

TIME COMPUTATION

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Creating a Schedule

A project schedule requires 3 pieces of information:

- ➡ A list of project *activities*
- ➡ *Activity durations*
- ➡ *Activity relationships* (dependencies)

	Activity Description	Duration	Preceding Activity	Preceding Activity
1	Strip Room	3	-	
2	Repair Walls & Ceilings	4	1,5,7	5,7
3	Repair Floor	1	1,5	5
4	Lay Vinyl Floor	1	3,12,13,14	12,13,14
5	Rough-in Plumbing & Electrical	5	1	1
6	Finish Plumbing & Electrical	2	2,3,5,9,10,11,19	10,11,19
7	Replace Existing Fume Duct	3	1	1
8	Install New Fume Hood	1	2,3,16	2,3,16
9	Install 1/3 Base Cabinet	1	2,3,8,15	8,15
10	Install Wall Cabinets	5	2,3,7,15	2,3,15
11	Install Chemical Sink	1	2,3,5,9,17	9,17
12	Paint Cabinet	6	6,8,9,10, 11,18	6,18
13	Paint Walls & Ceiling	3	2,3,6,8,9,10,18	18
14	Obtain Vinyl Floor Covering	5	-	-
15	Obtain Cabinets	10	-	-
16	Obtain Fume Hood	10	-	-
17	Obtain Chemical Sink	10	-	-
18	Painter Availability	20	-	-
19	Install 2/3 Base Cabinet	2	2,3,9,15	9

Objectives of time computations

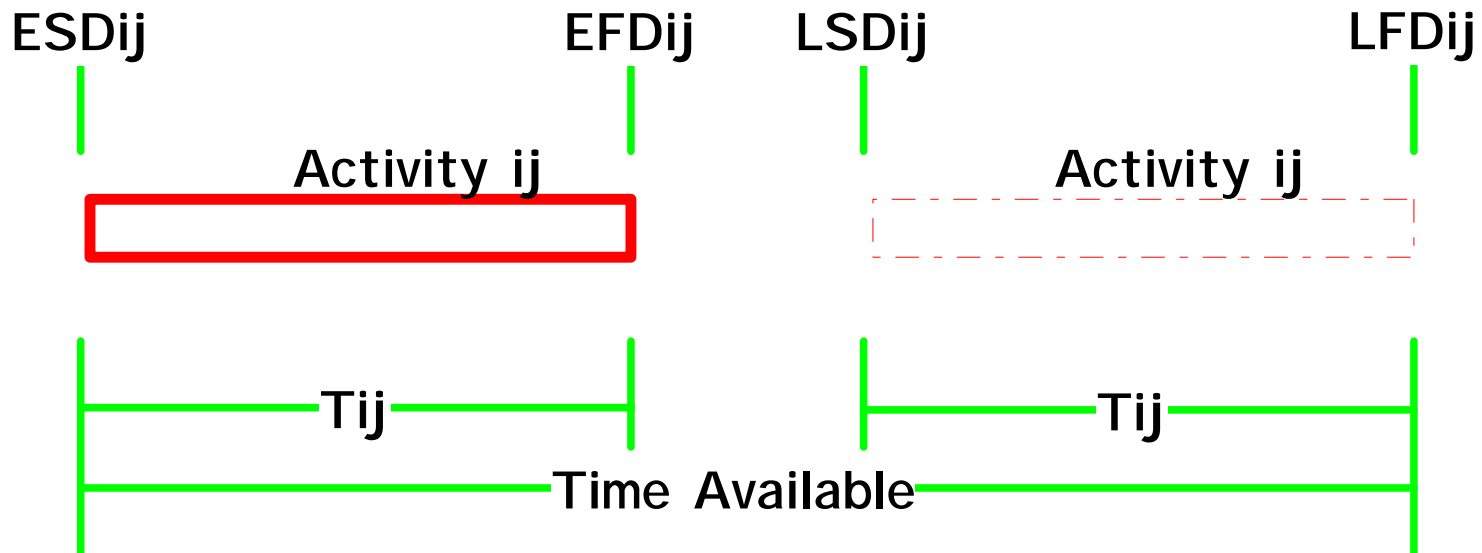
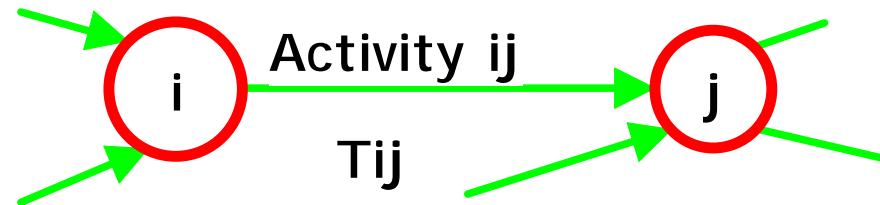
- ➔ Determine project duration.
- ➔ Determine the path of activities that establishes the project overall duration (critical path).
- ➔ Determine when activities *can begin* and when they *must end*.
- ➔ Determine the time of leeway (flexibility) for the scheduling of each activity.

Activity times:

An activity has four activity times associated with it.

- The early start date (ESD): The earliest time an activity can start.
- The early finish date (EFD): The earliest time an activity can finish.
- The late start date (LSD): The latest time an activity is allowed to start.
- The late finish date (LFD): The latest time an activity is allowed to finish.

Activity times



Activity Times Relationships:

$$EFD_{ij} = ESD_{ij} + T_{ij}$$

$$LSD_{ij} = LFD_{ij} - T_{ij}$$

Arrow Diagrams Computation

- The early start schedule:

The project schedule based on all activities starting on their early start times. This is calculated using the Forward Pass calculation.

- The late start schedule:

The project schedule based on all activities finishing on their late finish times. This is calculated using the Backward Pass calculation.

- The combination of the early start schedule and late start schedule allow us to determine all activity times and floats.

Computational Procedure for Forward Pass calculations

- Assign a date for project start at the initial node. This will be the Early Start date assigned to all initial activities.
- From the initial node date add the duration of each of the activities bursting from the initial node to establish their early finish dates.
- For all activities merging into a node select the maximum of the early finish dates of the activities to be the Early Start of activities bursting from the node.
- Continue the procedure until the end node.

Computational Procedure for Backward Pass calculations

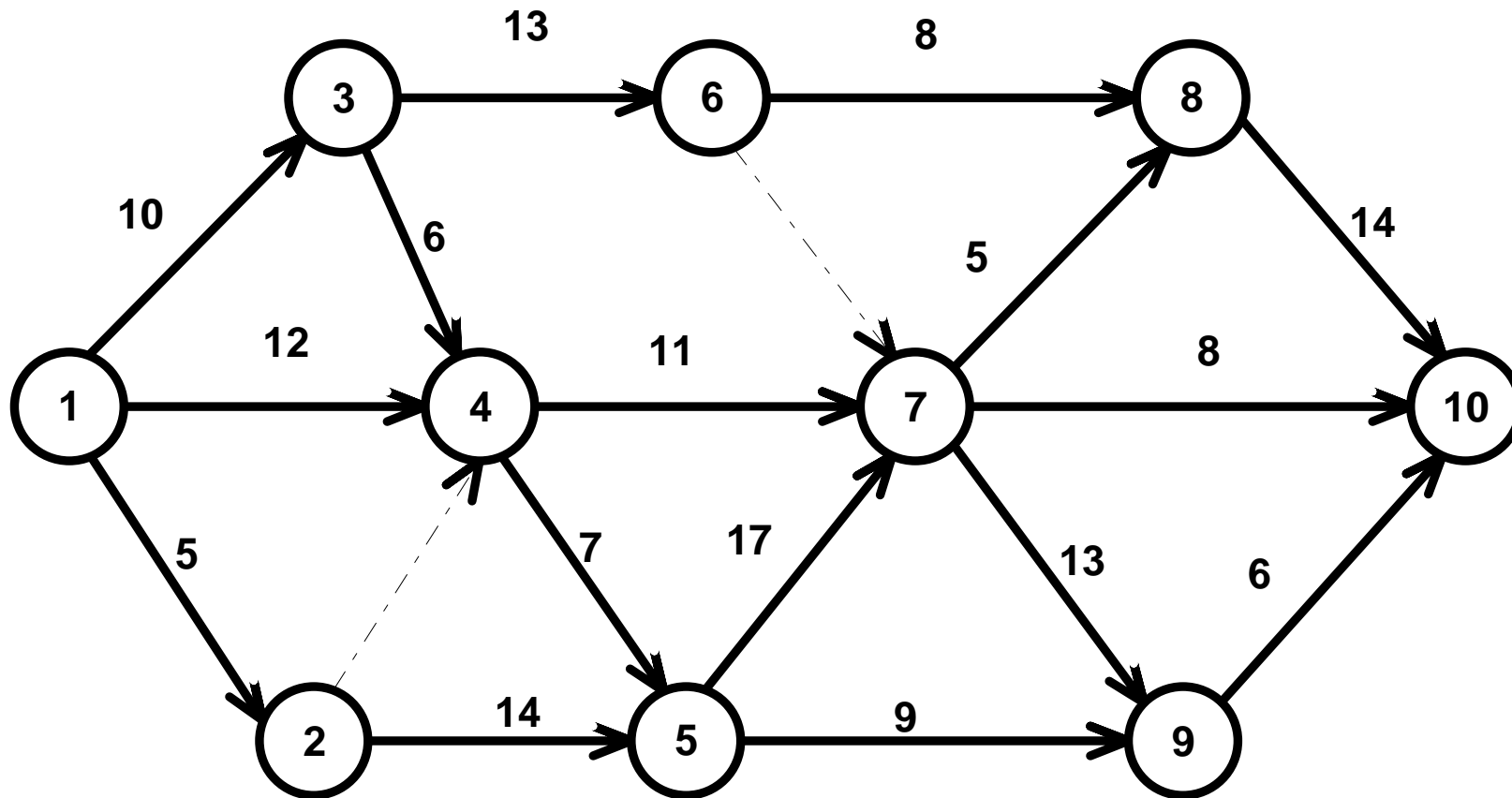
- Assign a date at the terminal node on which project must end. This will be the Late Finish date assigned to all terminal activities.
- From the terminal node latest allowable assigned date subtract the duration of activities merging into it to establish the late start date of these activities.
- For all activities bursting from a node select the minimum of the late start dates of the activities to be Late Finish date of the activities merging into that node.
- Continue the procedure until the initial node.

Scheduling Computations for Arrow Networks

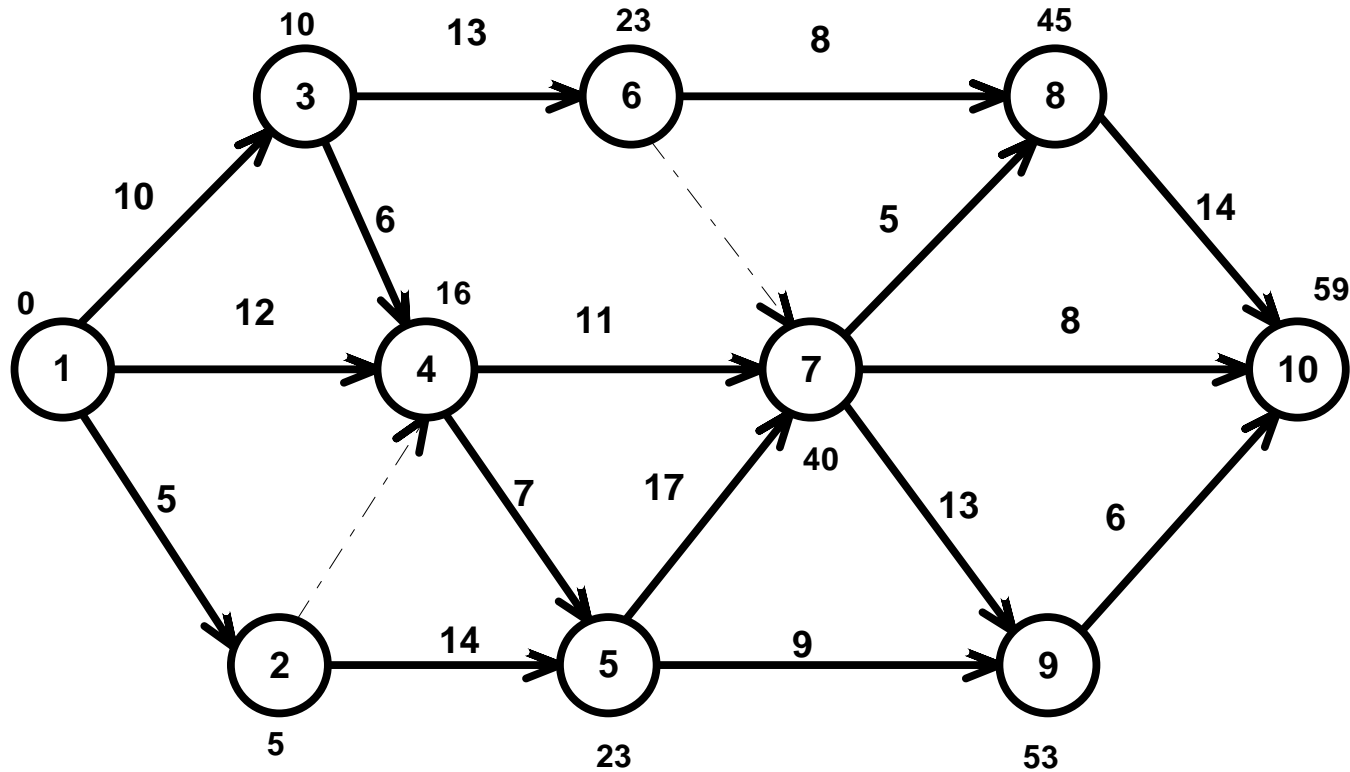
Schedule the following network

Activity	Duration	Comments
1-2	5	
1-3	10	
1-4	12	
2-4	0	Dummy
2-5	14	
3-4	6	
3-6	13	
4-5	7	
4-7	11	
5-7	17	
5-9	9	
6-7	0	Dummy
6-8	8	
7-8	5	
7-9	13	
7-10	8	
8-10	14	
9-10	6	

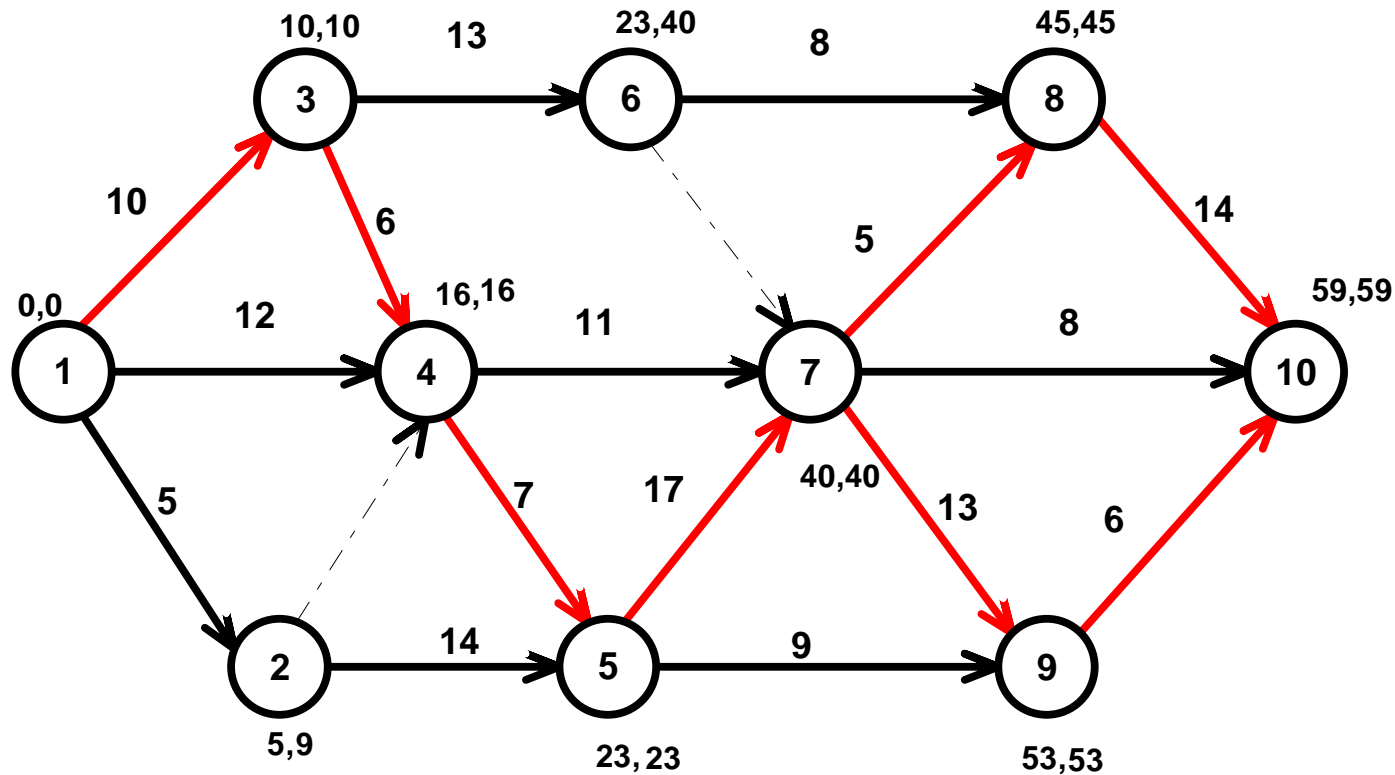
The Arrow Diagram



The Early Start Schedule



Early & Late Start Schedule



Activity Floats

- An activity float indicates how much flexibility we have in scheduling an activity
- There are four types of activity floats:
 - Total float (TF)
 - Free Float (FF)
 - Interfering Float (Intf)
 - Independent Float (Indf)
- The most widely used are the total and free floats

The Meaning Activity Floats

- TF: The amount of time an activity can be delayed without increase to the project duration.
- FF: The amount of time an activity can be delayed without delaying its succeeding activities
- INTF: The amount of time an activity can be delayed with definite delay to the succeeding activity but w/o increase in the project duration
- INDF: The amount of time an activity can be delayed without delaying its succeeding activities and w/o affecting its preceding activities (allowing preceding activities to finish on their late finish date)

Float Calculations for activity ij

- Total Float
 $TF_{ij} = LFD_{ij} - EFD_{ij}$
- Free Float
 $FF_{ij} = ESD_{jk} - EFD_{ij}$
- Interfering Float:
 $Intf_{ij} = LFD_{ij} - ESD_{jk}$
- Independent Float
 $Indf_{ij} = ESD_{jk} - LFD_{hi} - T_{ij}$

Time Computations for Precedence Diagrams

Activity times and activity time relationships discussed for the arrow network diagrams apply, obviously, to precedence diagrams.

Procedure for calculating activity times

- Assign the early start date to the initial activity.
- Determine the early finish date of this activity.

$$EFD_i = ESD_i + T_i$$

- The early start date of a successor activity is the maximum of the EFD of all preceding activities.

$$ESD_j = \text{Max } EFD_i \quad (\text{over all activities } i)$$

- The procedure is continued until the last activity

Procedure for calculating activity times (Continued)

- The late finish date of the terminal activity is also assigned.
- Determine the late start date of this activity.

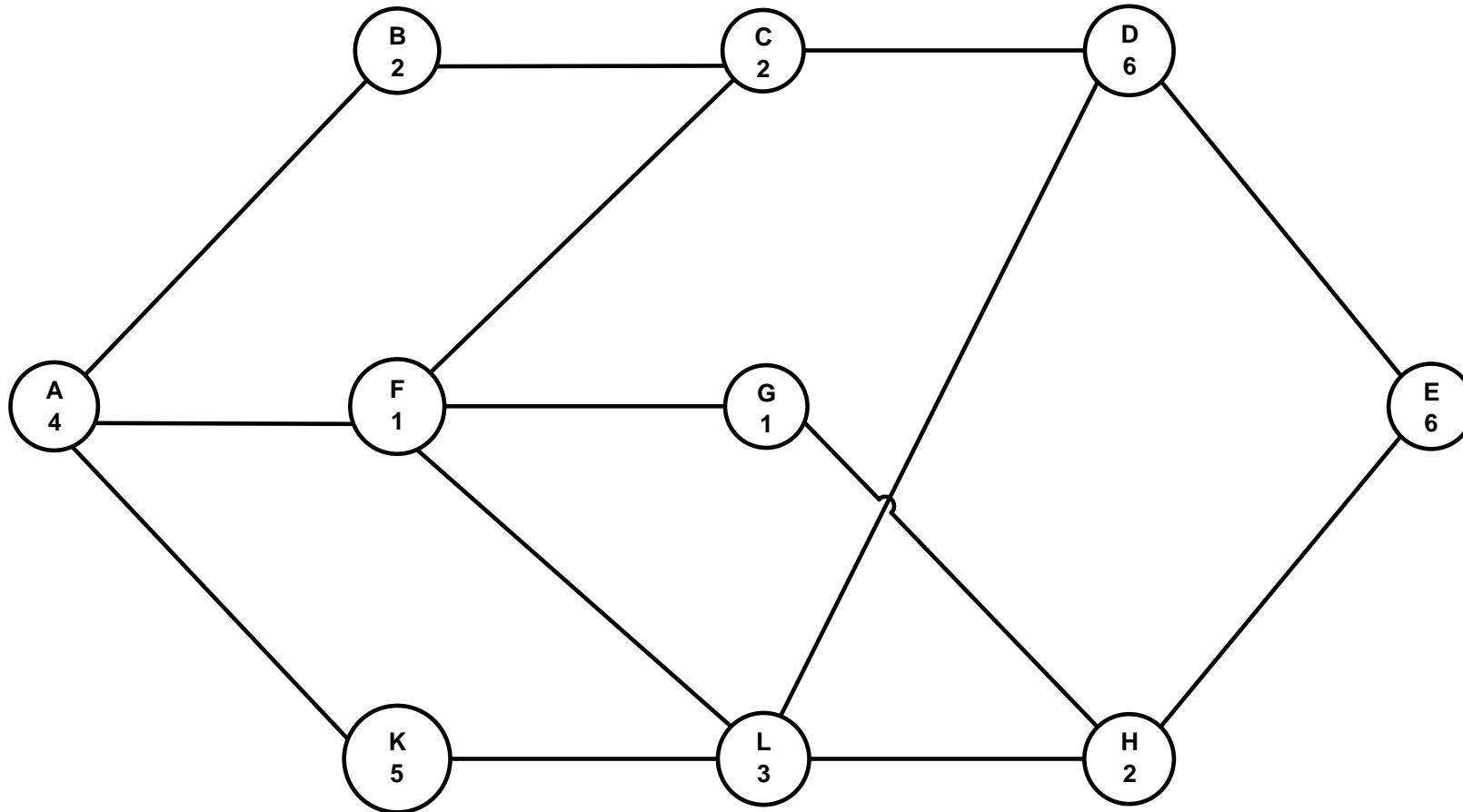
$$\text{LSD}_i = \text{LFD}_i - T_i$$

- The late finish date of an activity is the minimum of the LSD of all succeeding activities.

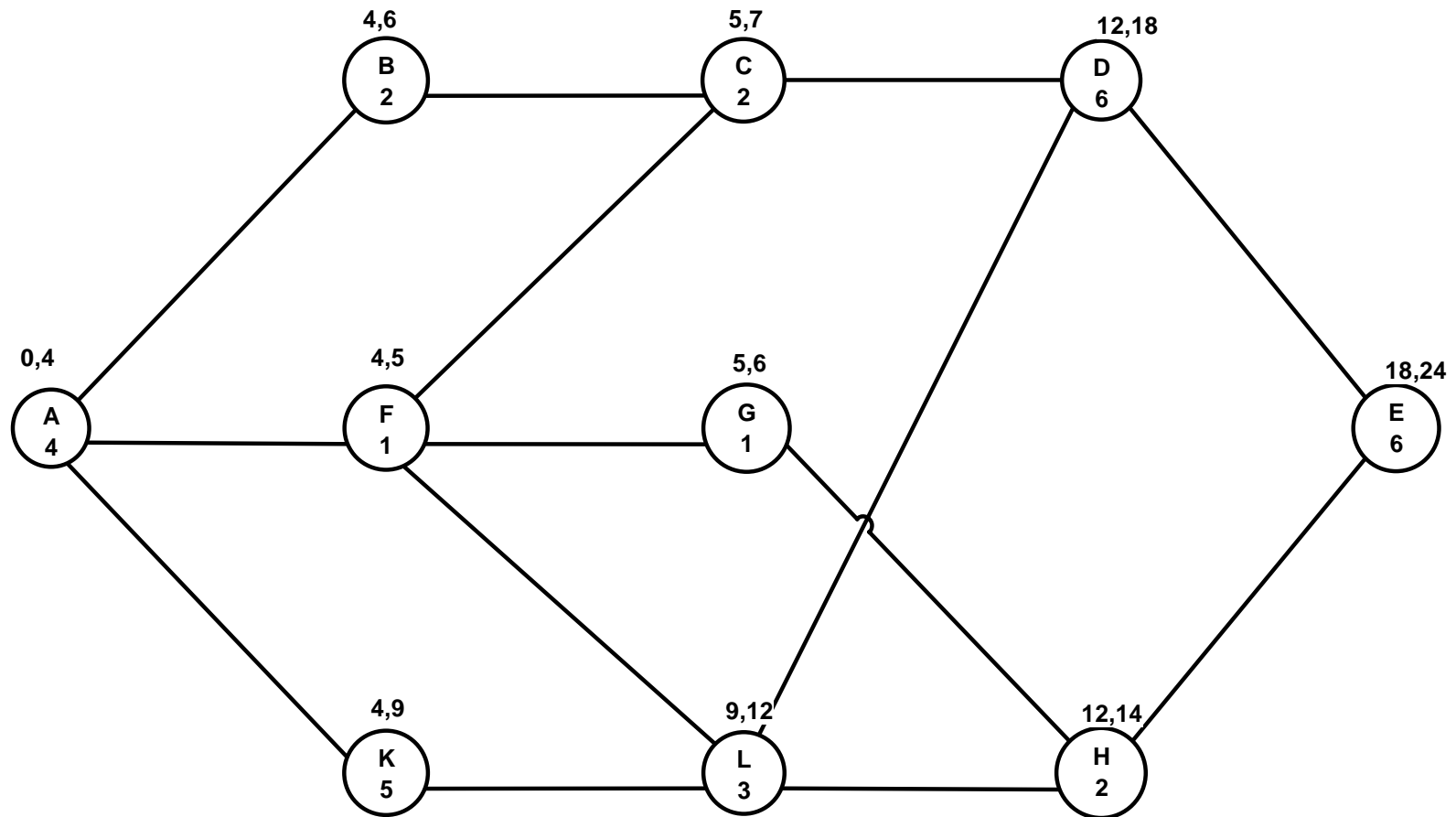
$$\text{LFD}_i = \text{Min LSD}_j \quad (\text{over all activities } j)$$

- The procedure is continued until the initial activity.
- The calculation of floats can follow the same procedure and formulae as in the case of arrow diagram network.

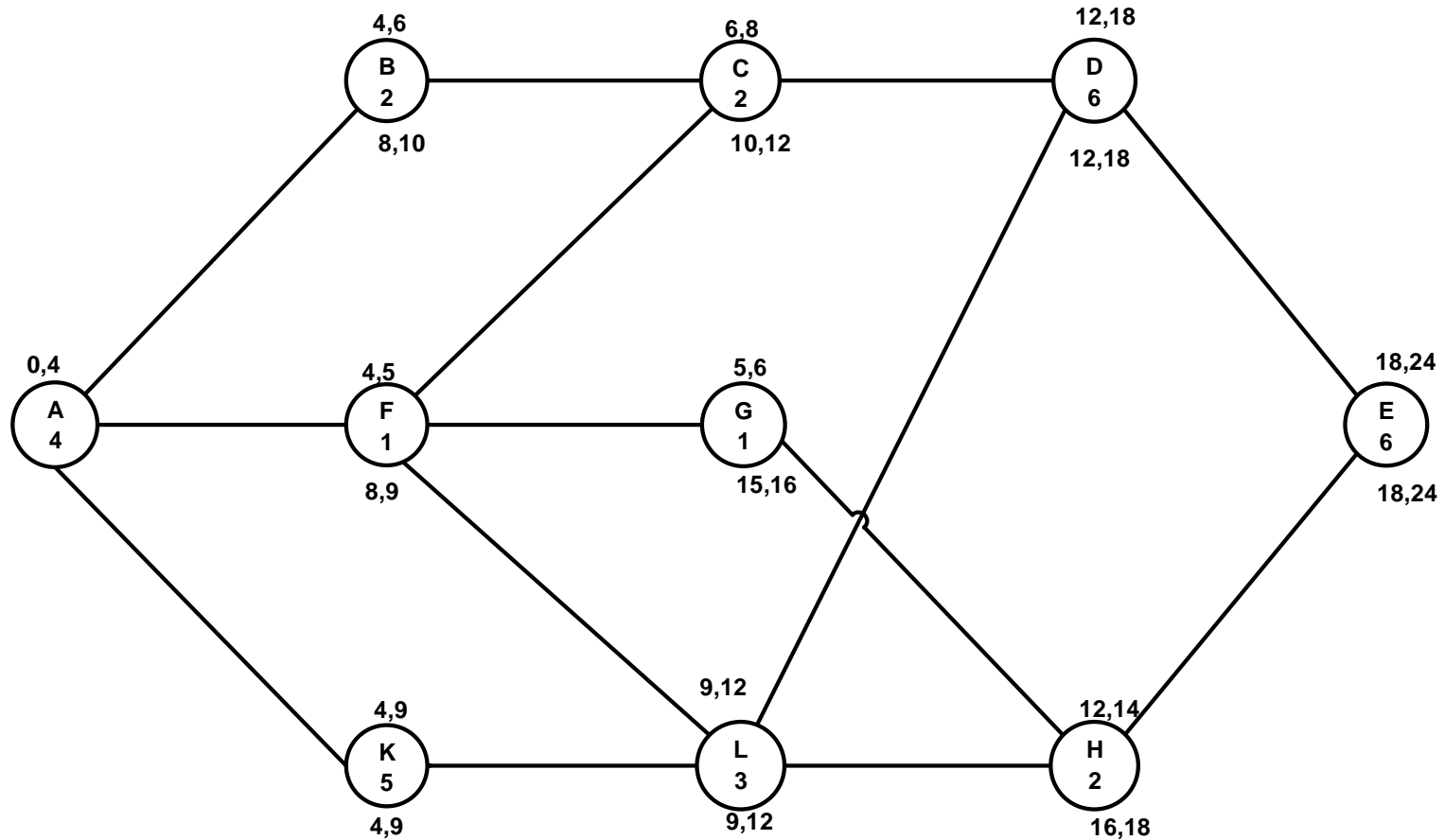
The Precedence Diagram



Early Start Schedule



Early & Late Start Schedules



Link Lags in Precedence Diagrams

- Definition:

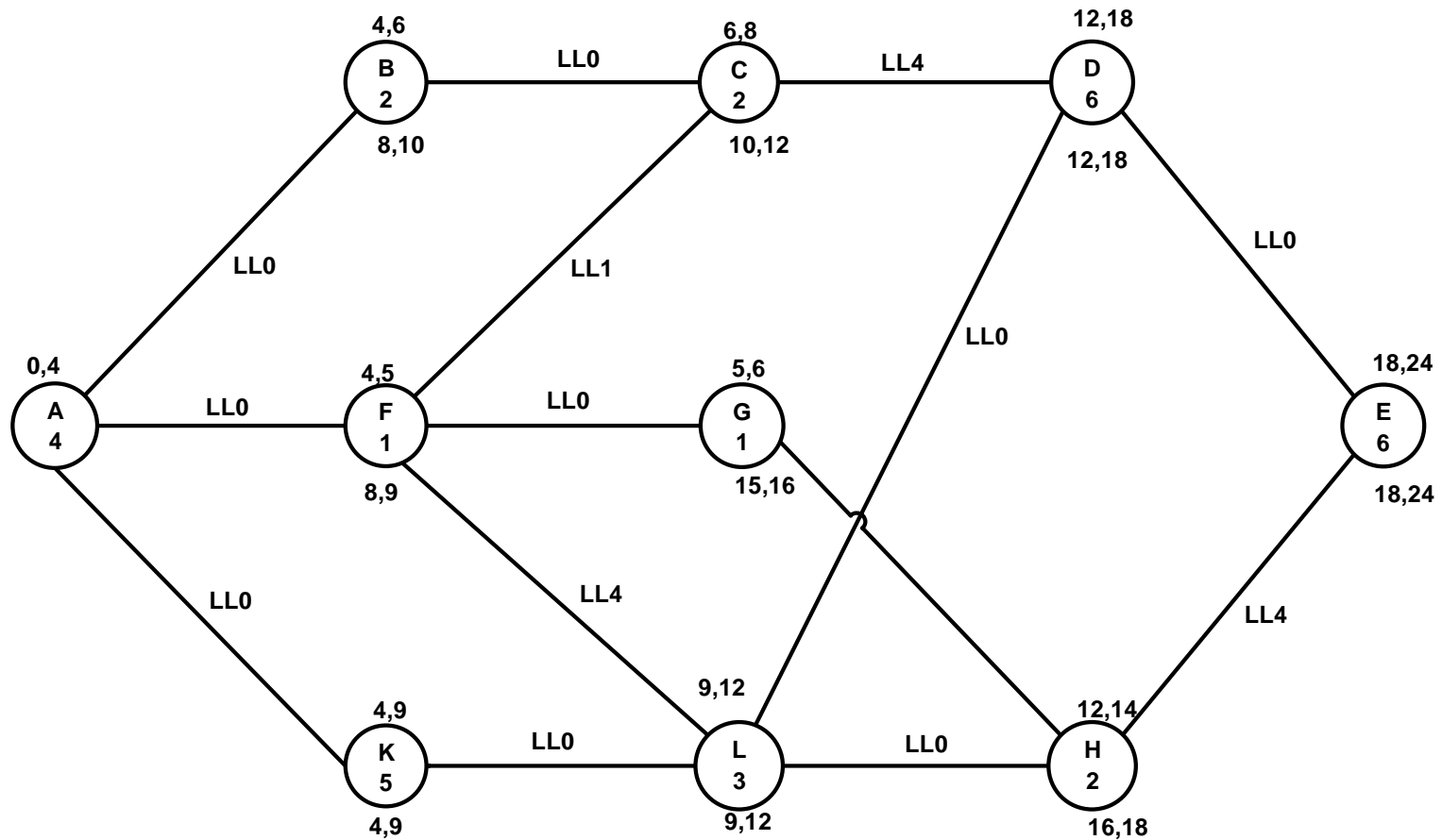
A link lag is the difference between the Early Start date of an activity and the Early Finish date of the preceding activity.

$$LAG_{ij} = ESD_j - EFD_i$$

- We can determine the schedule critical path by following the link lags that equal zero from the terminal activity to the initial activity.
- The free float of an activity may also be determined easily using the link lag.

The free float is the minimum value of link lags between an activity and all successor activities.

Link Lags



Activity Floats

Free Float

$$\begin{aligned}FF_i &= \text{Min ESD}_j - \text{EFD}_i \\ &= \text{Min LAG}_{ij}\end{aligned}$$

Interfering Float

$$\begin{aligned}\text{INTF}_i &= \text{LFD}_i - \text{Min ESD}_j \\ &= \text{TF}_i - \text{FF}_i\end{aligned}$$

Total Float

$$\begin{aligned}\text{TF}_i &= \text{LFD}_i - \text{EFD}_i \\ &= \text{Min} (\text{LAG}_{ij} + \text{TF}_j) \\ &\quad (\text{over all } j)\end{aligned}$$

Independent Float

$$\begin{aligned}\text{INDF}_j &= \text{Min ESD}_k - \text{Max LFD}_i - T_j \\ &= \text{FF}_j - \text{Max} (\text{TF}_i - \text{LAG}_{ij})\end{aligned}$$

Complete Schedule Information

