CPM Precedence Method

Construction Project Management

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Thoughts about Time

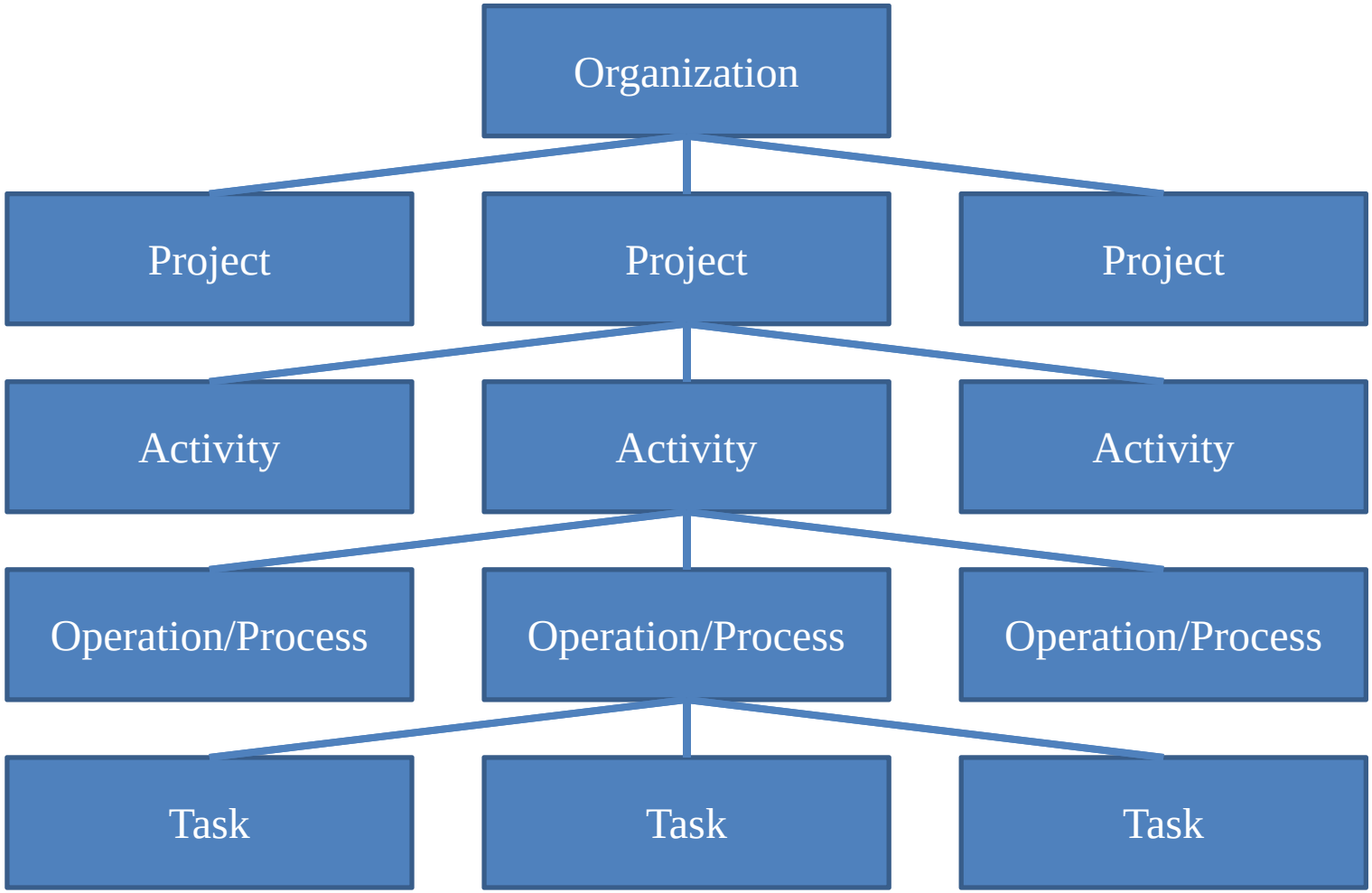
- Time and space
- Time and existence
- Time thieves from Momo by Michael Ende
- Living slow by Pierre Sansot
- Living in the present from Buddhism
- Longing for bucolic life style in Taoism and even in Confucianism

- Do these idea contradict the purpose of project time management?

Project Time Management

- The objective is timely completion of the project
- The basic approach is to break down the project into pieces that are understandable and manageable – activity.
- Activity is a unit of work that has information such as
  - Description
  - Duration
  - Location
  - Resources
  - Material
  - Geometric properties
  - …

Management Levels in Construction

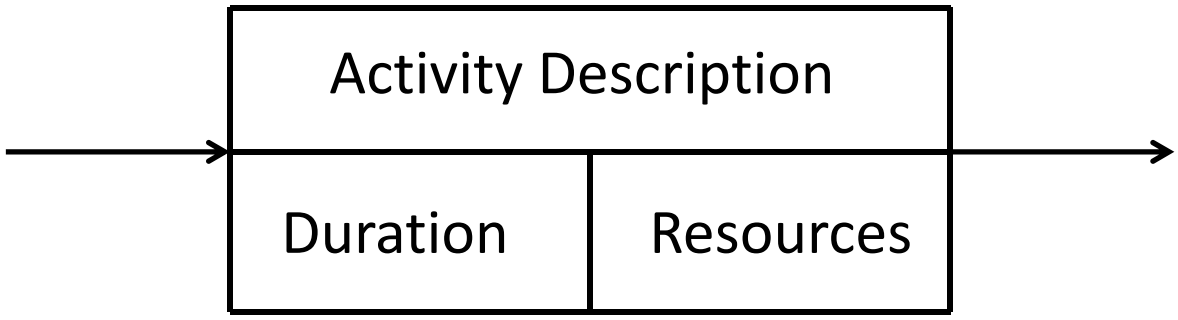


Project Time Management

- Activity definition
- Activity sequencing
- Duration estimating
- Schedule development
- Time control

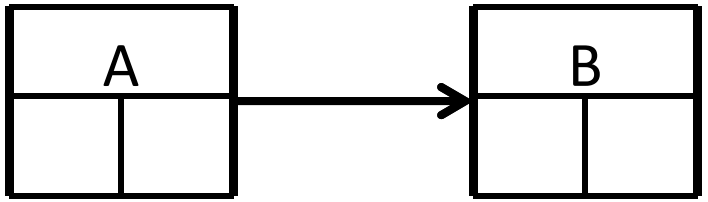
Activity on Node (AON) or Precedence Diagram

- Activities are represented on nodes or boxes
- Logical relationships are shown by arrows
- The length of arrows is not proportional to duration

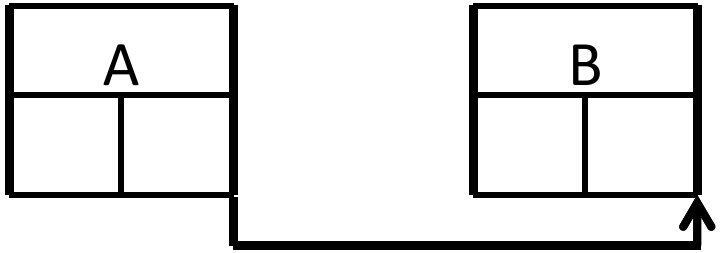


Dependency (Relationship)

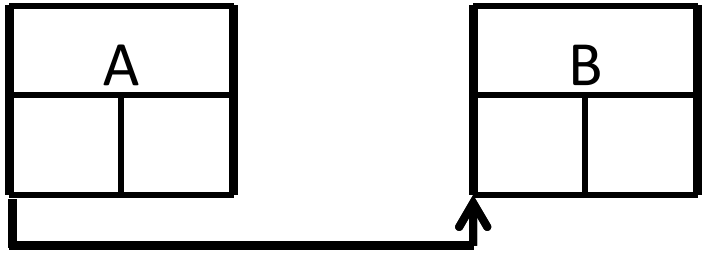
Finish to Start



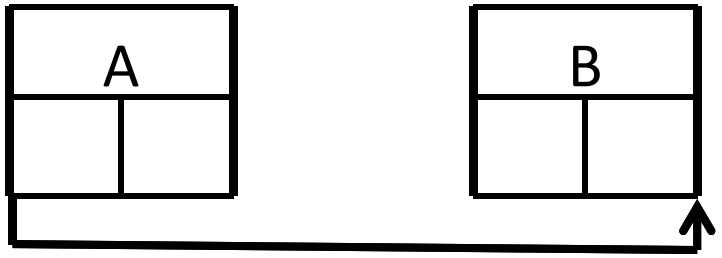
Finish to Finish



Start to Start



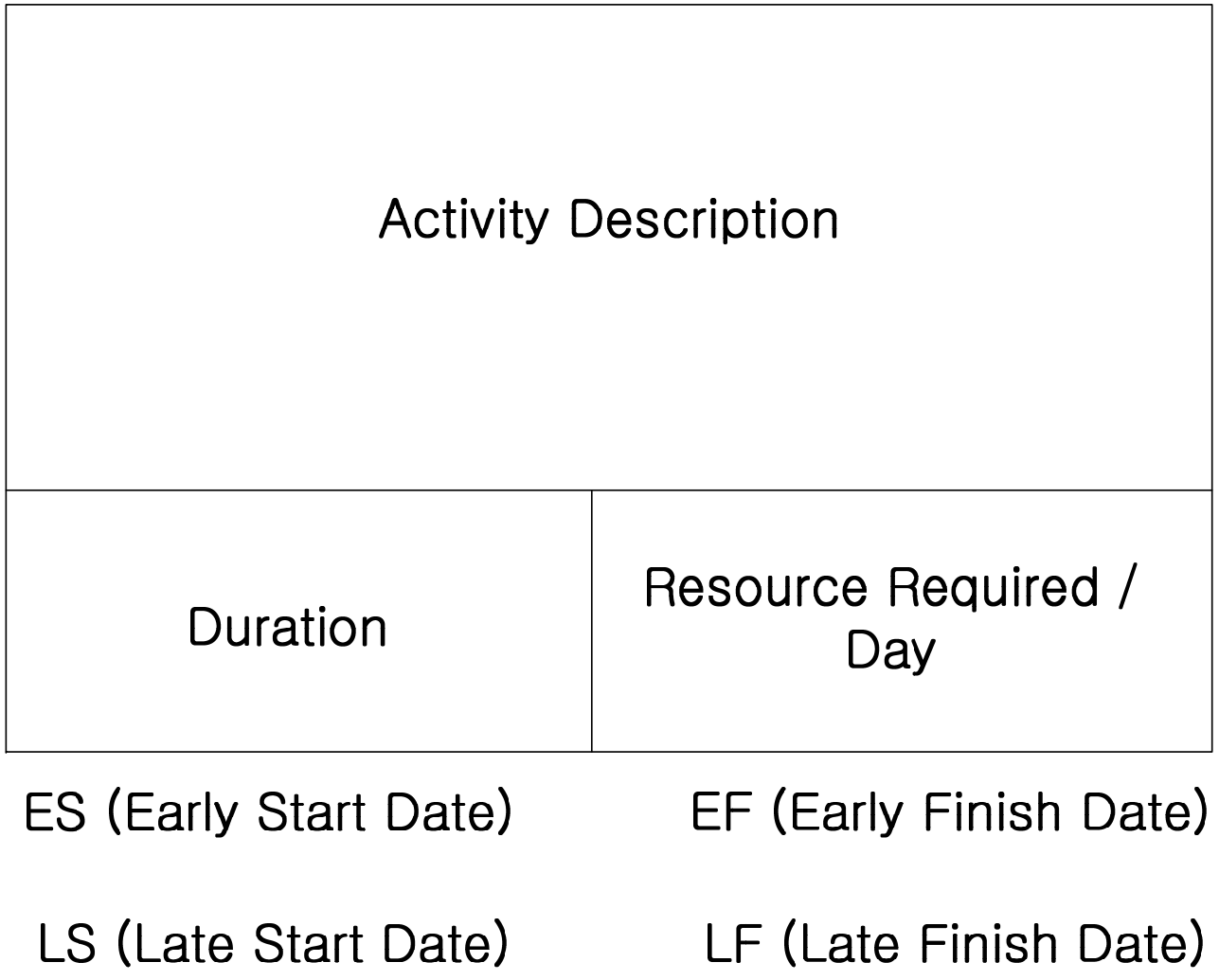
Start to Finish



Terminologies for Activity Times

- Early start date or earl start (ESD or ES)
  - The earliest time when the activity can start
- Early finish date or earl finish (EFD or EF)
  - The earliest time when the activity can finish
- Late start date or late start (LSD or LS)
  - The latest time when the activity can start
- Late finish date or late finish (LFD or LF)
  - The latest time when the activity can finish

Notation Example for Activity Information



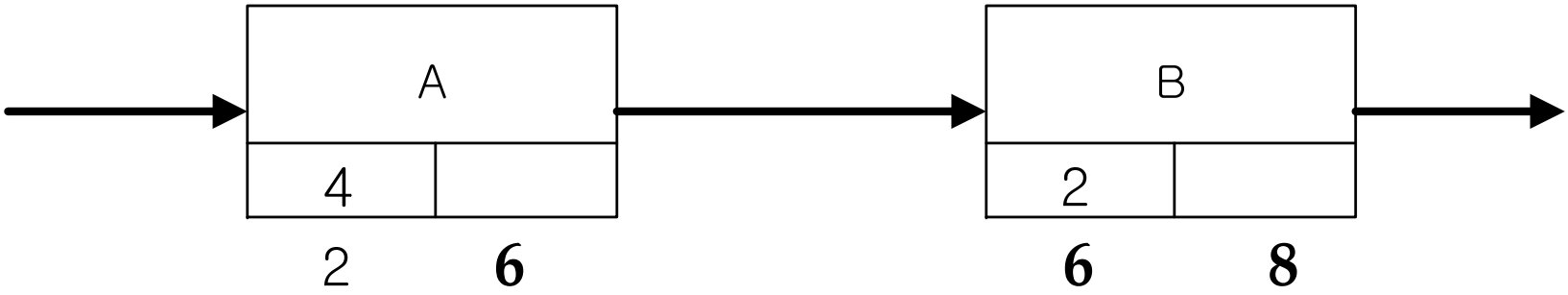
Forward Pass Computation

- A process to calculate the early times of activities
- If there is no external constraint, the relationship between start and finish times within the activity is:
  - Finish time = start time + activity duration
- Early start time = maximum of all possible candidates for the early start time
- Early finish time = maximum of all possible candidates for the early finish time
- Assuming that we work 24 hours per day
  - n days of duration = 24*n hours of work
    - E.g. 3 days of duration = 72 hours of work
  - Activity finish date = activity start date + duration
    - E.g. start date: day 3; duration: 2 days
    - finish date: day 3 + 2 days = day 5
    - To be exact, if the work started from 9:00 AM, it would finish on 9:00 AM on day 5
  - The start date of the successor (immediately following activity) is the same as the finish date of the predecessor

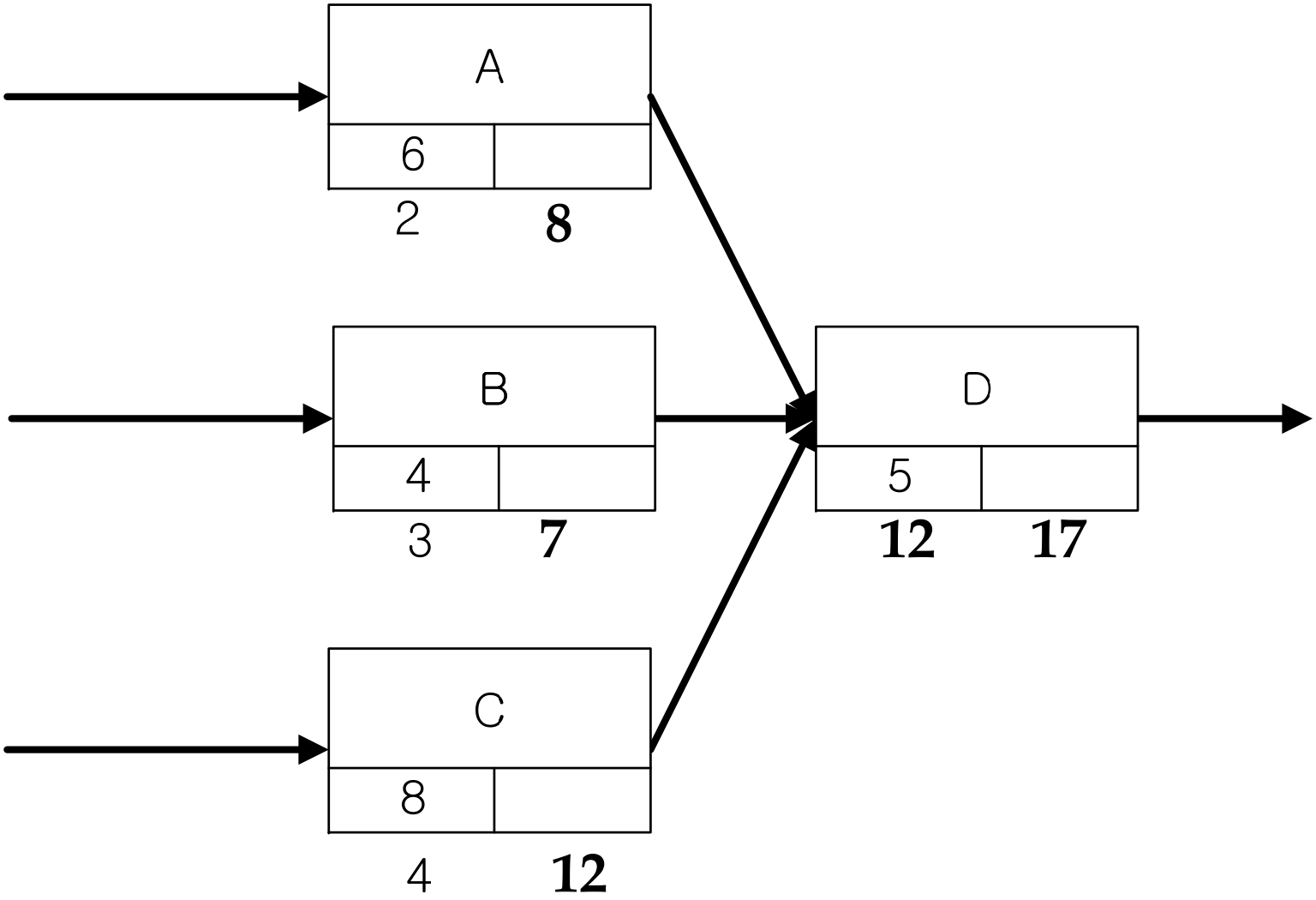
Forward Pass Computation (cont'd)

- Assuming that we work 8 hours per day
  - n days of duration = 8*n hours of work
    - E.g. 3 days of duration = 24 hours of work
  - Activity finish date = activity start date + duration – 1 day
    - E.g. start date: day 3; duration: 2 days
    - Finish date: day 3 + 2 days – 1 day = day 4
    - To be exact, if the work started from 9:00 AM, it would finish on 5:00 PM on day 4
  - The activity start date of the successor = the start date + duration
    - The successor's start date = day 3 + 2 days = day 5
    - To be exact, if the work started from 9:00 AM, it would start on 9:00 AM on day 5

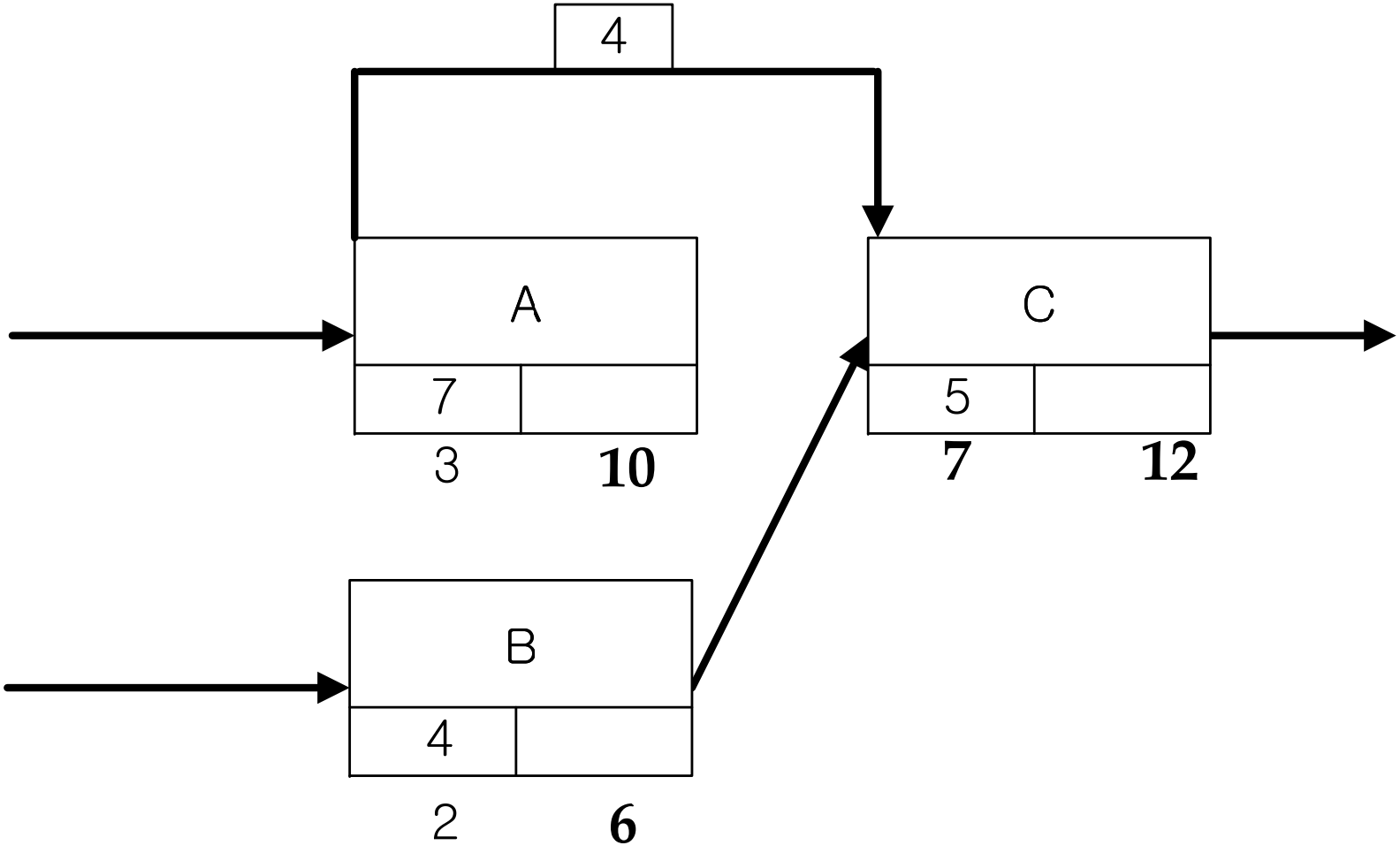
ES and EF Example



ES and EF Example

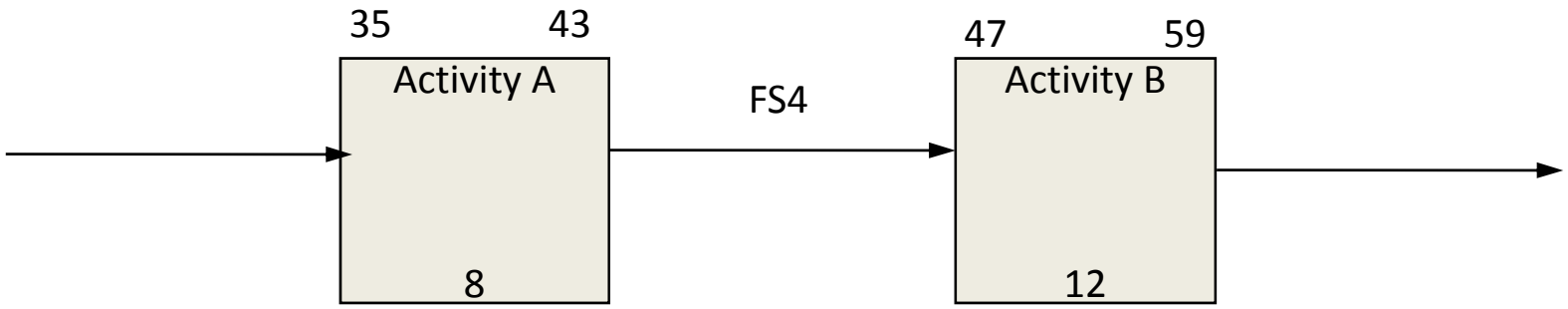


ES and EF Example



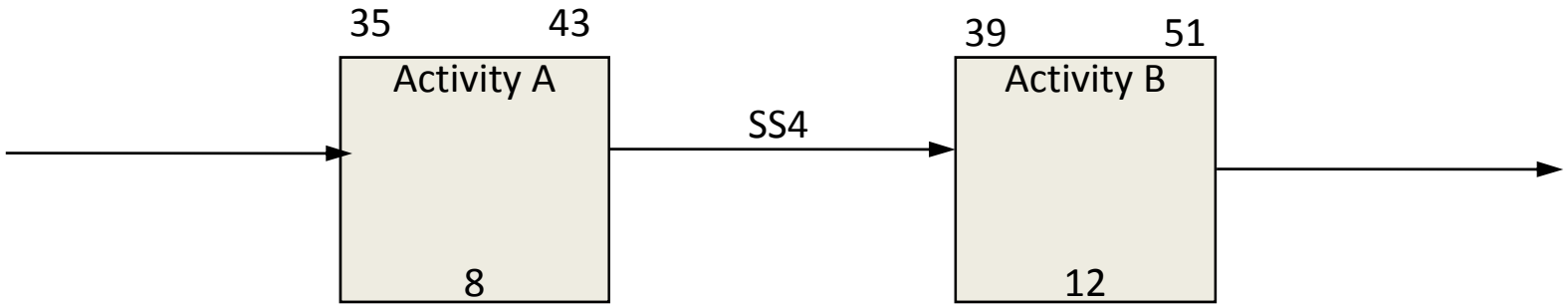
Another Notation for Dependency

Finish to Start



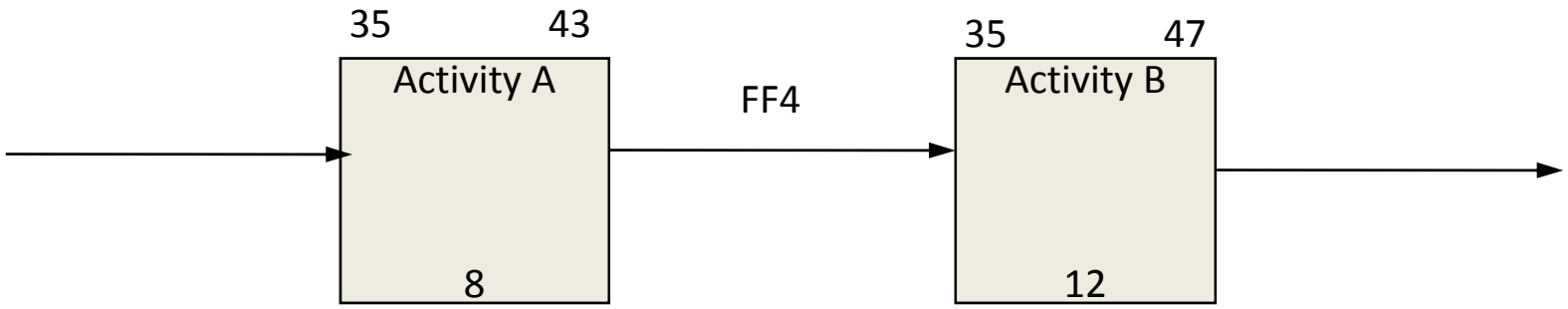
- $ES_B = EF_A + \text{Lag Value}_{AB} = 43 + 4 = 47$
- $EF_B = ES_B + \text{Duration}_B = 47 + 12 = 59$

Start to Start



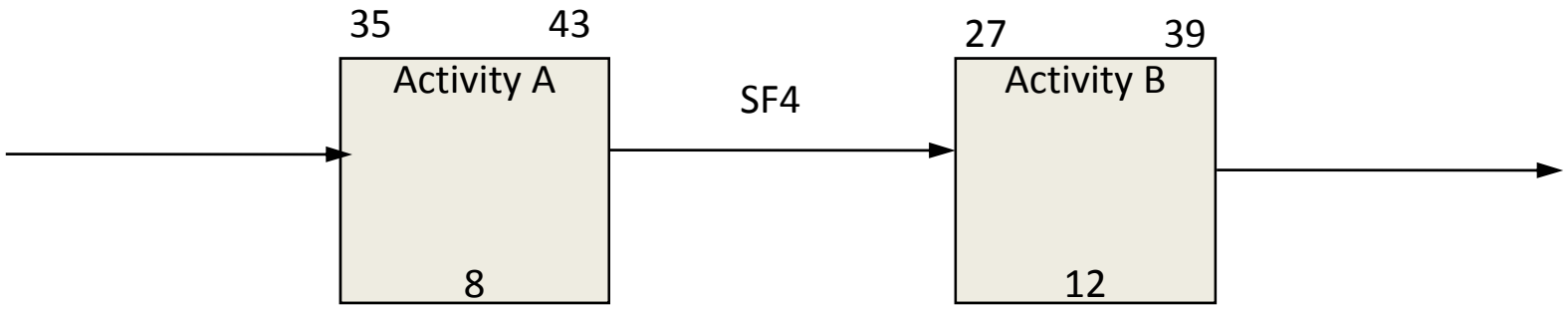
- $ES_B = ES_A + \text{Lag Value}_{AB} = 35 + 4 = 39$
- $EF_B = ES_B + \text{Duration}_B = 39 + 12 = 51$

Finish to Finish



- $EF_B = EF_A + \text{Lag Value}_{AB} = 43 + 4 = 47$
- $ES_B = EF_B - \text{Duration}_B = 47 - 12 = 35$

Start to Finish



- $EF_B = ES_A + \text{Lag Value}_{AB} = 35 + 4 = 39$
- $ES_B = EF_B - \text{Duration}_B = 39 - 12 = 27$

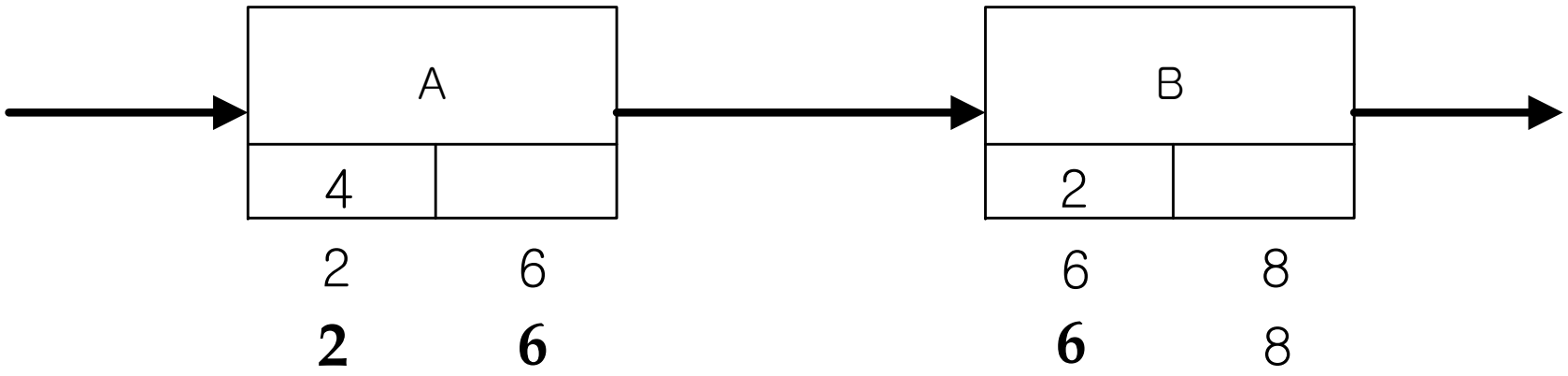
Forward Pass Computation Example

Backward Pass Computation

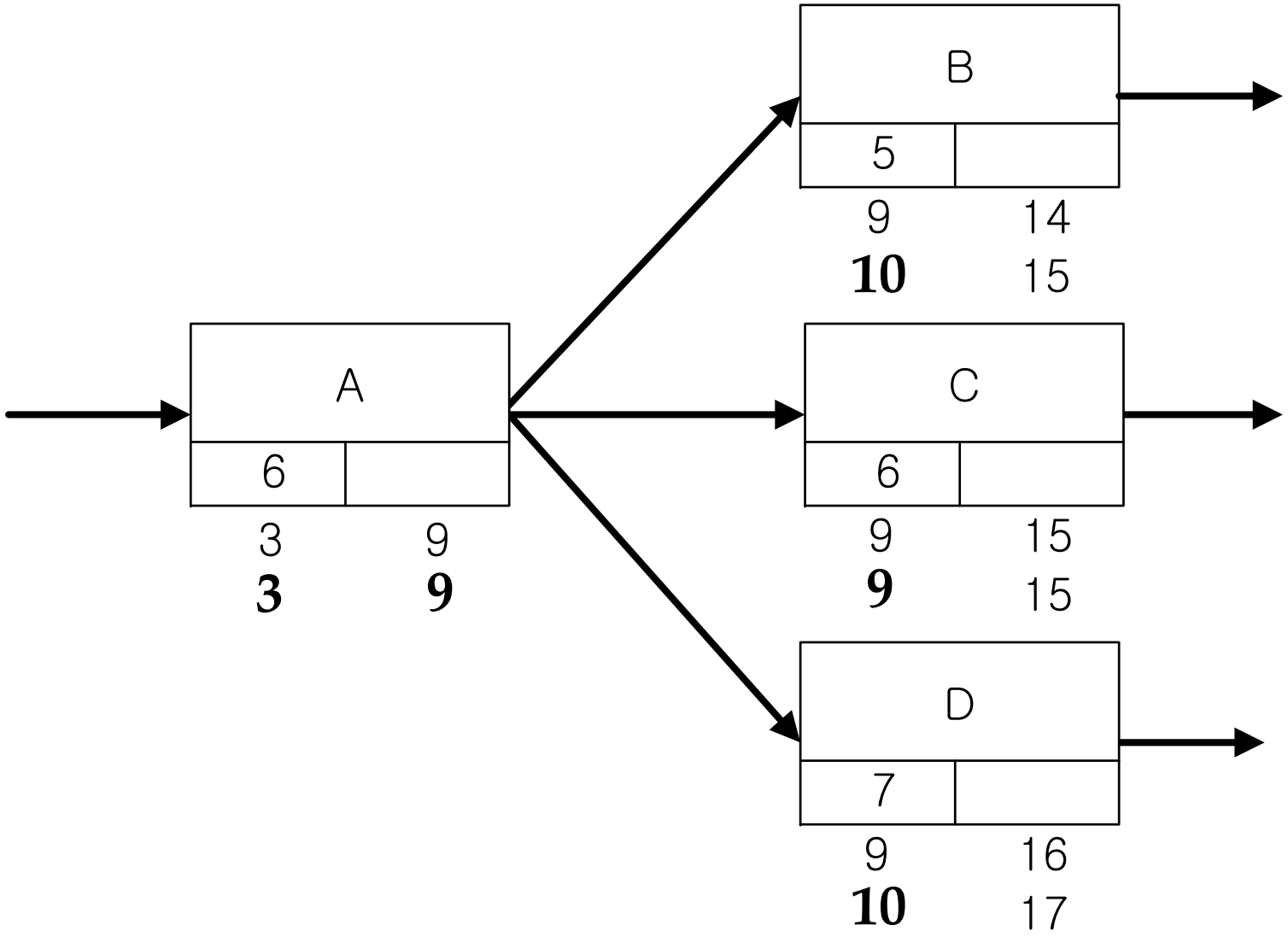
- A process to calculate the late times of activities
- Backward calculation is conducted from the late finish time of the last activity of the project
- The late finish time of the project should be the same as the early finish time of the project
- If there is no external constraint, the relationship between start and finish times within the activity is:

  Start time = late time - activity duration
- Late start time = minimum of all possible candidates for the late start time
- Late finish time = minimum of all possible candidates for the late finish time

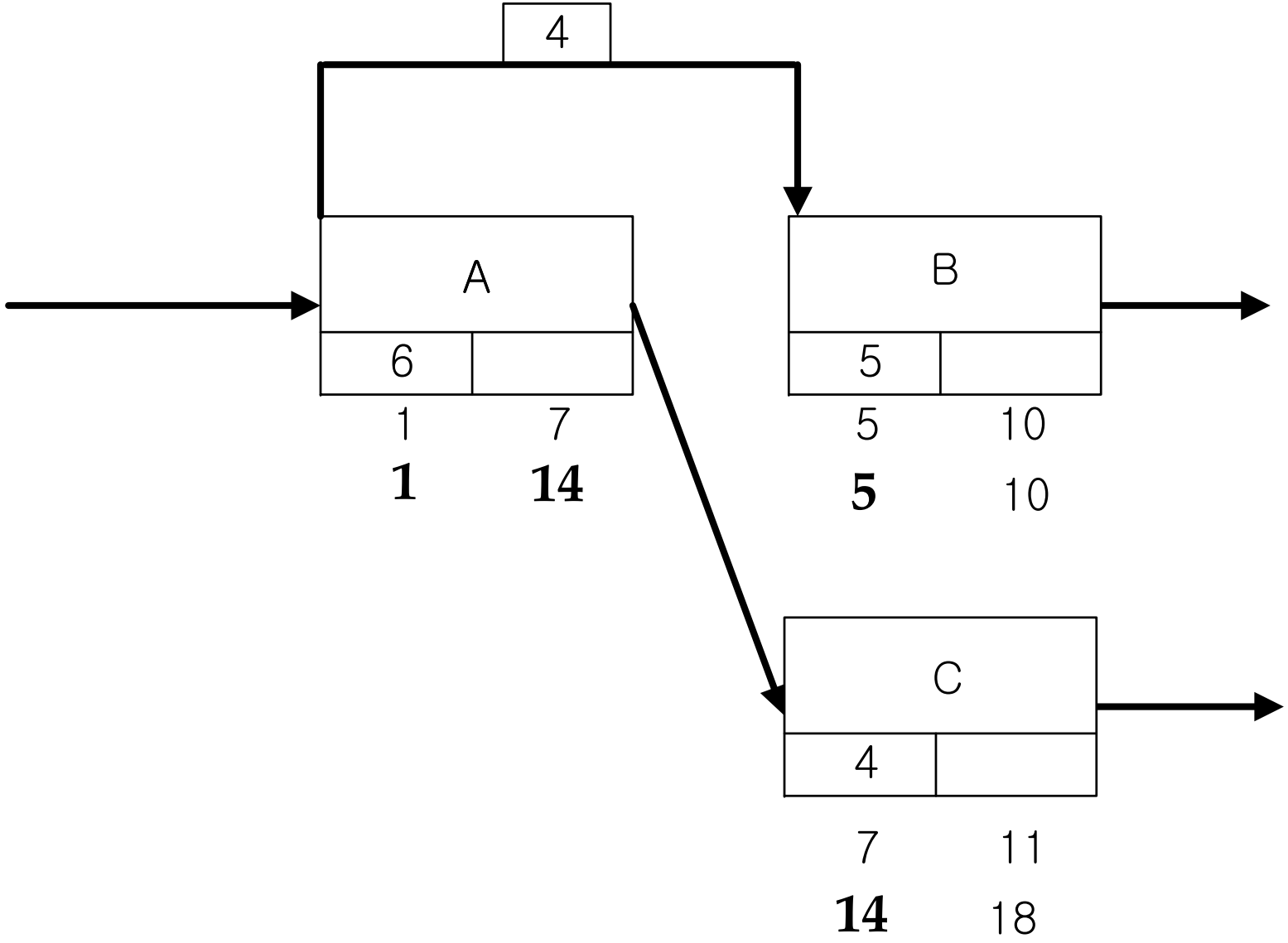
LS and LF Example



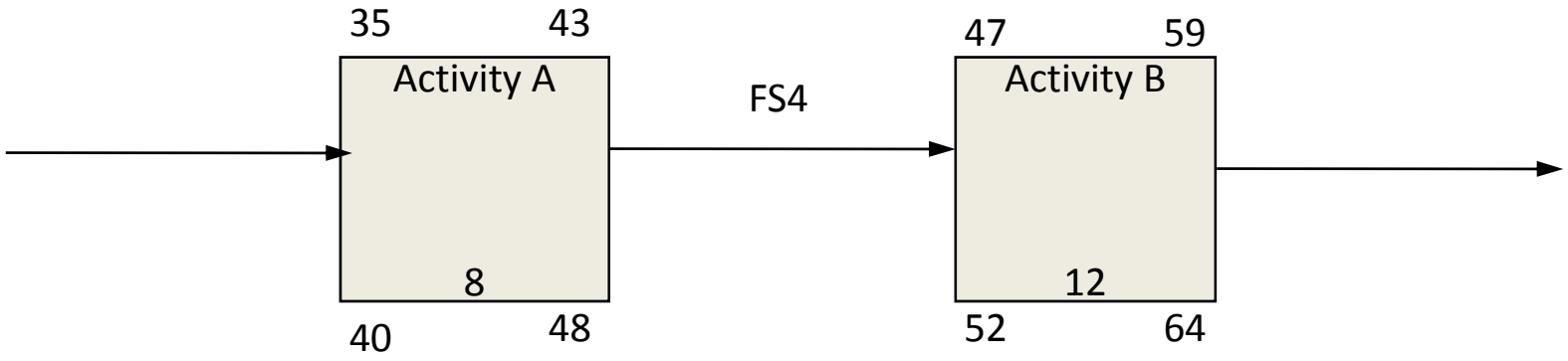
LS and LF Example



LS and LF Example

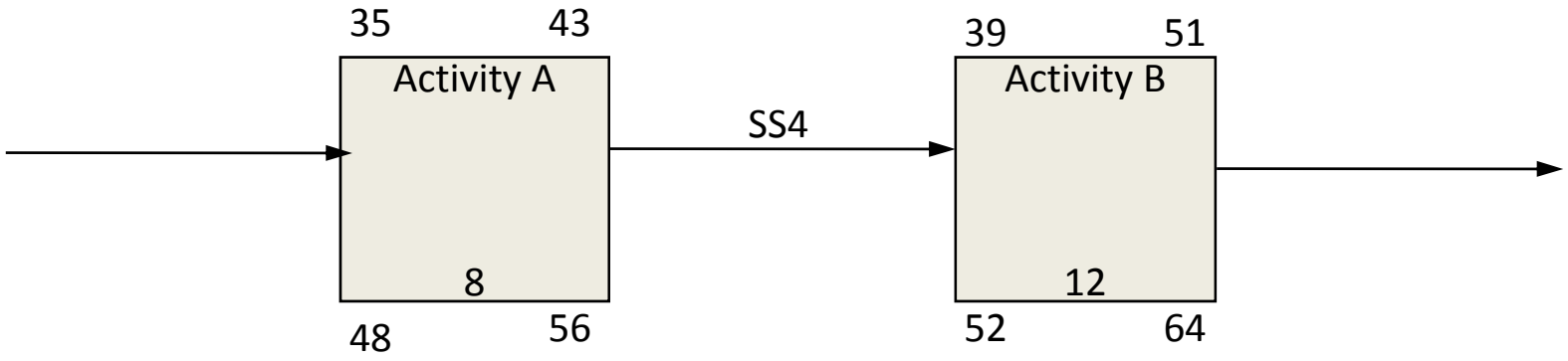


Finish to Start



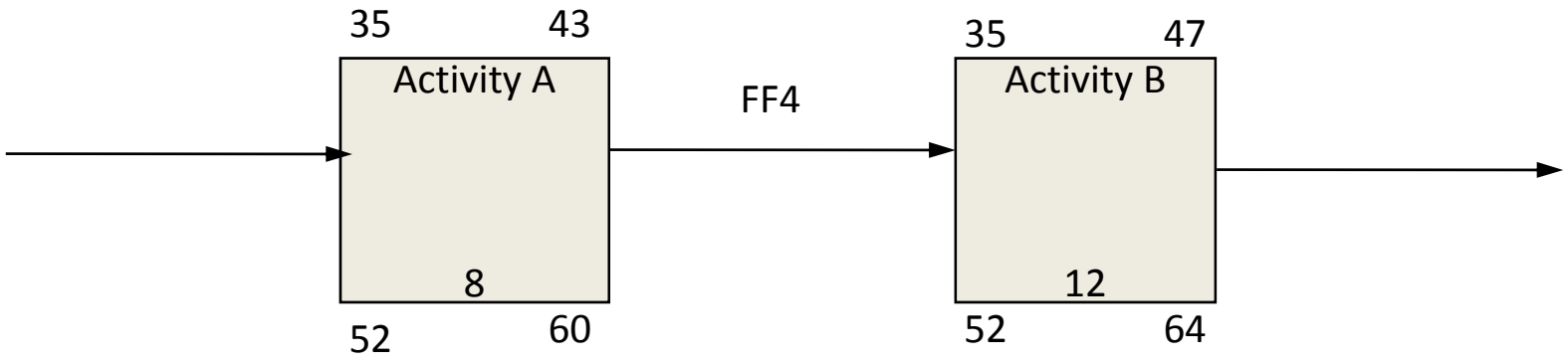
- $LF_A = LS_B$ - Lag Value $_{AB} = 52 - 4 = 48$
- $LS_A = LF_A$ - Duration $_A = 48 - 8 = 40$

Start to Start



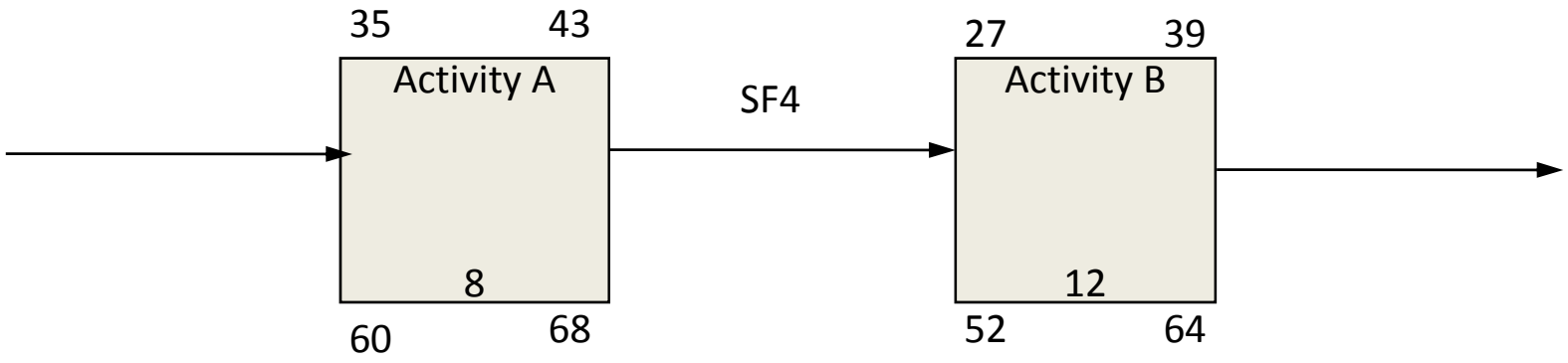
- $LS_A = LS_B - \text{Lag Value}_{AB} = 52 - 4 = 48$
- $LF_A = LS_A + \text{Duration}_A = 48 + 8 = 56$

Finish to Finish



- $LF_A = LF_B$ - Lag Value $_{AB} = 64 - 4 = 60$
- $LS_A = LF_A$ - Duration $_A = 60 - 8 = 52$

Start to Finish



- $LS_A = LF_B$ - Lag Value $_{AB} = 64 - 4 = 60$
- $LF_A = LS_A + Duration_A = 60 + 8 = 68$

Backward Pass Computation Example

Float (Slack)

Total float

- The maximum amount of time that an activity can be delayed from its early start or finish without extending the project completion time

  Late finish – early finish = finish total float

  Late start – early start = start total float

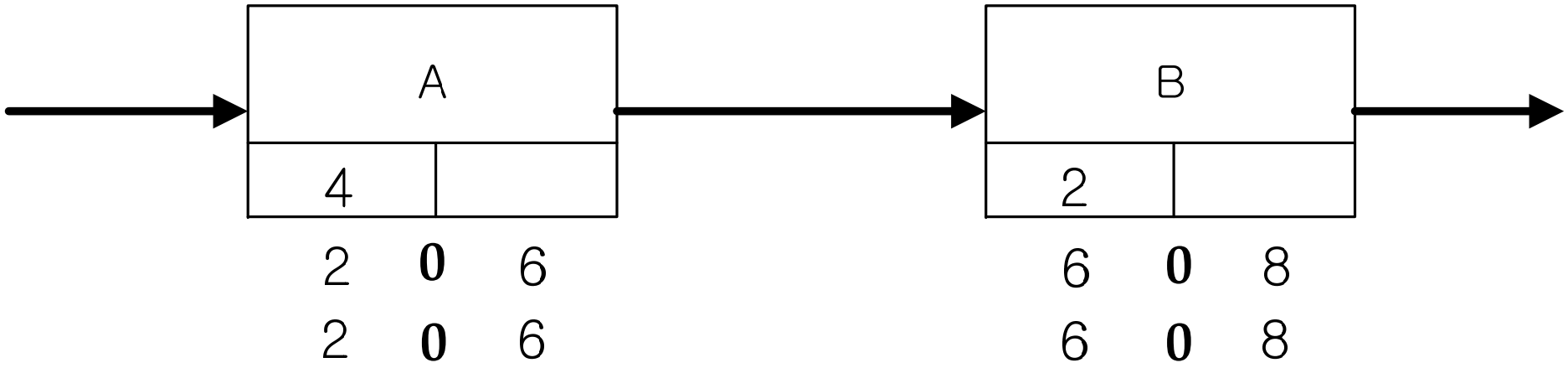
  Finish total float and start total float are the same if there is no external constraints

Free float

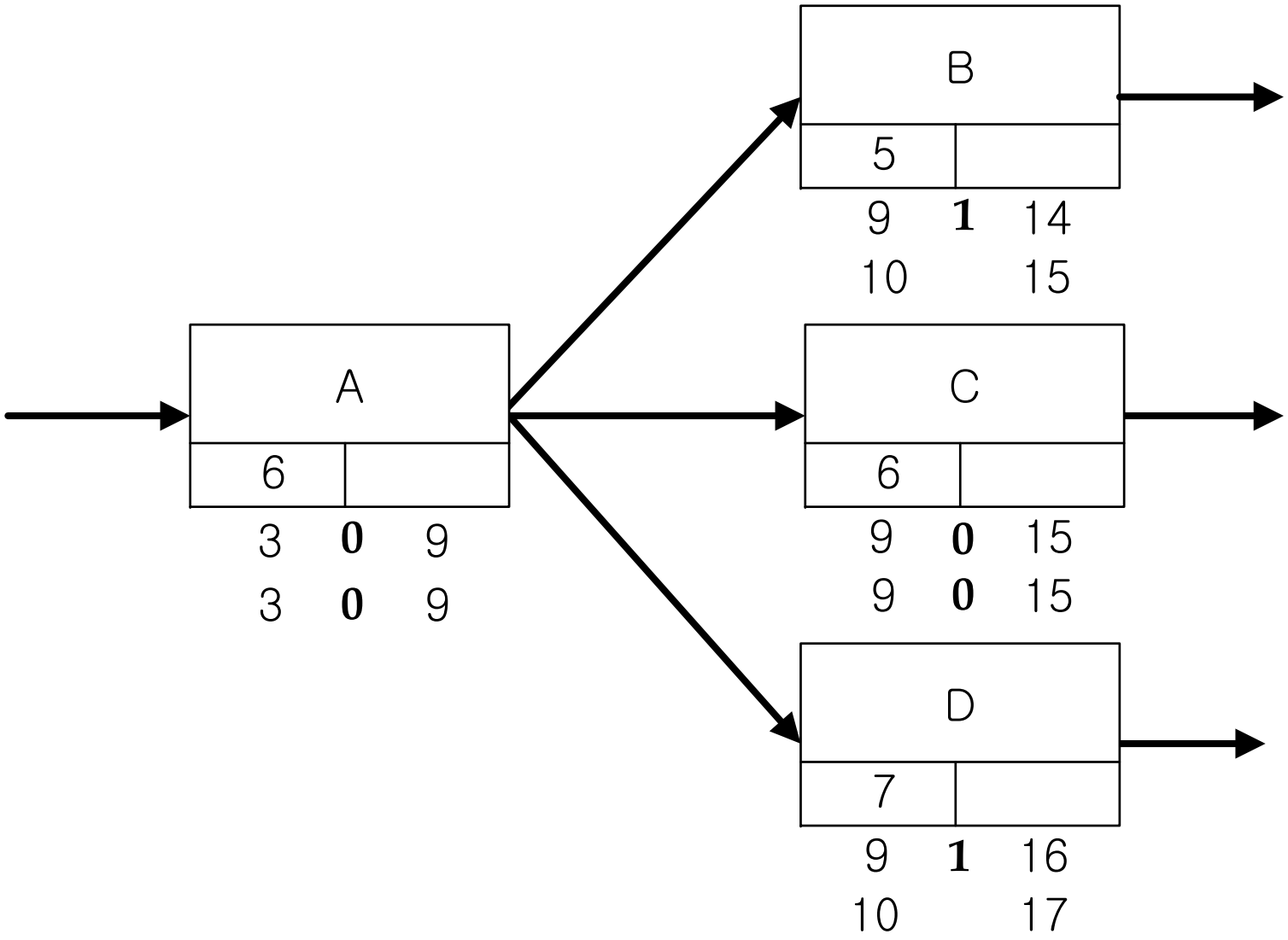
- The amount of time that an activity can be delayed without extending the early start or finish of its immediate successors
- Since free float concerns the activity itself whereas total float concerns the entire project, free float cannot be larger than total float

  Free float = minimum of early start times of immediate successors – early finish

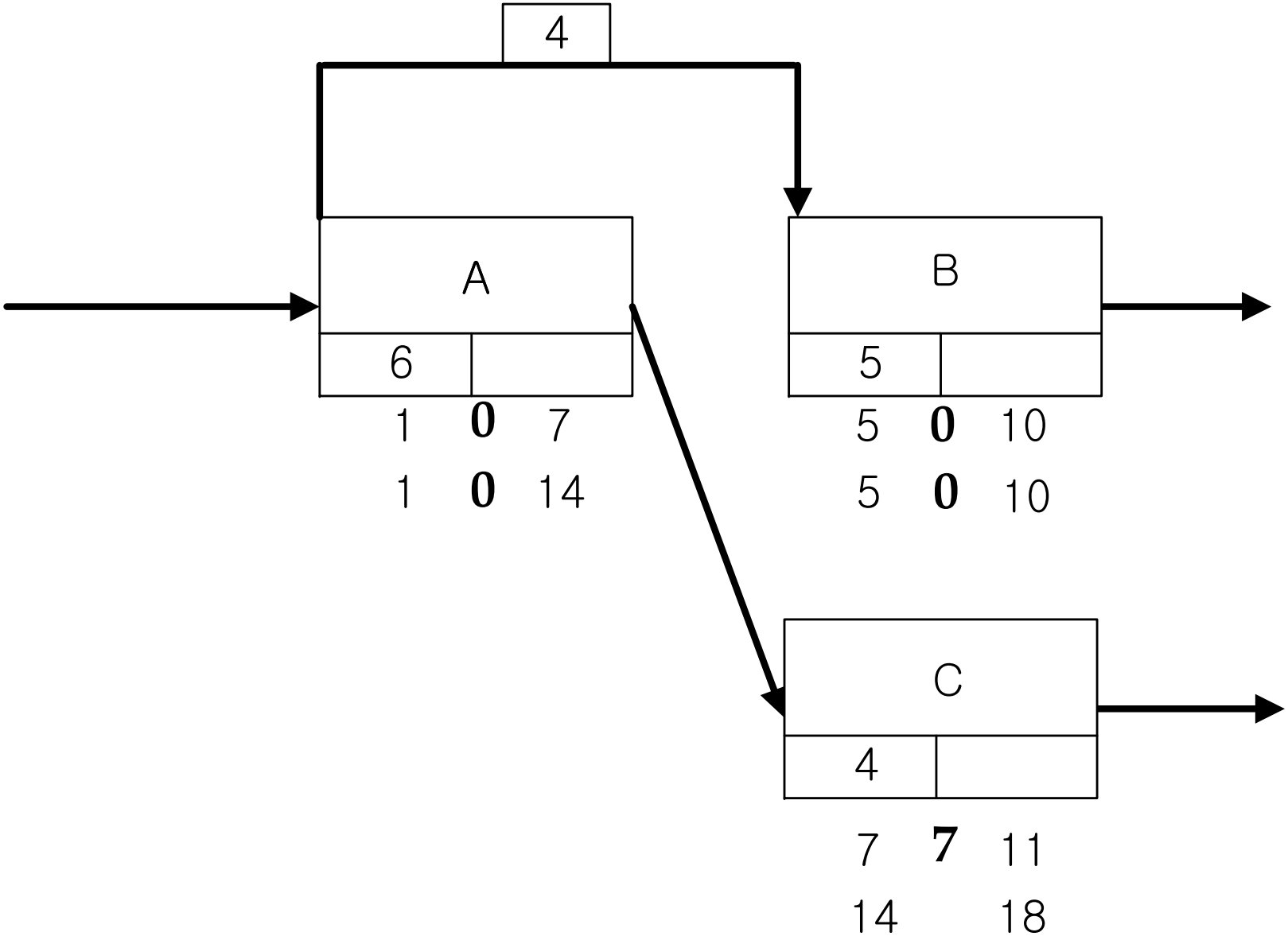
TF and FF Example



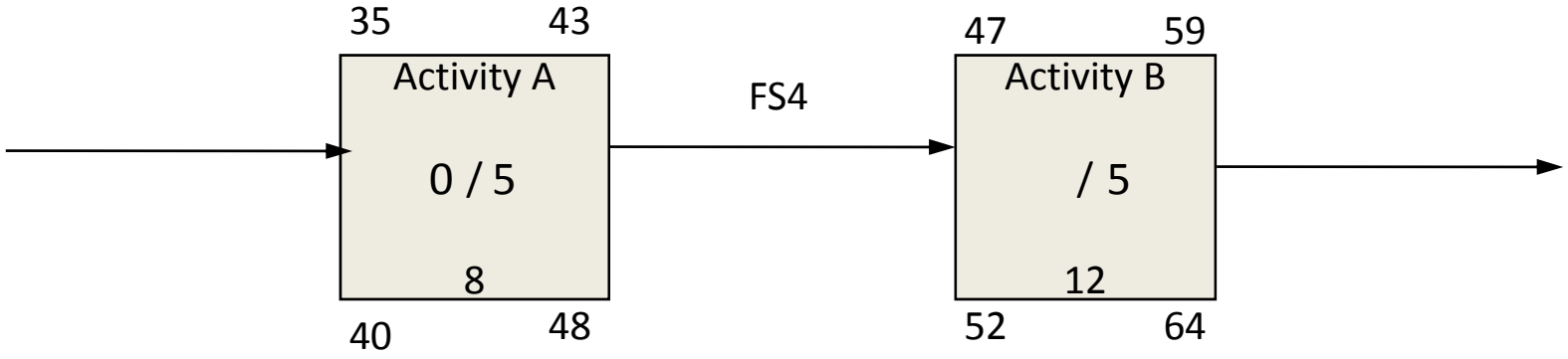
TF and FF Example



TF and FF Example

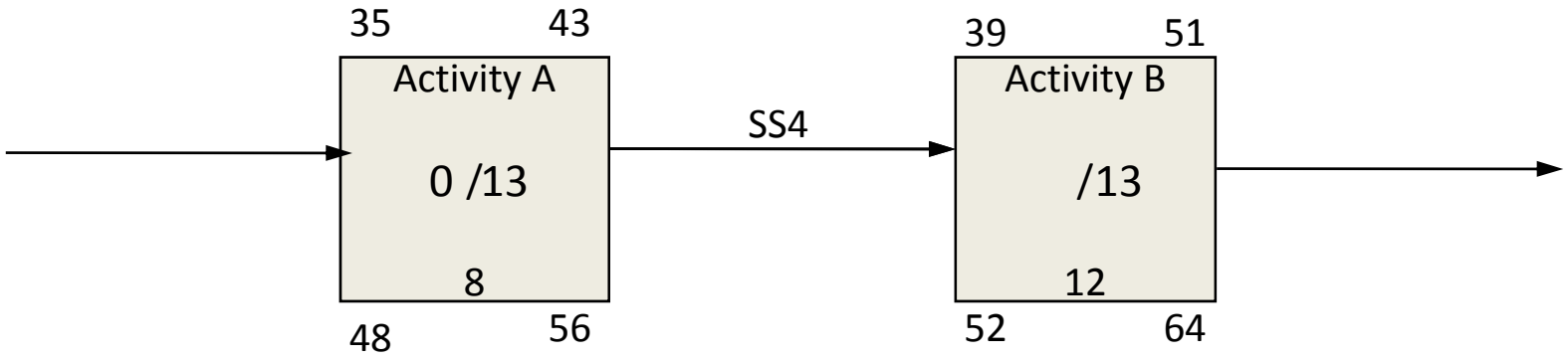


Finish to Start



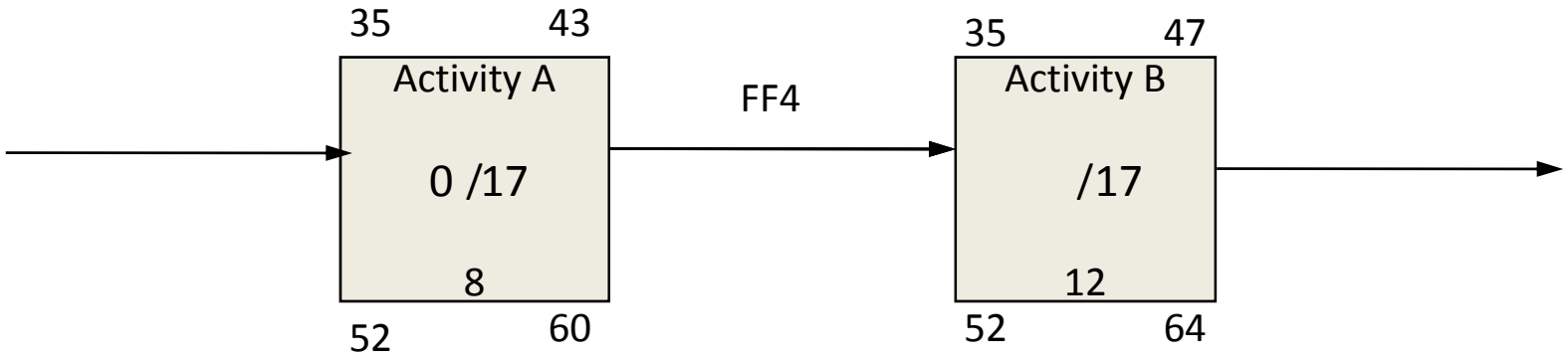
- TF = LF - EF = 64 - 59 or 48 - 43 = 5
- $FF_A = ES_B - \text{Lag Value}_{AB} - EF_A = 47 - 4 - 43 = 0$

Start to Start



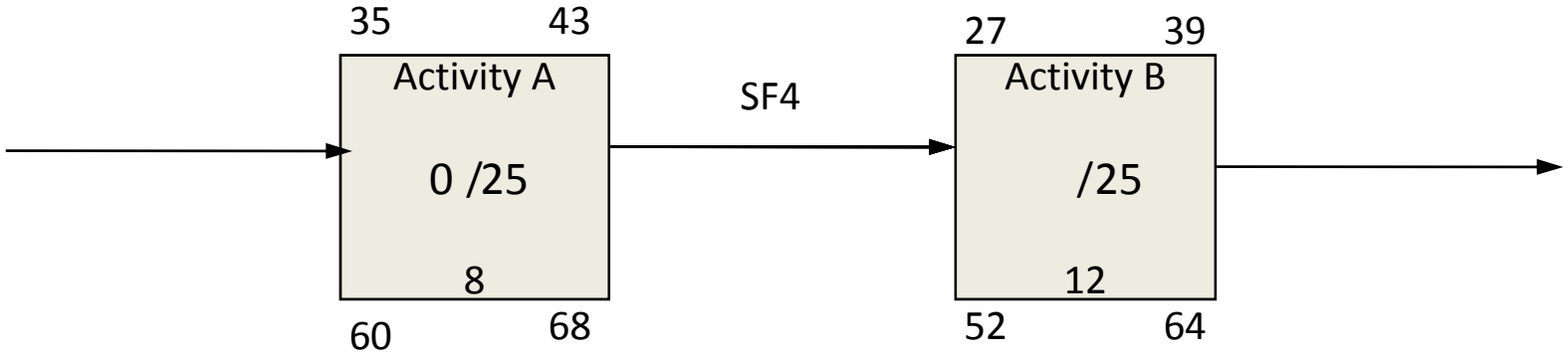
- TF = LF - EF = 64 - 51 or 56 - 43 = 13
- $FF_A = ES_B - \text{Lag Value}_{AB} - ES_A = 39 - 4 - 35 = 0$

Finish to Finish



- TF = LF - EF = 64 - 47 or 60 - 43 =17
- $FF_A = EF_B - \text{Lag Value}_{AB} - EF_A = 47 - 4 - 43 = 0$

Start to Finish



- TF = LF - EF = 64 - 39 or 68 - 43 =25
- $FF_A = EF_B - \text{Lag Value}_{AB} - ES_A = 39 - 4 - 35 = 0$

Critical Path

- The sequence of activities with the least amount of total float
- The longest path in the CPM network
- The critical path is composed of critical activities
- Any delay on the critical path with zero total float would result in schedule overrun
- Multiple critical paths can exist

Float Computation Example