

공정관리 1(원리/관리기술/CPM/CLASHING)

건축시공 및 건설관리 입문 Introduction to Building Construction Engineering & Management

Moonseo Park

Professor, PhD

39동 433

Phone 880-5848, Fax 871-5518

E-mail: mspark@snu.ac.kr

Department of Architecture &
Architectural Engineering
College of Engineering
Seoul National University



Four Main Charts used in Construction Domain

- **Gantt Chart / Bar Chart**

- It is easy to create and easy to understand visually, but the relationship is unclear and it is impossible to calculate the total project schedule.

- **PERT (Program Evaluation and Review Technique)**

- First used in US Navy for the Polaris Submarine Project

- **CPM (Critical Path Method)**

- Chemical Factory Project (Dupont) in 1957

- **LOB (Line of Balance)**

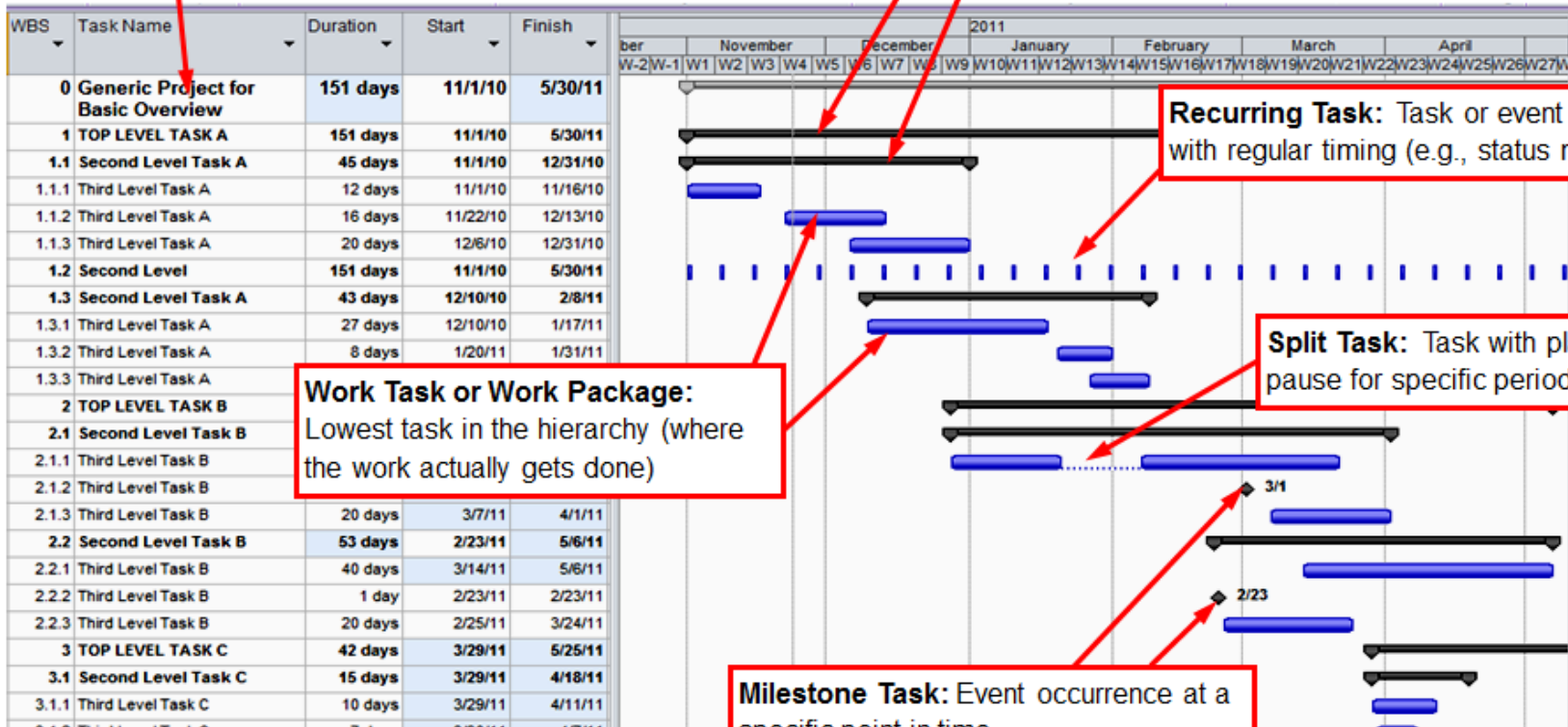
- Advantage for skyscraper projects. It is advantageous when controlling the interference or start time between cycle processes.

Gantt Chart

- A chart shows the progress rate at the horizontal axis and activities at the vertical axis.
- Advantages
 - Easy to create
 - Easy to understand visually
- Disadvantages
 - Unclear actual progress compared to planned schedule
 - Difficult to identify the relationship between activities

Project Summary Task: Special task identifying entire project

Summary Task: Any with lower-level subtasks



Recurring Task: Task or event that recurs with regular timing (e.g., status meeting)

Work Task or Work Package: Lowest task in the hierarchy (where the work actually gets done)

Split Task: Task with planned pause for specific period of time.

Milestone Task: Event occurrence at a specific point in time

Line of Balance

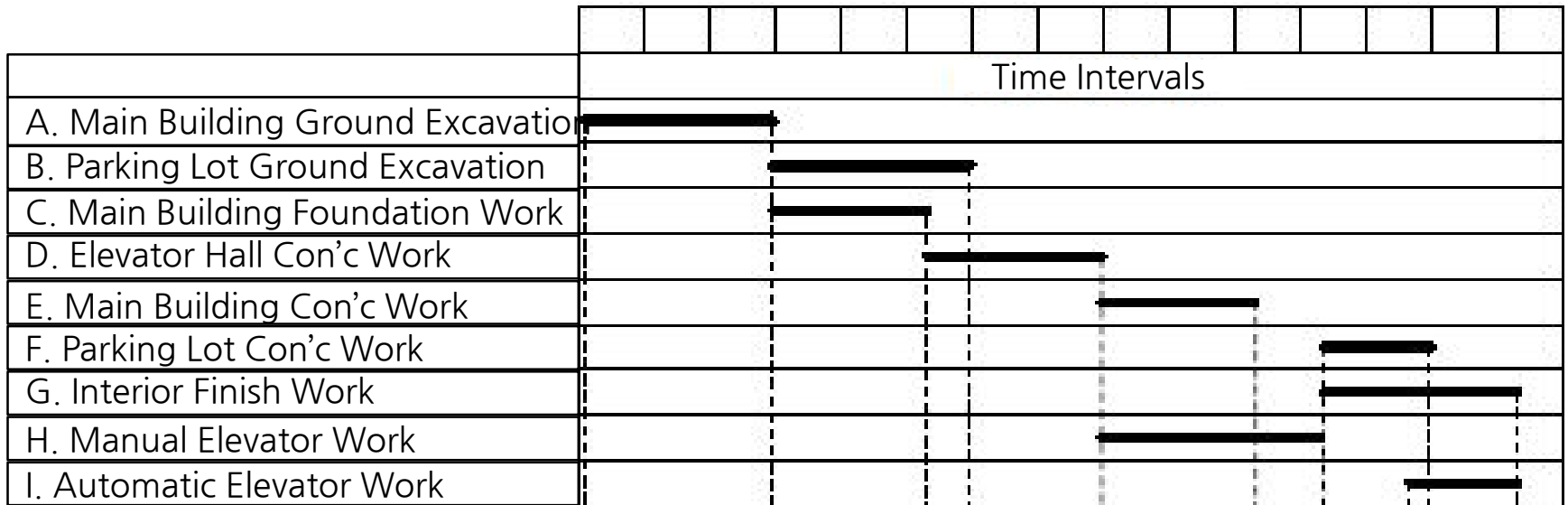
- A management control process for collecting, measuring and presenting facts relating to time, cost and accomplishment

- Advantages
 - Easy to understand total trend of a construction project
 - Able to identify progress
 - Easy to identify the deviation between actual and planned progress

- Disadvantages
 - Difficult to identify details of each activity
 - Not detailed schedule chart, but a supportive chart for monitoring schedule progress

PERT/CPM

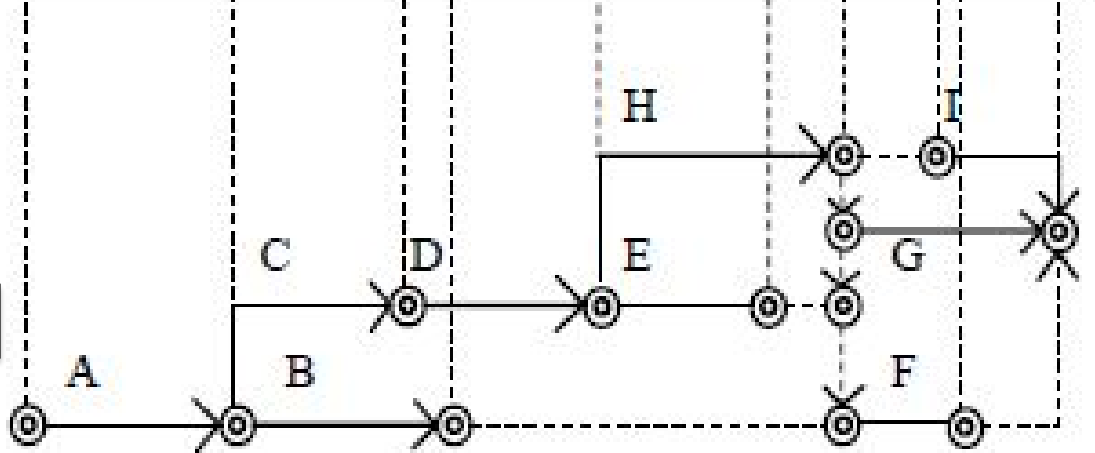
- Since 50s, this method has been widely used in US government agencies and private companies for better managing a complex project.
- Also **widely used in Construction Domain**
- PERT/CPM is a method based on NAS (Network Analysis System): Compensating the defect of the Gantt chart (unclear relationship between activities)



Bar Chart

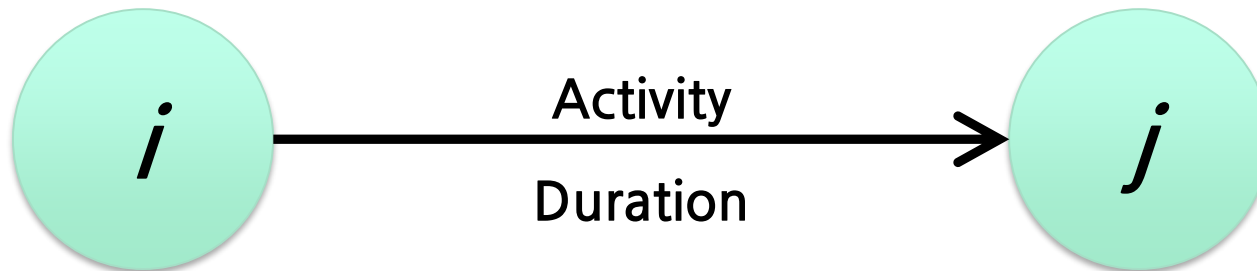
Conversion

PERT/CPM



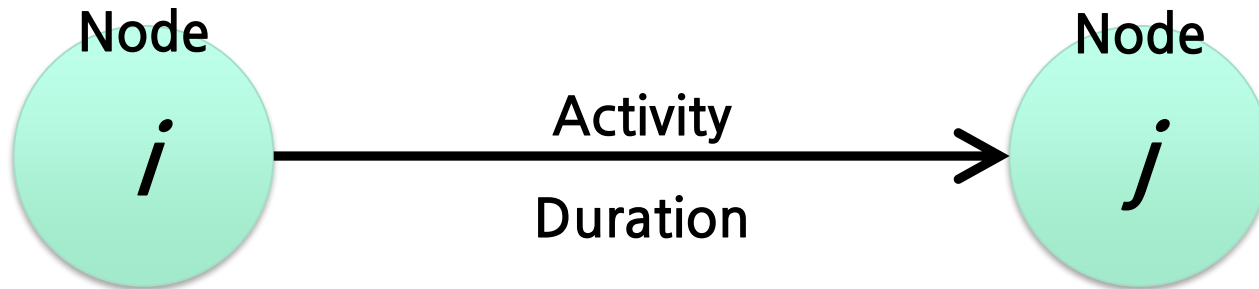
Components of Network: Activity

- A basic element of work, task or measurable amount of work that must be accomplished in order to complete a project.
- An activity occurs over a given period of time, utilizes resources and produces a deliverable for the project.



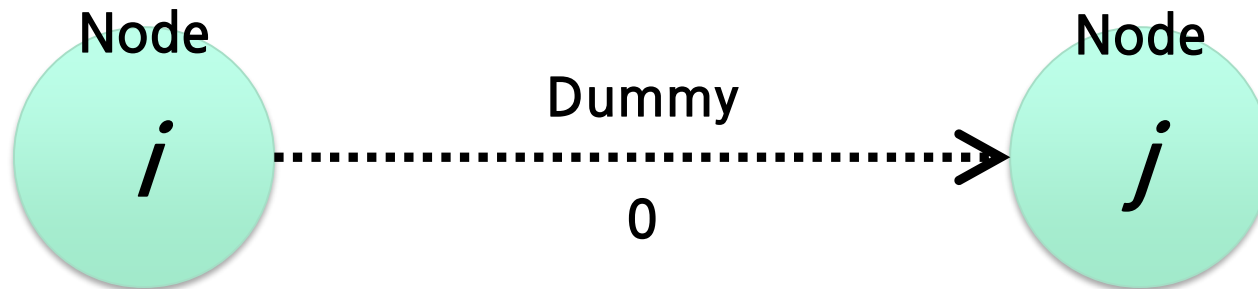
Components of Network: Node (Event)

- A connecting point that links activities and activities
- Indicates the beginning or completion of an activity



Components of Network: Dummy

- It does not have actual work, but it shows the relation between work and process constraints.
- Generally, it does not consume time and resources.
- Marked by dotted arrow



Time for CPM

EST

Earliest Start Time (조기시작시간)

EFT

Earliest Finish Time (조기종료시간)

LST

Latest Start Time (만기시작시간)

LFT

Latest Finish Time (만기종료시간)

Calculating Float Time

Total Float Time
(TF, 총 자유시간)

- The amount of time that an activity can be delayed from its early start date without delaying the project finish date

$$TF = LS - ES$$

Free Float Time
(FF, 자유여유시간)

- The amount of time that an activity can be delayed without delaying the early start date of any successor activity

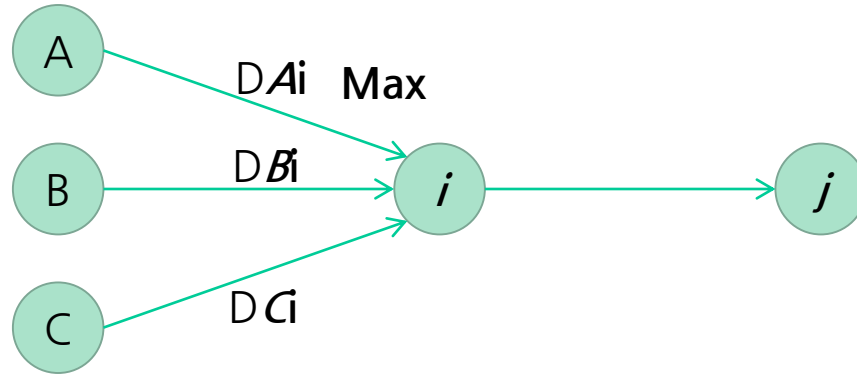
$$FF = ES \text{ of next activity} - EF \text{ of activity}$$

Critical Path

- The **longest path** in a network
 - All floats on the CP are 0
 - Entire process dominated by CP line
 - The means of shortening the process should focus on shortening the CP
 - More than two CPs can be in one network
 - If you spend extra time in tasks other than CP, it becomes a CP

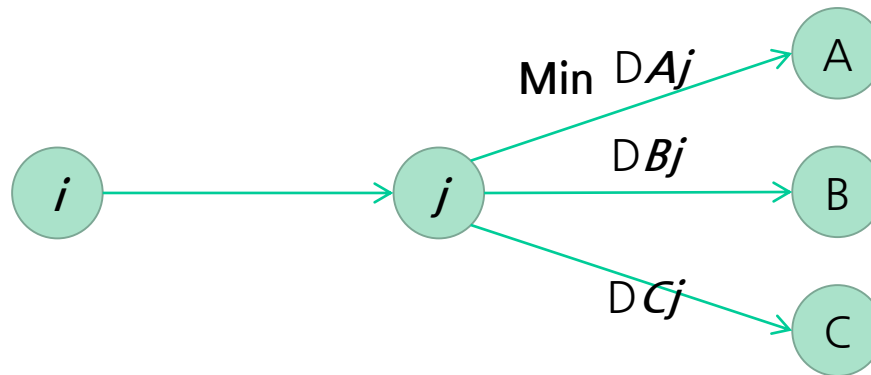
CPM Schedule Calculation

Forwarding
Calculation



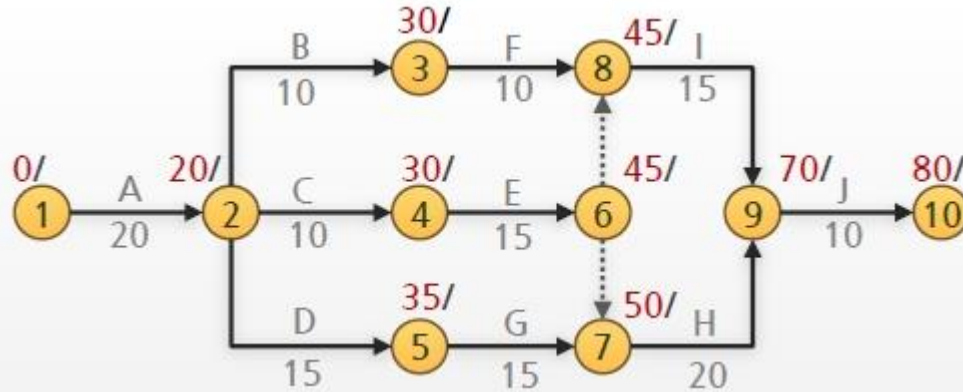
Project
Start
Date

Backward
Calculation



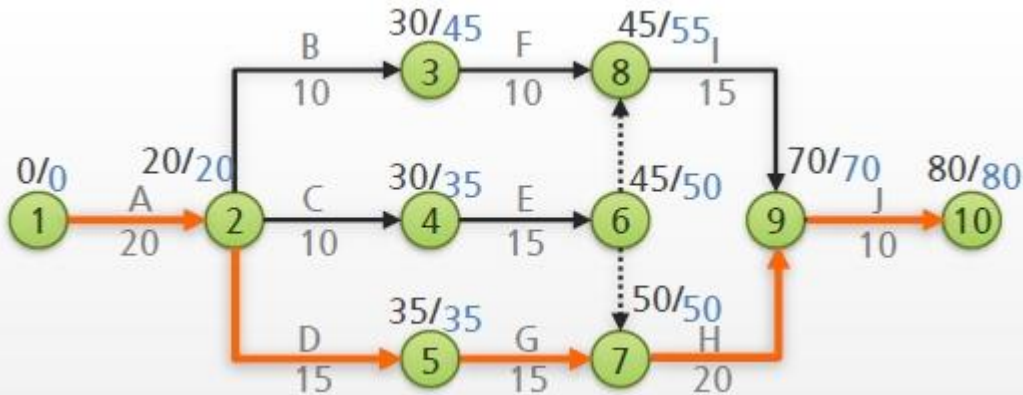
Project
Completion
Date

Forwarding
Calculation

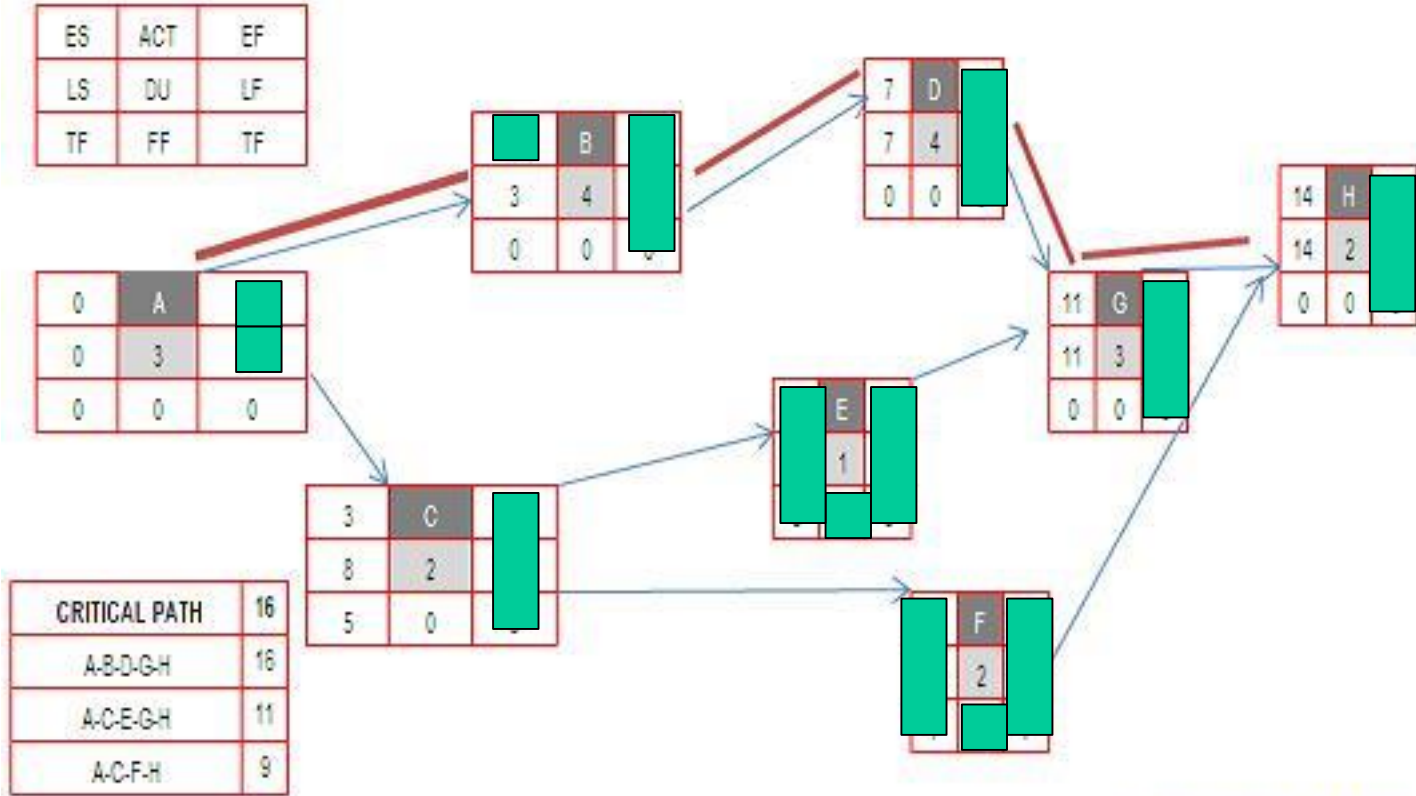


Based
on
ES/EF

Backward
Calculation

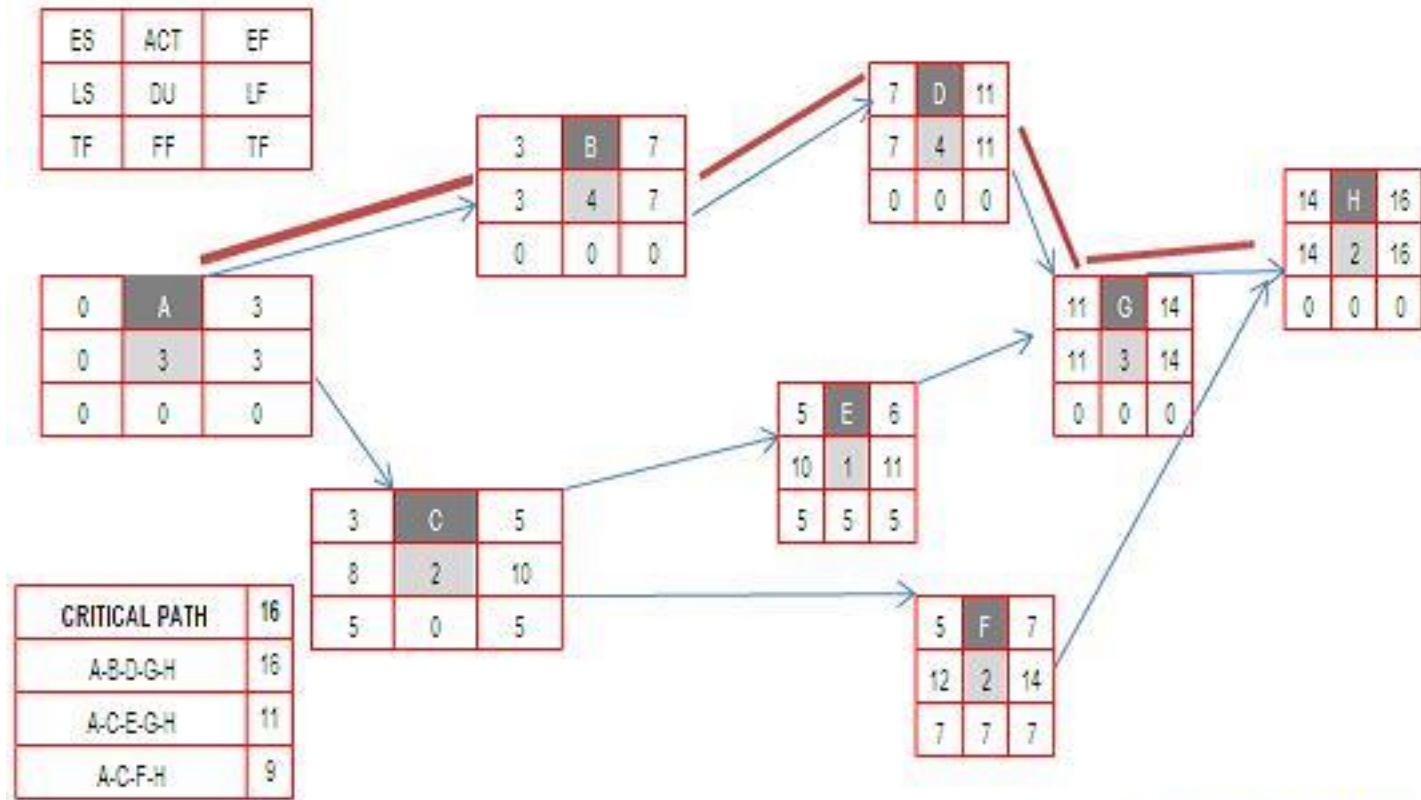


Based
on
LS/LF



Free Float = (ES of next Activity – EF of current Activity)

Total Float = (Late Start date – Early Start date)



Free Float = (ES of next Activity – EF of current Activity)

Total Float = (Late Start date – Early Start date)

PDM (Precedence Diagramming Method)

FS

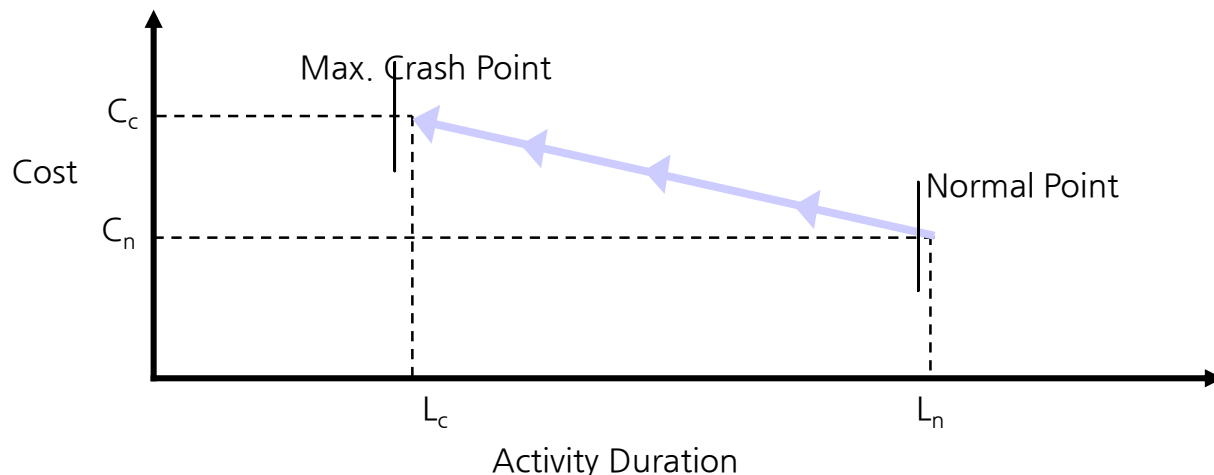
FF

SF

SS

Crashing

- Crashing : the procedure whereby an activity's duration is shortened by adding resources and paying extra 'direct' costs.
- Trade-off between the minimum cost-longest duration option at one extreme and any other options that can reduce an activity's duration at a higher cost.

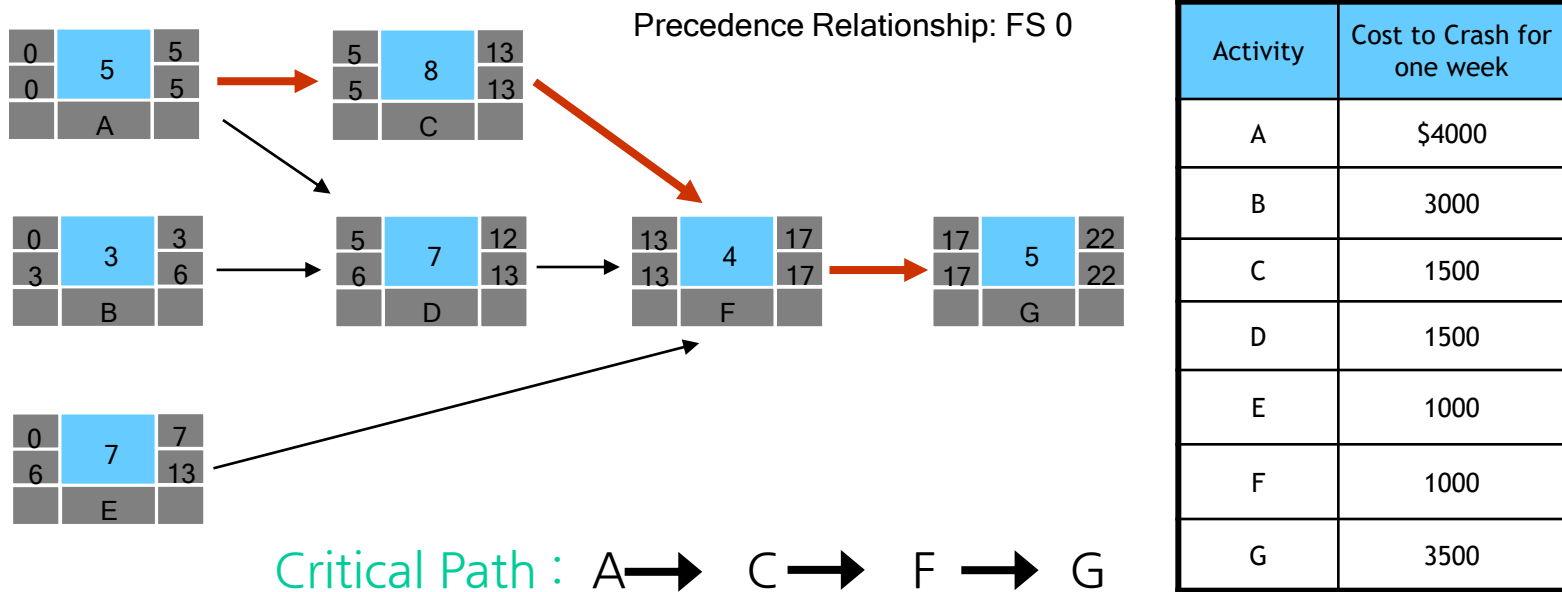


- May be an economic way as well as shortening the project duration, once other construction costs (e.g., indirect cost, delay penalty) are considered.

- Crashing Steps
 - Examine the critical path(s) at each step
 - Select the activity that is the least expensive to crash on each critical path
 - If there exist multiple critical paths, compare the cost of crashing of each option

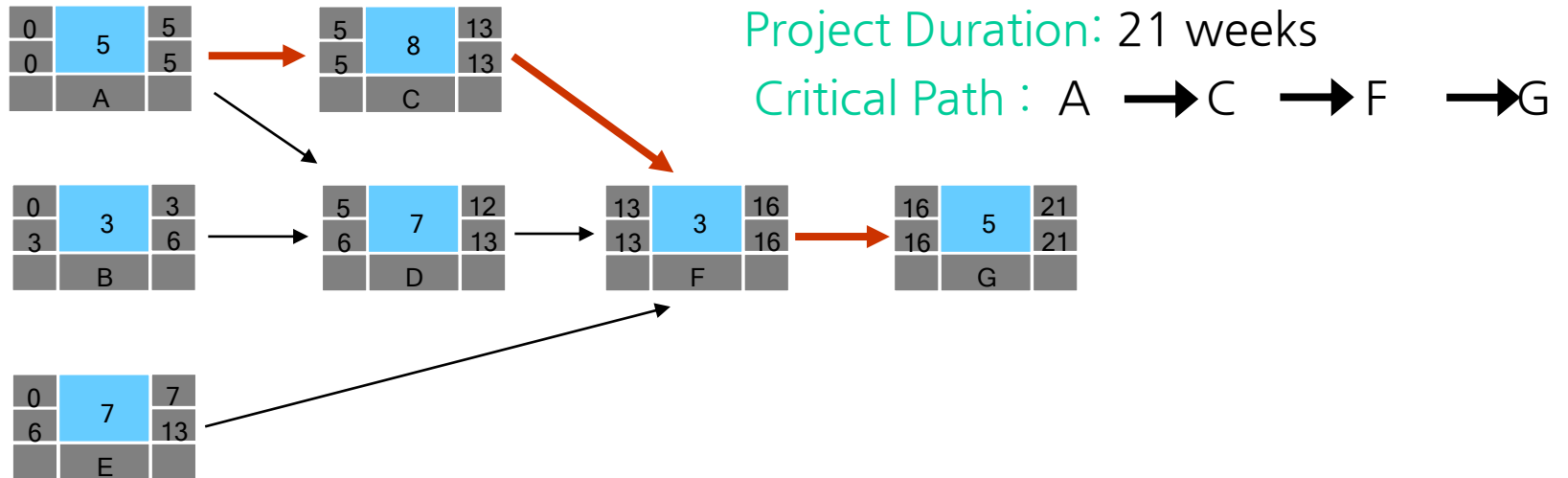
A Crashing Example

- Original Schedule



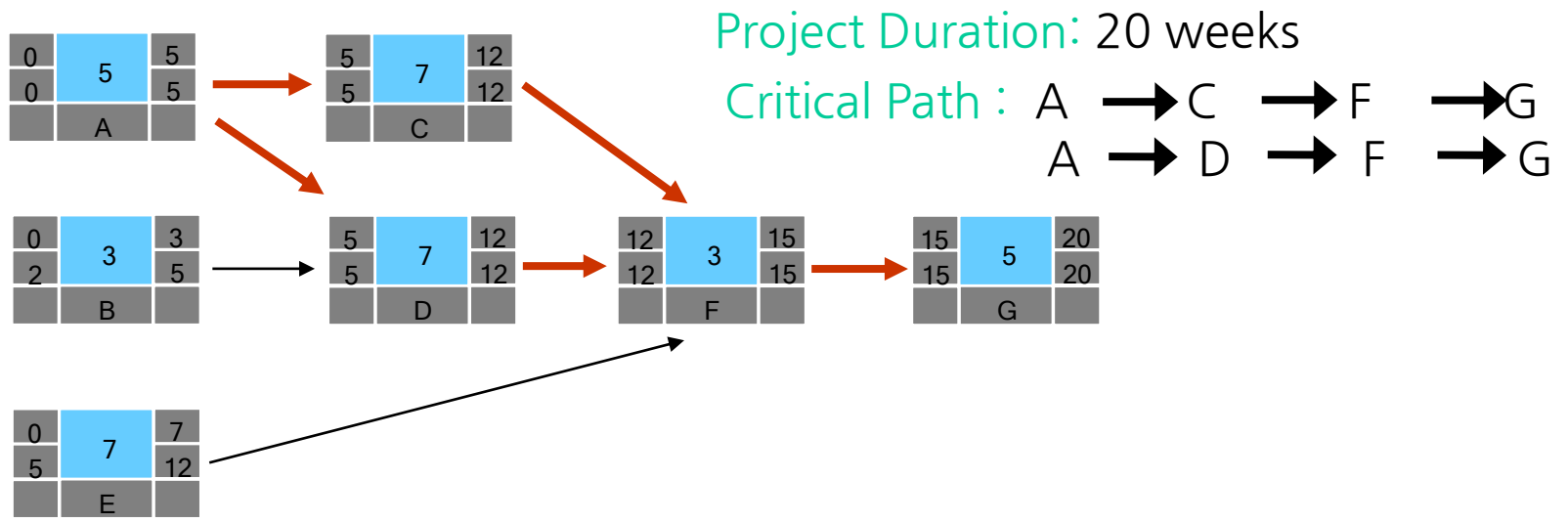
- Rescheduling Objective: Shortening the project duration from 22 weeks to 19 weeks
 - * Restriction: only one week crashing is allowed for each activity.

- 1st Step



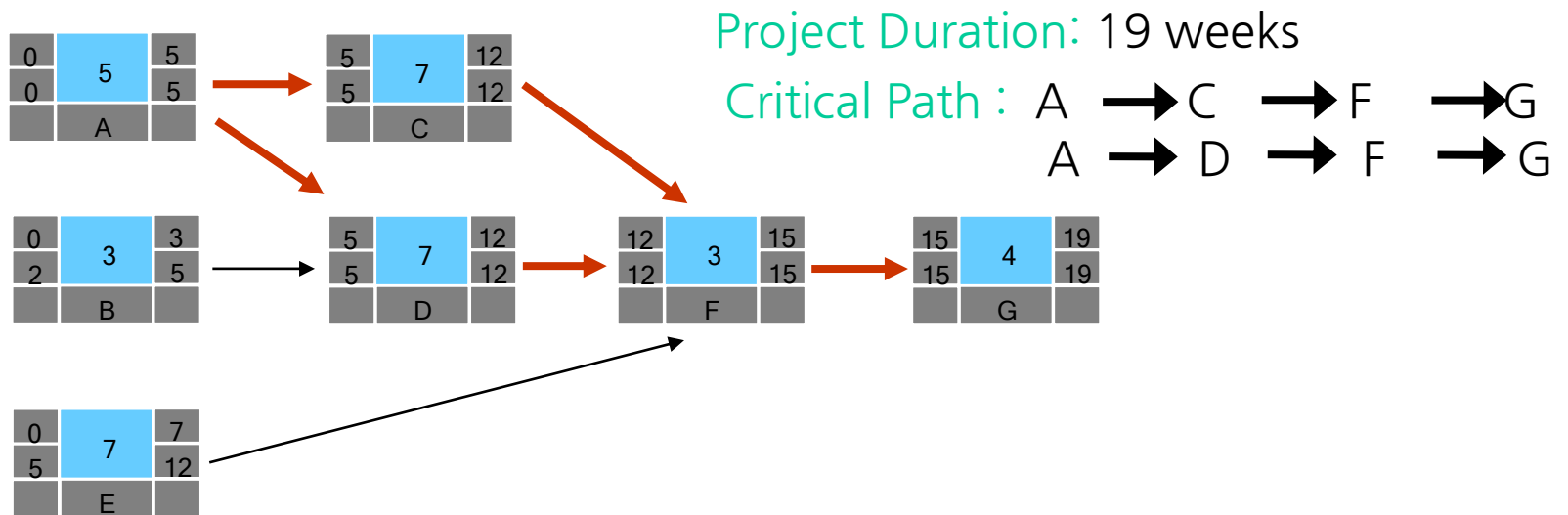
Options	Candidate Activities	Cost to Crash (\$)	Selected
1	A	4000	
2	C	1500	
3	F	1000	√ (4 to 3)
4	G	3500	

■ 2nd Step



Options	Candidate Activities	Cost to Crash (\$)	Selected
1	A	4000	
2	C	1500	✓ (8 to 7)
4	G	3500	

■ 3rd Step

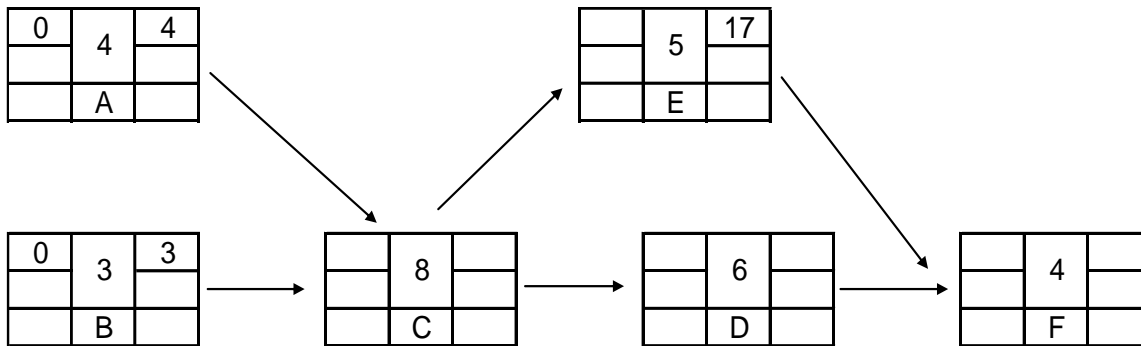


Options	Candidate Activities	Cost to Crash (\$)	Selected
1	A	4000	
2	C, D	1500 + 1500 =3000	Not feasible according to the given condition
4	G	3500	✓ (5 to 4)

Crashing Practice

- Original Schedule

Precedence Relationship: FS 0



ES	Duration	EF
LS		LF
TT	Activity Code	FF

Activity	Cost to crash for one day
A	\$3500
B	2000
C	1500
D	2000
E	2500
F	2500

- Find the maximum days, by which you can shorten the project duration, given \$6,500 additional money. Only direct costs are considered and fraction of costs is not allowed in calculation

Crashing Practice

Crashing Practice

Crashing Practice

Crashing Practice

Terms in Korean

용어	기호	내용
Event	○	작업의 결합점, 개시점 또는 종료점
Activity	—▶	작업, 프로젝트를 구성하는 작업 단위
Dummy	……>	더미, 가공작업, 작업이나 시간의 소요는 없음
가장빠른 개시시각	EST	Earliest starting time 작업을 시작하는 가장빠른 시각
가장빠른 종료시각	EFT	Earliest finishing time 작업을 끝낼 수 있는 가장빠른 시각
가장늦은 개시시각	LST	Latest starting time 공기에 영향이 없는 범위에서 작업을 늦게 시작하여도 좋은 시각
가장늦은 종료시각	LFT	Latest finishing time 공기에 영향이 없는 범위에서 작업을 늦게 종료하여도 좋은 시각
Path		네트워크 중 둘 이상의 작업이 이어짐.
Longest path	LP	임의의 두 결합점간의 패스중 소요시간이 가장 긴 패스
Critical path	CP	네트워크상에 전체공기를 규제하는 작업과정(가장 긴 패스)
Float		작업의 여유시간
Slack	SL	결합점이 가지는 여유시간
Total float	TF	최초의 개시일에 작업을 시작하여 가장늦은 종료일에 완료할 때 생기는 여유일(그작업의 (LFT-그작업의 EFT))
Free float	FF	최초의 개시일에 작업을 시작하여 후속작업을 최초 개시일에 시작하여도 생기는 여유일(후속 작업의 EST-그작업의 EFT)
Dependent float	DF	후속작업의 TF 에 영향을 주는 여유 (DF=TF-FF)