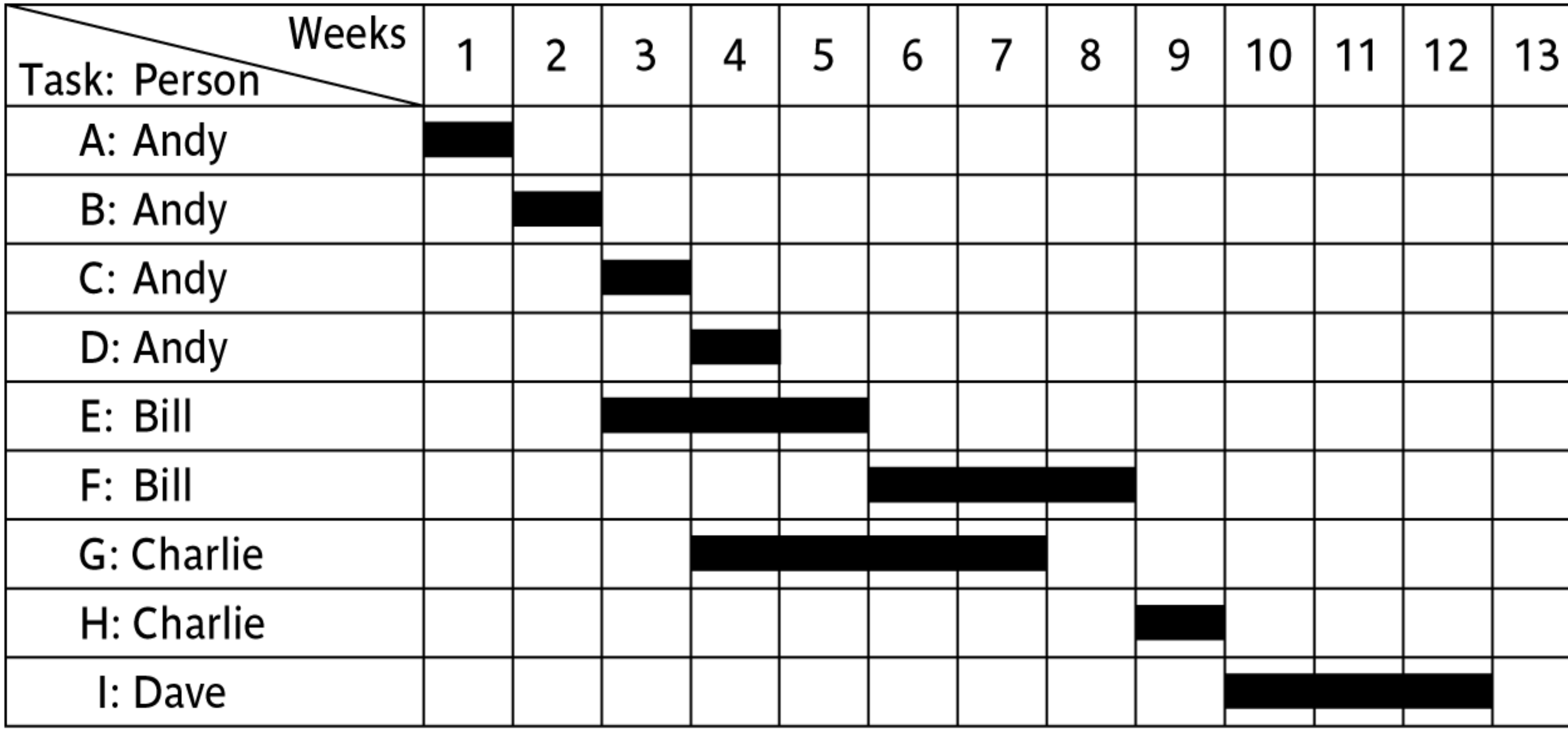
USDP – Unified Software Development Process – Jacobson, Booch, Rambaugh

Hybrid approach



Final outcome of the Activity planning

A project plan as a bar chart



Activity key

A: Overall design
B: Specify module 1
C: Specify module 2
D: Specify module 3
E: Code module 1
F : Code module 3
G : Code module 2
H: Integration testing
I : System tesing

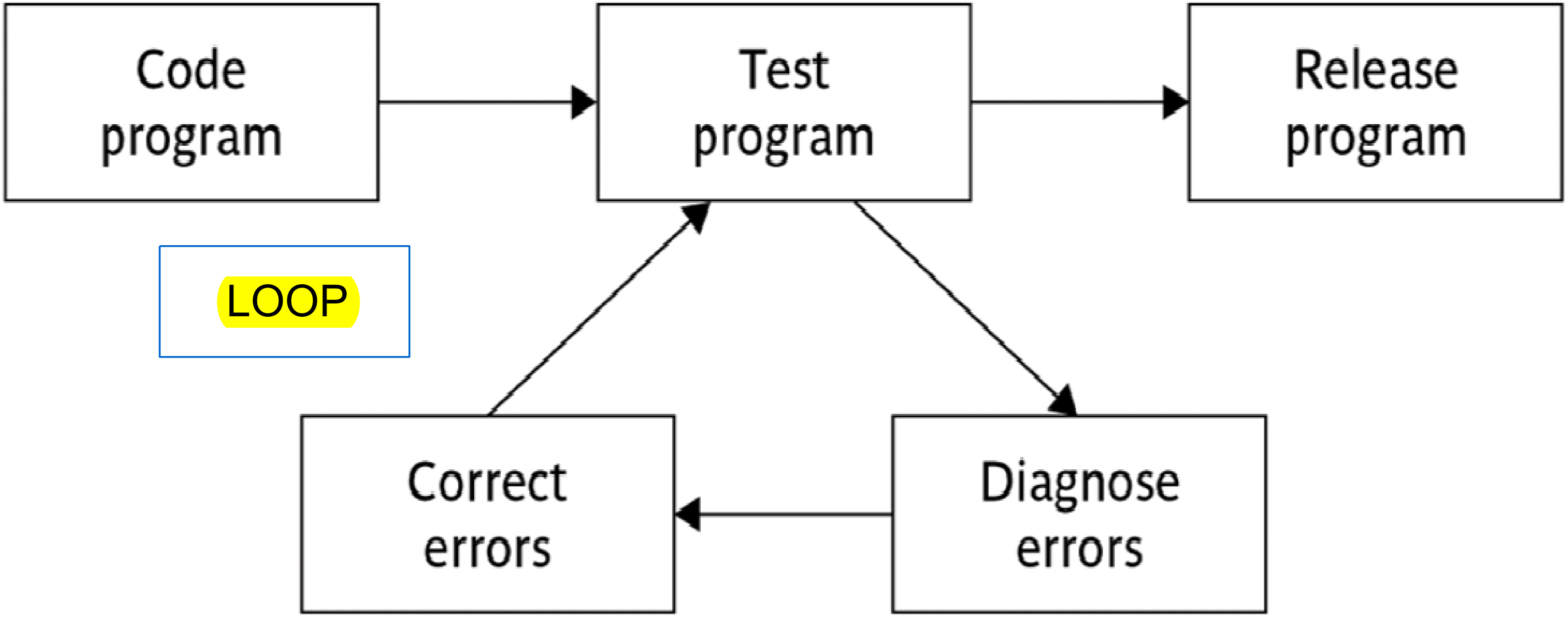
Network Planning Model

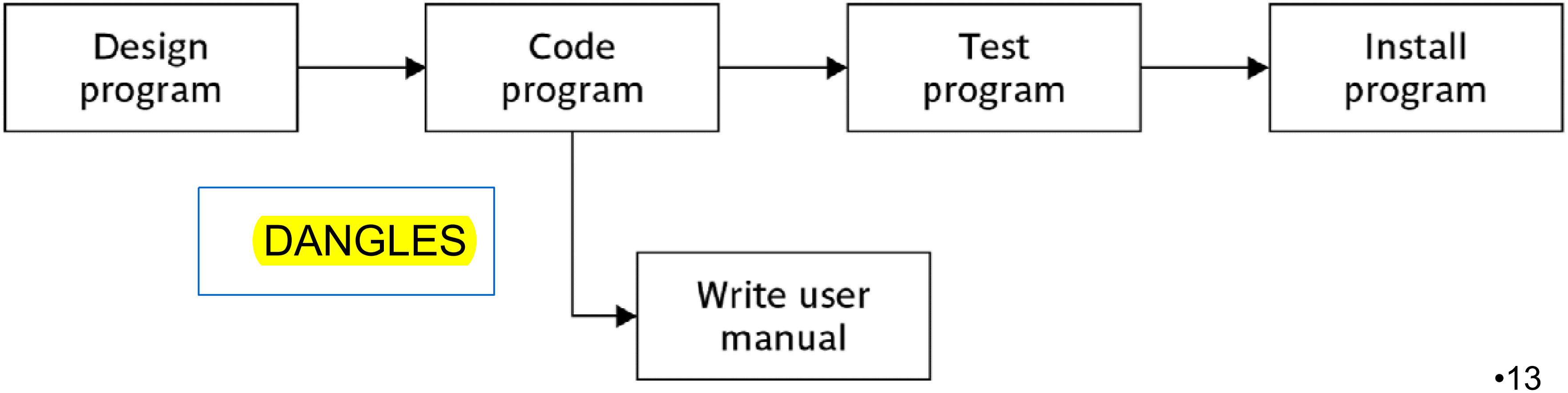
- Project scheduling techniques model the project activities and their relationships as a network
- In the network time flows from left to right.
- Developed in 1950s.
- Uses **activity-on-arrow** to visualize network.
  - Activity network shows the different activities making up a project, their estimated durations, and interdependencies.
  - Each activity is represented by a rectangular node and the duration of the activity is shown alongside each task.
- Circles and arrows are used.
- Technique is called precedence network.
- PERT (program evaluation review technique)
- CPM (critical path analysis)

Constructing Precedence Network

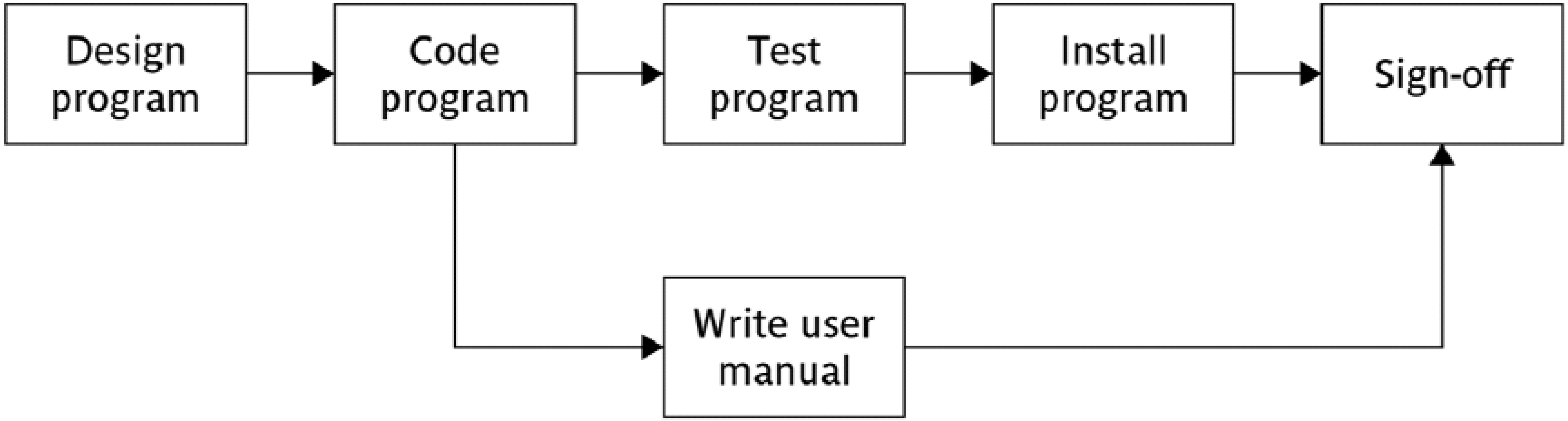
- A project network should have only one **start** node.
- A project network should have only one **end** node.
- A node has a **duration**.
- Links normally have **no duration**.
- **Precedents** are the immediately preceding activities.
- **Time** moves from left to right.
- A network may not contain **loop**
  - a cycle of activities keeps on repeating before the beginning of another activity.
- A network should not contain **dangles**
  - any activity should not be disconnected from the network before the completion of all activities.

Loops and Dangles



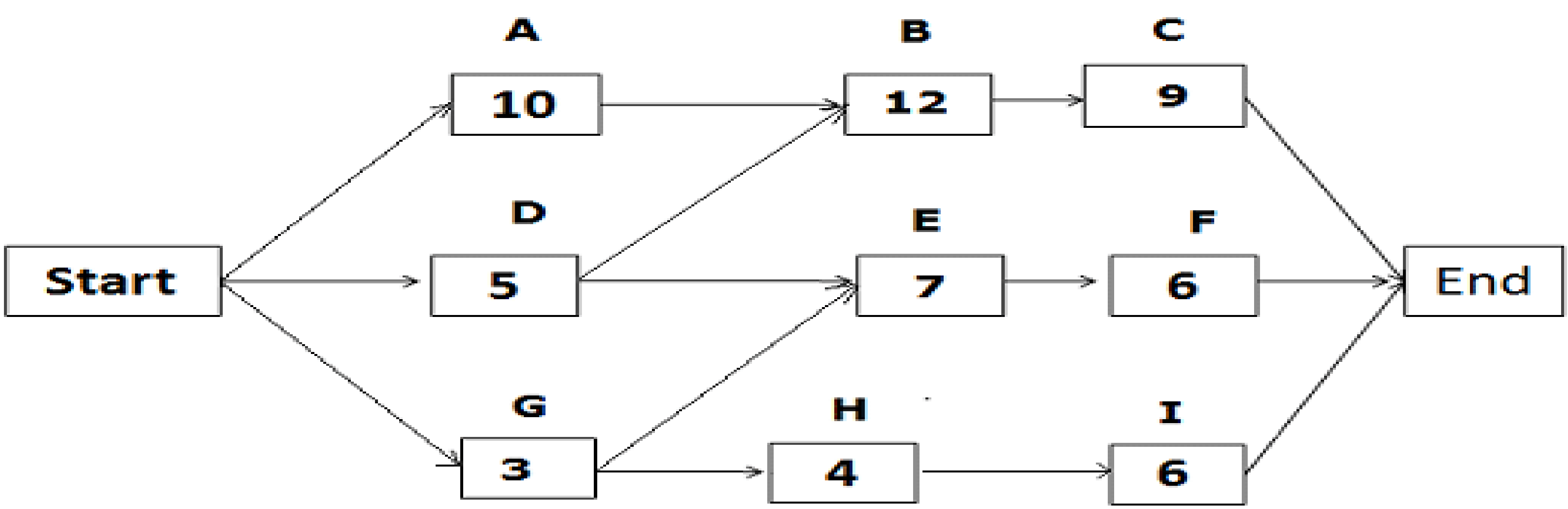


Resolving a dangle



Critical Path Method (CPM)

- The **Critical Path Method** (CPM), a project modeling technique developed by Morgan R. Walker and James E. Kelly in late 1950s.
- The critical path can be defined in many ways including:
  - The longest path in the network diagram, or the shortest duration in which the project can be completed.



CPM (Contd..)

- **Critical path** is the sequence of activities from start to end, and it has the longest duration among all paths in a network diagram.
- The activities under critical path are known as **critical activities.** An activity is critical if it can't be delayed else the entire project will be delayed. Hence, slack for critical activities is 0.
- In ideal conditions, a network diagram, and therefore, the project, should have only one critical path.
- The CPM has four key elements...
  - Critical Path Analysis
  - Float/slack Determination
  - Early Start & Early Finish Calculation
  - Late Start & Late Finish Calculation

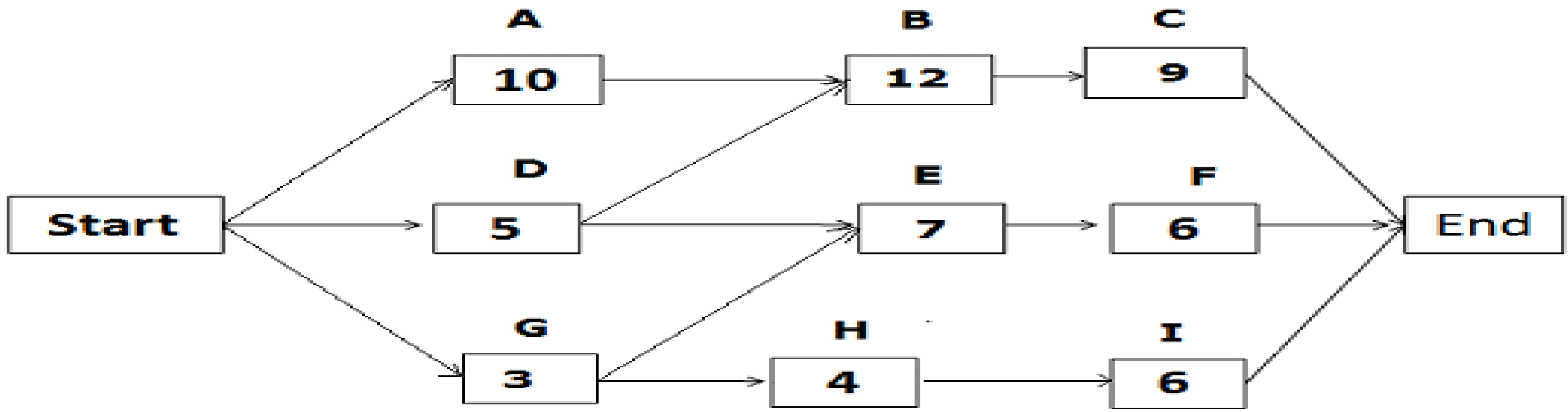
Critical Path Method (CPM)

- The following is the procedure to find the critical path on a network diagram:
  - Draw the network diagram.
  - Identify all paths in the network diagram.
  - Find the duration of each path.
  - The path with the largest duration is the critical path.

- Float (slack time) is the amount of time an activity can slip before it causes the project to be delayed.

- **Example:** Based on the below network diagram, identify the **total paths, critical path, and float for each path**.

Example



- The above network diagram has five paths; the paths and their duration are as follows:
  - Start -> A -> B -> C-> End, duration: 31 days.
  - Start ->D -> E ->F -> End, duration: 18 days.
  - Start -> D -> B -> C -> End, duration: 26 days.
  - Start -> G ->H ->I -> End, duration: 13 days.
  - Start -> G -> E ->F -> End, duration: 16 days.

contd..

- Since the duration of the first path is the longest, it is the critical path. The float on the critical path is zero.

- The float for the second path “Start ->D -> E ->F -> End” = duration of the critical path – duration of the path “Start ->D -> E ->F -> End” = 31 – 18 = 13. Hence, the float for the second path is 13 days.

- Using the same process, we can calculate the float for other paths as well.
  - Float for the third path = 31 – 26 = 5 days.
  - Float for the fourth path = 31 – 13 = 18 days.
  - Float for the fifth path = 31 – 16 = 15 days.

Early Start (ES) & Early Finish (EF)

- **Early Start (ES)** for the first activity on any path will be 1, because no activity can be started before the first day.

- The formula used for calculating **Early Start** and **Early Finish** dates.
  - **ES of the activity = EF of predecessor activity + 1**
  - **EF of the activity = Activity duration + ES of activity – 1**

- Early Start and Early Finish Dates for the path Start -> A -> B -> C -> End
  - **ES of activity, A** = 1
  - **EF of activity, A** = ES of activity A + activity duration – 1

$$= 1 + 10 - 1 = 10$$

Contd..

- **ES of activity, B** = EF of predecessor activity + 1
  = 10 +1 = 11
- **EF of activity, B** = ES of activity B + activity duration – 1
  = 11 + 12 – 1 = 22
- **ES of activity C**=EF of predecessor activity+1=22+1 = 23
- **EF of activity C** = ES of activity C + activity duration – 1
  = 23 + 9 – 1 = 31
- Using above method:
  – Early Start and Early Finish Dates for the activities in the path Start -> D -> E -> F -> End
  – Early Start and Early Finish Dates for the activities in path Start -> G -> H -> I -> End

Late Start (LS) and Late Finish (LF)

- **Late Finish** of the last activity in any path will be the same as the Last Finish of the last activity on the critical path, because you cannot continue any activity once the project is completed.
- The formula used for **Late Start** and **Late Finish** dates:
  - **Late Start (LS) of Activity = Late Finish of activity – activity duration + 1**
  - **Late Finish (LF) of Activity = Late Start of successor activity – 1**
- Late Start and Late Finish Dates for the path Start -> A -> B -> C -> End
  - On a critical path, Early Start, and Early Finish dates will be the same as Late Start and Late Finish dates.

Contd..

- Late Start and Late Finish Dates for the path Start -> D -> E -> F -> End
  - **LF of activity F** = 31 (because you cannot allow any activity to cross the project completion date)
  - **LS of activity F** = LF of activity F – activity duration + 1

    = 31 – 6 +1 = 26

  - **LF of activity E** = LS of successor activity – 1

    = LS of activity F – 1 = 26 – 1 = 25
  - **LS of Activity E** = LF of activity E – activity duration+ 1

    = 25 – 7 + 1 = 19

contd..

- **Late Finish of activity D** = LS of successor activity – 1
  - If you look at the network diagram, you will notice that activity D has two successor activities, B and E. So, which activity will you select?
  - You will select the activity with the earlier(least) Late Start date. Here, Late Start of activity B is 11, and Late Start of activity E is 19.
  - Therefore, you will select activity B which has the earlier Late Start date.
- **LF of activity D** = LS of activity B – 1 = 11 – 1 = 10
- **LS of Activity D** = LF of activity D – activity duration + 1

  = 10 – 5 + 1 = 6
- Using above method:
  - Late Start and Late Finish Dates for the path Start -> G -> H -> I -> End

Critical Path Method (CPM)

- The following is the procedure to find the critical path on a network diagram:
  - **Draw** the network diagram.
  - **Identify** all paths in the network diagram.
  - **Find** the duration of each path.
  - The path with the **largest duration** is the critical path.

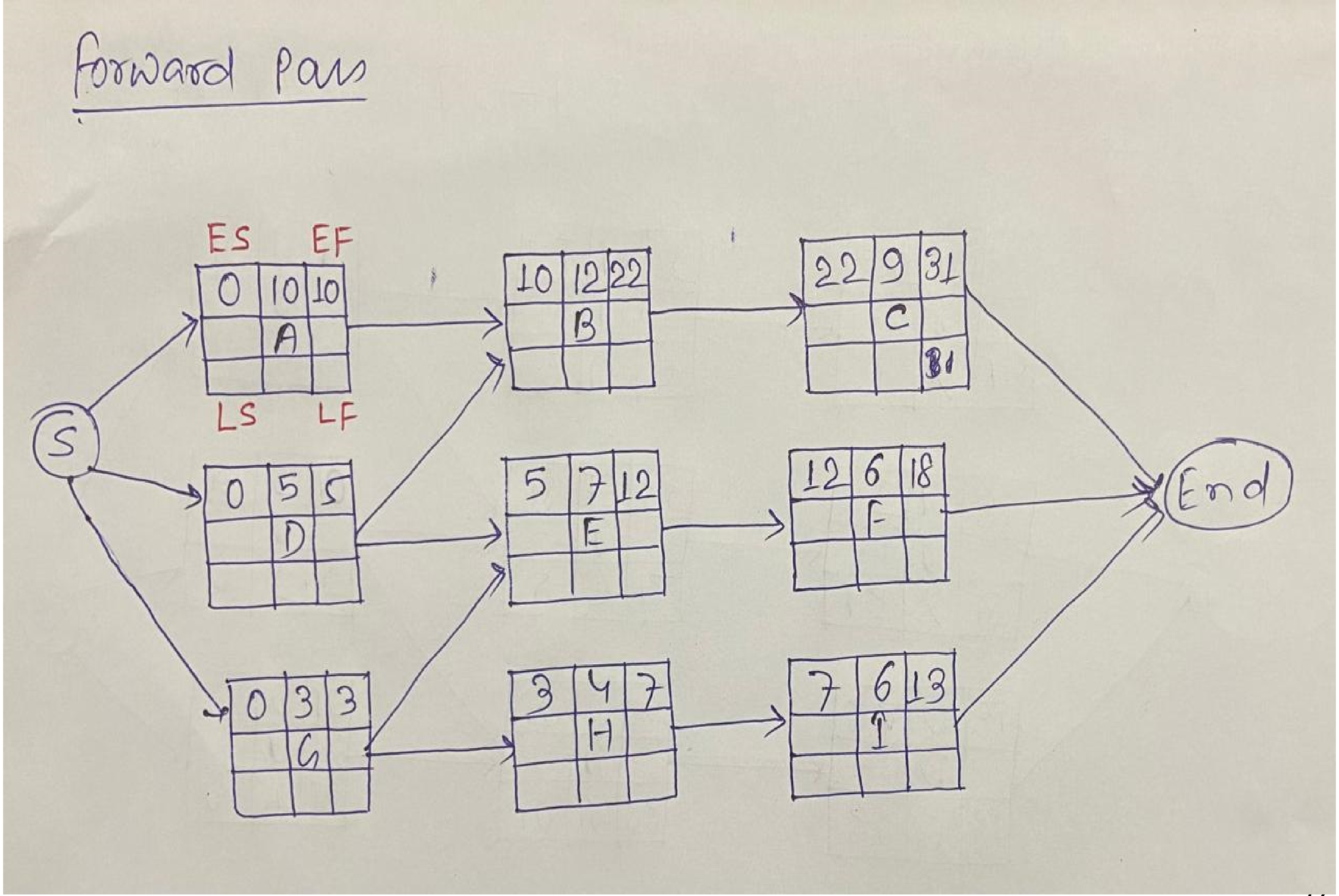
- **Float (slack time)** is the amount of time an activity can slip before it causes your project to be delayed.
  - **Float = LS - ES; or LF - ES - duration**;

- **Example:** Based on the below network diagram, identify the total paths, critical path, and float for each path.

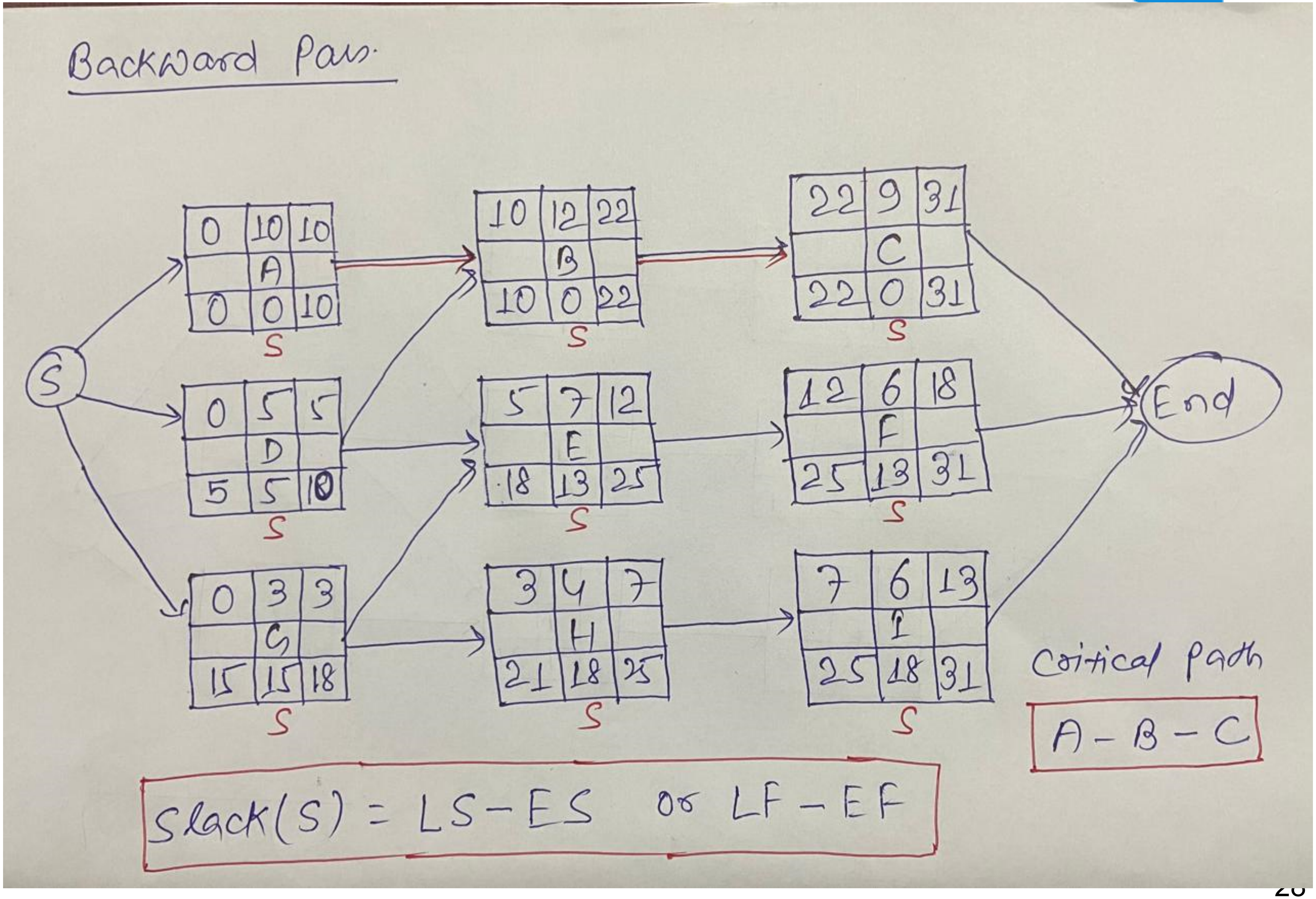
Activity Representation

T_E	t	T_E+t
Earliest start (ES)	Duration	Earliest finish (EF)
Activity label, activity description		
Latest Start (LS)	Float	Latest finish (LF)
T_L-t	T_L -T_E	T_L

Forward Pass



Backward Pass



Free Float vs Interferring Float

- **Free float** is the amount of time a task can be delayed without delaying the early start of any successor activity.
  - **FF=ESnext −EFcurrent**

- **Example:**
  - Task A: Duration = 5 days, Earliest Start (ES) = Day 1, Earliest Finish (EF) = Day 6
  - Task B (successor to A): Earliest Start (ES) = Day 8

- Free Float for Task A, $FF_A = ES_B - EF_A = 8-6 = 2$ days

- This means Task A can be delayed by 2 days without affecting Task B.

- **Interfering float** is the amount of time a task can be delayed without delaying the project completion, but it may delay the early start of successor activities.
  - **Interfering Float (IF) = Total Float (TF) − Free Float (FF)**

- **Example:**
  - Task A: Total Float = 5 days; Free Float = 2 days
  - IF=5−2=3 days

- This means Task A can be delayed by 3 more days, but this delay will push back the start of its successor tasks (without affecting the overall project deadline).

Brainstorming on Critical path

- **Critical path:** any delay in an activity on this path will delay whole project
- **Brainstorming???**
  - **Can there be more than one critical path?**
    - Yes, there could be more than one critical path if the two longest paths through the network were of equal length.
  - **Can there be no critical path?**
    - Where the target completion date for the project was imposed rather than calculated from the earliest finish dates, it might be later than the earliest finish date. In this case there would be no chains of activities with zero floats
  - **Sub-critical paths?**
    - Sub-critical paths are chains of activities, not on the planned critical path, but which have small floats, and which could easily become the critical path as the project develops.

PERT chart

- **PERT (Project Evaluation and Review Technique)** charts consist of a network of boxes and arrows.
- The **boxes** represent activities and the **arrows** represent task dependencies.
- PERT chart represents the statistical variations in the project estimates assuming a normal distribution.
- Thus, in a PERT chart instead of making a single estimate for each task, **pessimistic, likely, and optimistic** estimates are made.
- A critical path in a PERT chart is shown by using **thicker arrows**.
- **Gantt chart** representation of a project schedule is helpful in planning the **utilization of resources**, while **PERT chart** is useful for **monitoring** the timely progress of activities.

- **Expected Time Duration** can be calculated as below:
  - $t_e = (t_o + 4*t_m + t_p\ ) / 6$
- **Standard Deviation, SD,** measures the amount of variation of a set of values. A low SD means that the values tend to be closer to the mean of the set, while a high SD indicates the values are spread out over a wider range. It can be calculated as below:

$$\text{Standard deviation} = \frac{t_p - t_0}{6}$$

- **Variance** is the level of volatility of the time required to carry an activity from the average time. It is calculated as below:

$$\text{Variance} = \left(\frac{t_p - t_0}{6}\right)^2 = (\text{Standard deviation})^2$$

EST, LFT, and Slack

- **Earliest Start Time, EST,** represents the earliest time an activity can be started. It can be calculated as below:
  - **EST(X) = EST(Predecessor) + Duration (t_e)**
  - In case of multiple predecessor, the longest EST will be considered.
- **Latest Finish Time, LFT,** represents the latest finish time by which an activity should be completed. It can be calculated as below:
  - **LFT(X) = LFT (Successor) - Duration (t_e)**
  - In case of multiple successor, the shortest LFT will be considered.
- **Slack** represents the amount of delay that an activity can make. It can be calculated as below: **Slack(X) = LFT(X) - EST (X)**

Example-1

A small consultancy project consist of following activities gives below.

(a) Calculate the values of expected time (te) standard deviation, and variance for each activity.

(b) Draw network diagram and mark te

(c) Calculate EST and LFT and mark them on diagram.

(d) Calculate total slack for each activity.

(e) Calculate variance of critical path.

(f) Calculate the probability that job on critical path will be finished by the due date of 38 days. (omit)

Activity on Edge	t_0	t_m	t_p
1-2	2	5	14
1-6	2	5	8
2-3	5	11	29
2-4	1	4	7
3-5	5	11	17
4-5	2	5	14
6-7	3	9	27
5-8	2	2	8
7-8	7	13	31

Solution

- We know that,

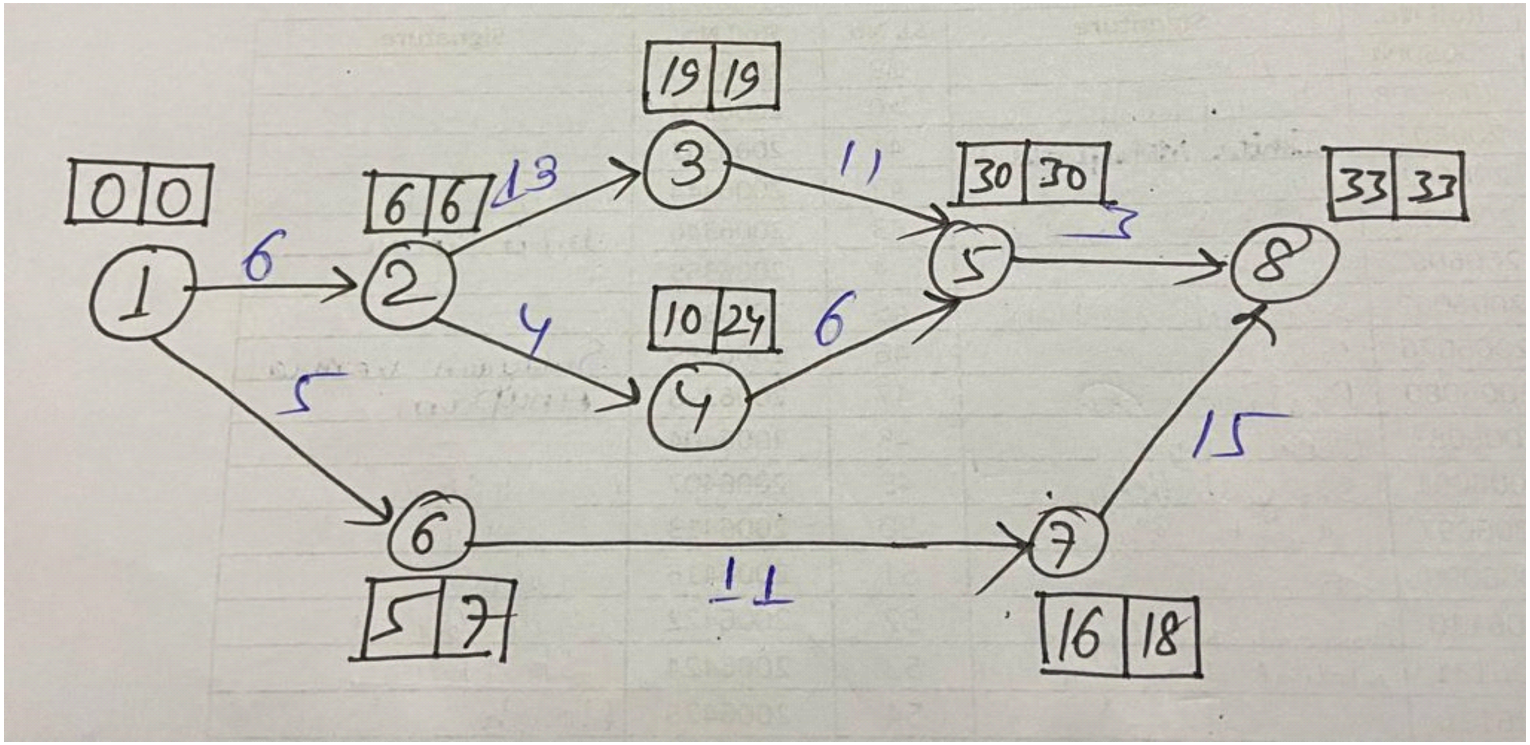
  Expected Time, $t_e = (t_o + 4*t_m + t_p) / 6$

  Standard deviation = $(t_p - t_o) / 6$

  Variance = (Standard deviation)2

Activity	t_0	t_m	t_p	t_e	s_t	Varr.
1-2 (a1)	2	5	14	6	2	4
1-6 (a2)	2	5	8	5	1	1
2-3 (a3)	5	11	29	13	4	16
2-4 (a4)	1	4	7	4	1	1
3-5 (a5)	5	11	17	11	2	4
4-5 (a6)	2	5	14	6	2	4
6-7 (a7)	3	9	27	11	4	16
5-8 (a8)	2	2	8	3	1	1
7-8 (a9)	7	13	31	15	4	16

- The network diagram along with the EST and LFT time is as below:



contd..

- **Critical path:** Path with the longest duration in the network diagram.
- There are 3 paths: 1 – 2 – 3 – 5- 8 (33) critical path.
  1 – 6 – 7 – 8 (31) Next most critical path.
  1 – 2 – 4 – 5 – 8 (19) Next most critical path.
- Slack time for each activity is as below:

1-2 (a1): 6 – 6 = 0
1-6 (a2): 7 – 5 = 2
2-3 (a3): 19 – 19 = 0
2-4 (a4): 24 – 10 = 14
3-5 (a5): 30 – 30 = 0
4-5 (a6): 30 – 30 = 0
6-7 (a7): 18 – 16 = 2
5-8 (a8): 33 – 33 = 0
7-8 (a9): 33 – 33 = 0

contd..

- The variance of critical path **1 – 2 – 3 – 5 – 8** is

  V(CP) = V(1-2) + V(2-3) + V(3-5) + V(5-8)

  =4 + 16 + 4 + 1 = 25.

- The probability that the project will meet the due date I calculated by the formula.

$$Z = \frac{\text{due date} - \text{expected date of completion}}{\sqrt{\text{variance}}} = \frac{38-33}{\sqrt{4+16+4+1}} = \frac{5}{5} = 1$$

- For the value of Z = 1 the corresponding standard normal distribution table is 0.841 i.e, 84.1%.

Exercise Problem

- A small project consisting of eight activities has the following characteristics:

Time – Estimates (in weeks)

Activity	Preceding activity	Most optimistic time (a)	Most likely time (m)	Most Pessimestic time (b)
A	None	2	4	12
B	None	10	12	26
C	A	8	9	10
D	A	10	15	20
E	A	7	7.5	11
F	B,C	9	9	9
G	D	3	3.5	7
H	E, F, G	5	5	5

(i) Determine the expected time (te), standard deviation and variance for each activity.

(ii) Draw the PERT network for the project. Represent EST and LFT in the diagram.

(iii) Determine the critical path, variance of critical path, and slack of each activity.

(iv) If a 30- week deadline is imposed, what is the probability that the project will be finished within the time limit?