Time Planning and Control

Activity on Node Network (AON)

Processes of Time Planning and Control

Processes of Time Planning

1. Visualize and define the *activities.*
2. Sequence the activities (Job *Logic*).
3. Estimate the *activity duration*.
4. *Schedule* the project or phase.
5. Allocate and balance *resources*.

Processes of Time Control

1. Compare target, planned and actual dates and update as necessary.
2. *Control* the time schedule with respect to *changes*

Network Based Project Management

☑ *Network Techniques Development:*

- ☑ CPM by DuPont for chemical plants (1957)
- ☑ PERT by Booz, Allen & Hamilton with the U.S. Navy, for Polaris missile (1958)

☑ They consider precedence relationships and interdependencies

☑ Each uses a different estimate of activity times

Developing the Network by:

1. Arrow diagramming (AOA)

2. Node diagramming (AON)

3. Precedence diagramming (APD) –

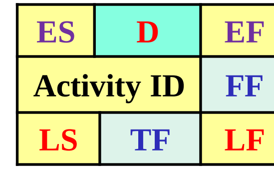
4. Time scaled Network (TSN)

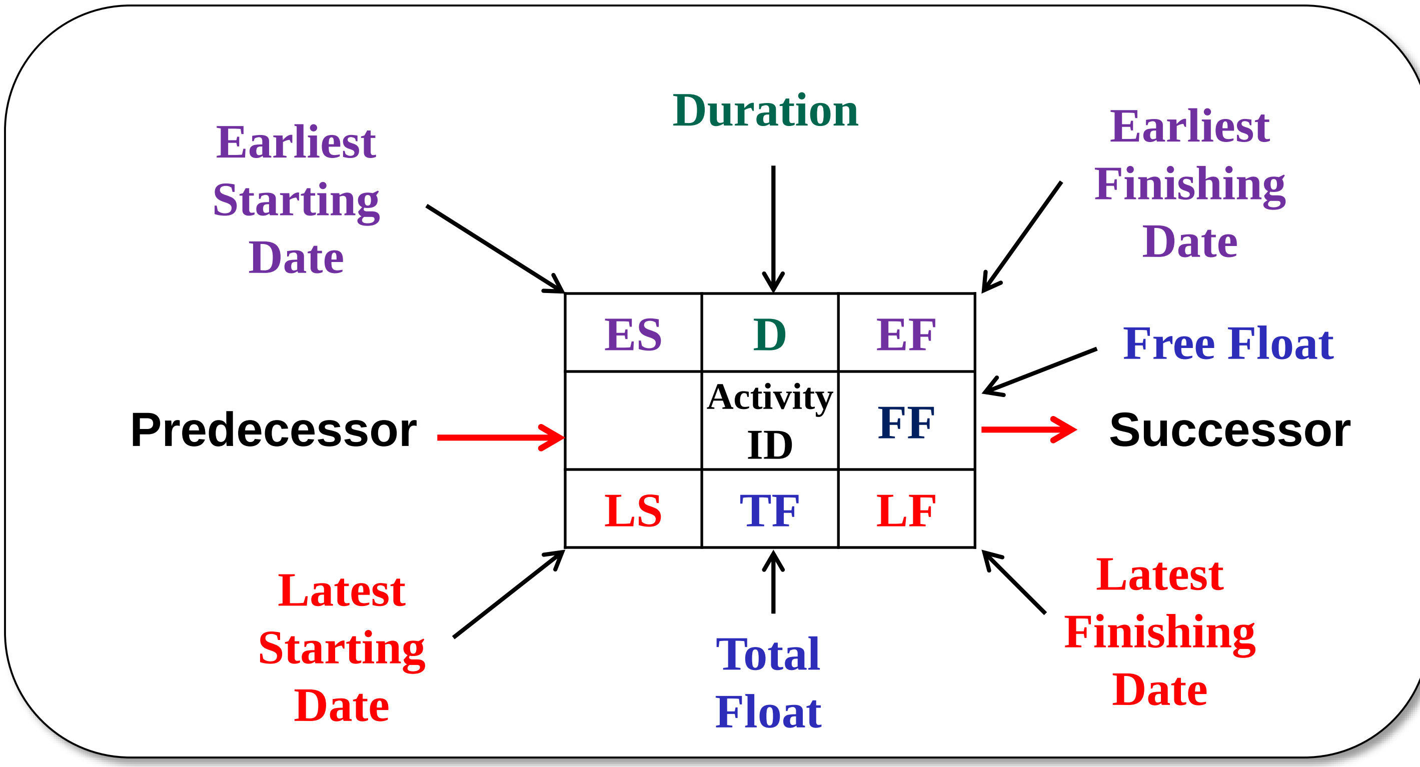
■ Activity on Node Notation

ES	D	EF
Activity ID		FF
LS	TF	LF

- Each time-consuming activity is portrayed by a **rectangular figure**.
- The dependencies between activities are indicated by **dependency lines (arrows)** going from one activity to another.
- Each **activity duration** in terms of working days is shown in the upper, central part of the activity box.
- The principal advantage of the activity on node network is that it **eliminates the need for dummies**.

Activity Box





The left side of the activity box (node) is the start side, while the right side is the finish (end) side.

Activity on Node Network

ES	D	EF
Activity ID		FF
LS	TF	LF

- Each activity in the network must be preceded either by the start of the project or by the completion of a previous activity.
- Each path through the network must be **continuous** with no gaps, discontinuities, or dangling activities.
- All activities must have at least one activity following, except the activity that terminates the project.
- Each activity should have a unique numerical designation (activity code). Activity code is shown in the upper, central part of the activity box, with the numbering proceeding generally from project start to finish.

Network Format

ES	D	EF
Activity ID		FF
LS	TF	LF

- A **horizontal diagram** format is the standard format.
- The general developing of a network is from start to finish, from project beginning on the left to project completion on the right.
- The sequential relationship of one activity to another is shown by the dependency lines between them.
- The length of the lines between activities has no significance.
- Arrowheads are not always shown on the dependency lines because of the obvious left to right flow of time.
- Dependency lines that go backward from one activity to another (**looping**) should not be used.
- **Crossovers** occur when one dependency line must cross over another to satisfy job logic.

ES	D	EF
Activity ID		FF
LS	TF	LF

Example

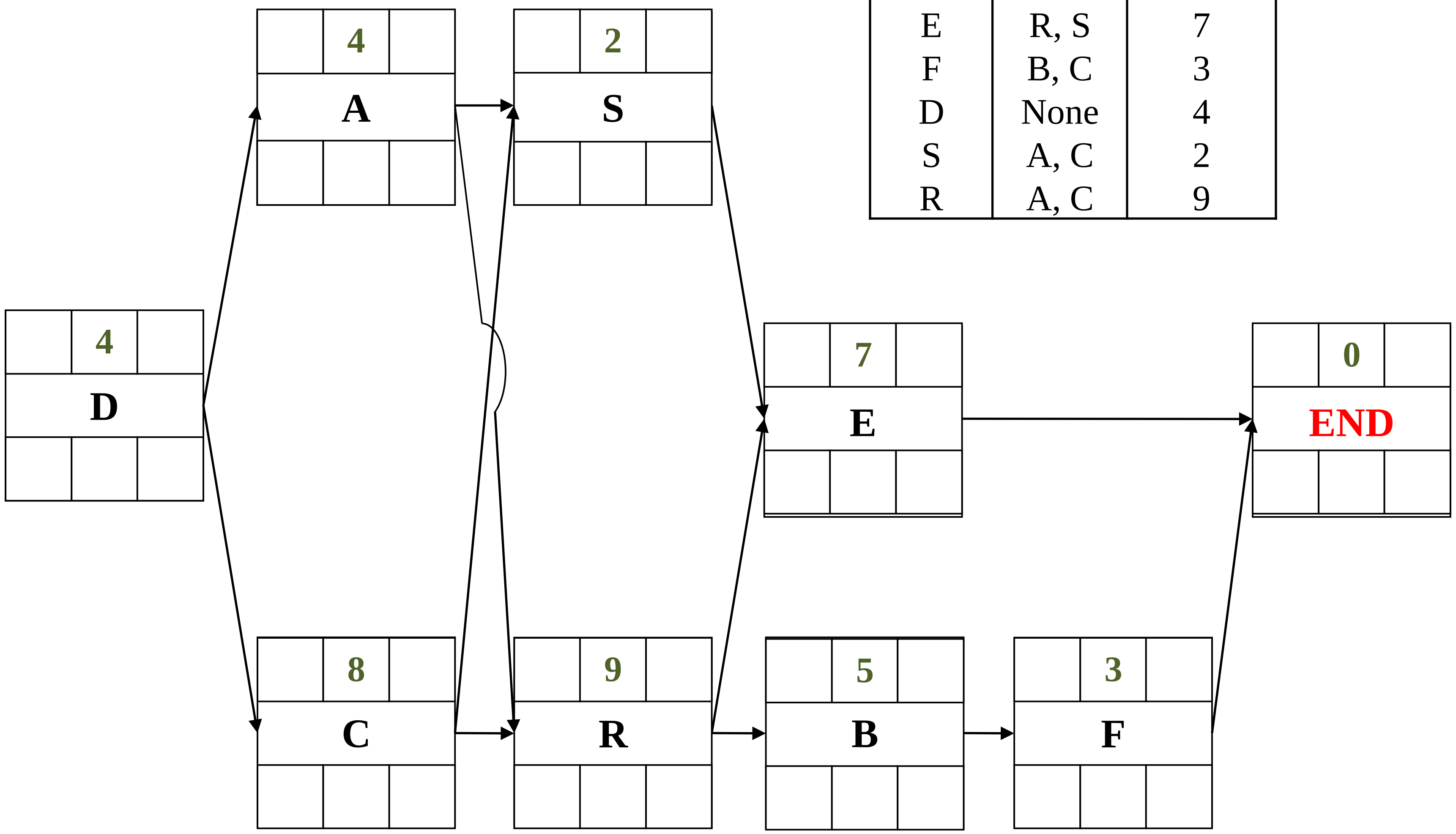
The activity list shown below represents the activities, the job logic and the activities' durations of a small project. Draw an activity on node network to represent the project.

Activity	Depends on	Duration (days)
A	D	4
B	R	5
C	D	8
E	R, S	7
F	B, C	3
D	None	4
S	A, C	2
R	A, C	9

Example

Activity	Depends on	Duration (days)
A	D	4
B	R	5
C	D	8
E	R, S	7
F	B, C	3
D	None	4
S	A, C	2
R	A, C	9

ES	D	EF
Activity ID		FF
LS	TF	LF



ES	D	EF
Activity ID		FF
LS	TF	LF

Network Computations

The purpose of network computations is to determine:

- *The overall project completion time; and*
- *The time brackets within which each activity must be accomplished (Activity Times).*

In activity on node network, all of the numbers associated with an activity are incorporated in the one node symbol for the activity, whereas the arrow symbols contain each activity's data in the predecessor and successor nodes, as well as on the arrow itself or in a table.

ES	Duration	EF
Activity ID		FF
LS	TF	LF

■ *EARLY ACTIVITY TIMES*

ES	D	EF
Activity ID		FF
LS	TF	LF

1. The ***"Early Start" (ES)*** or "Earliest Start" of an activity is the earliest time that the activity can possibly start allowing for the time required to complete the preceding activities.

2. The ***"Early Finish" (EF)*** or "Earliest Finish" of an activity is the earliest possible time that it can be completed and is determined by adding that activity's duration to its early start time.

COMPUTATIONS OF EARLY ACTIVITY TIMES

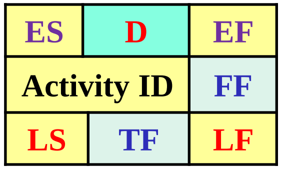
ES	D	EF
Activity ID		FF
LS	TF	LF

- **Direction**: Proceed from project start to project finish, from **left to right**.
- **Name**: This process is called the "**forward pass**".
- **Assumption**: every activity will start as early as possible. That is to say, each activity will start just as soon as the last of its predecessors is finished.
- The **ES** value of each activity is determined first.
- The **EF** time is obtained by adding ***the activity duration*** to the ES time.

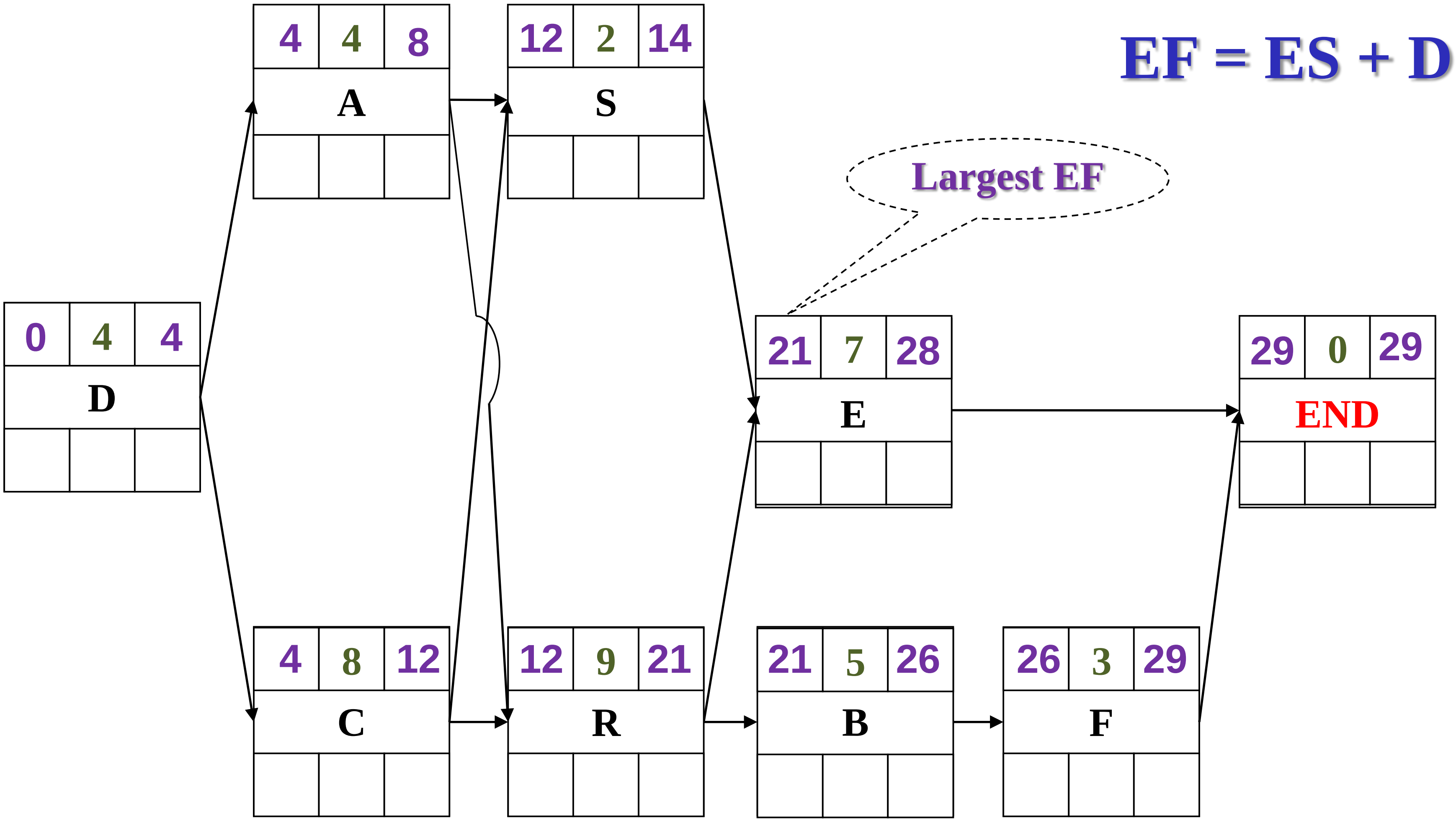
$$EF = ES + D$$

- In case of merge activities the earliest possible start time is equal to the latest (or **largest**) of the EF values of the immediately preceding activities.

Example



Calculate the early activity times (ES and EF) and determine project time.



■ LATE ACTIVITY TIMES

ES	D	EF
Activity ID		FF
LS	TF	LF

3. The ***"Late Finish" (LF)*** or "Latest Finish" of an activity is the very latest that it can finish and allow the entire project to be completed by a designated time or date.

4. The ***"Late Start" (LS)*** or "Latest Start" of an activity is the latest possible time that it can be started if the project target completion date is to be met and is obtained by subtracting the activity's duration from its latest finish time.

COMPUTATIONS OF LATE ACTIVITY TIMES

ES	D	EF
Activity ID		FF
LS	TF	LF

- **Direction**: Proceed from project end to project start, from **right to left**.
- **Name**: This process is called the "**backward pass**".
- **Assumption**: Each activity finishes as late as possible without delaying project completion.
- The **LF** value of each activity is obtained first and is entered into the lower right portion of the activity box.
- The **LS** is obtained by subtracting the activity duration from the LF value.

$$LS = LF - D$$

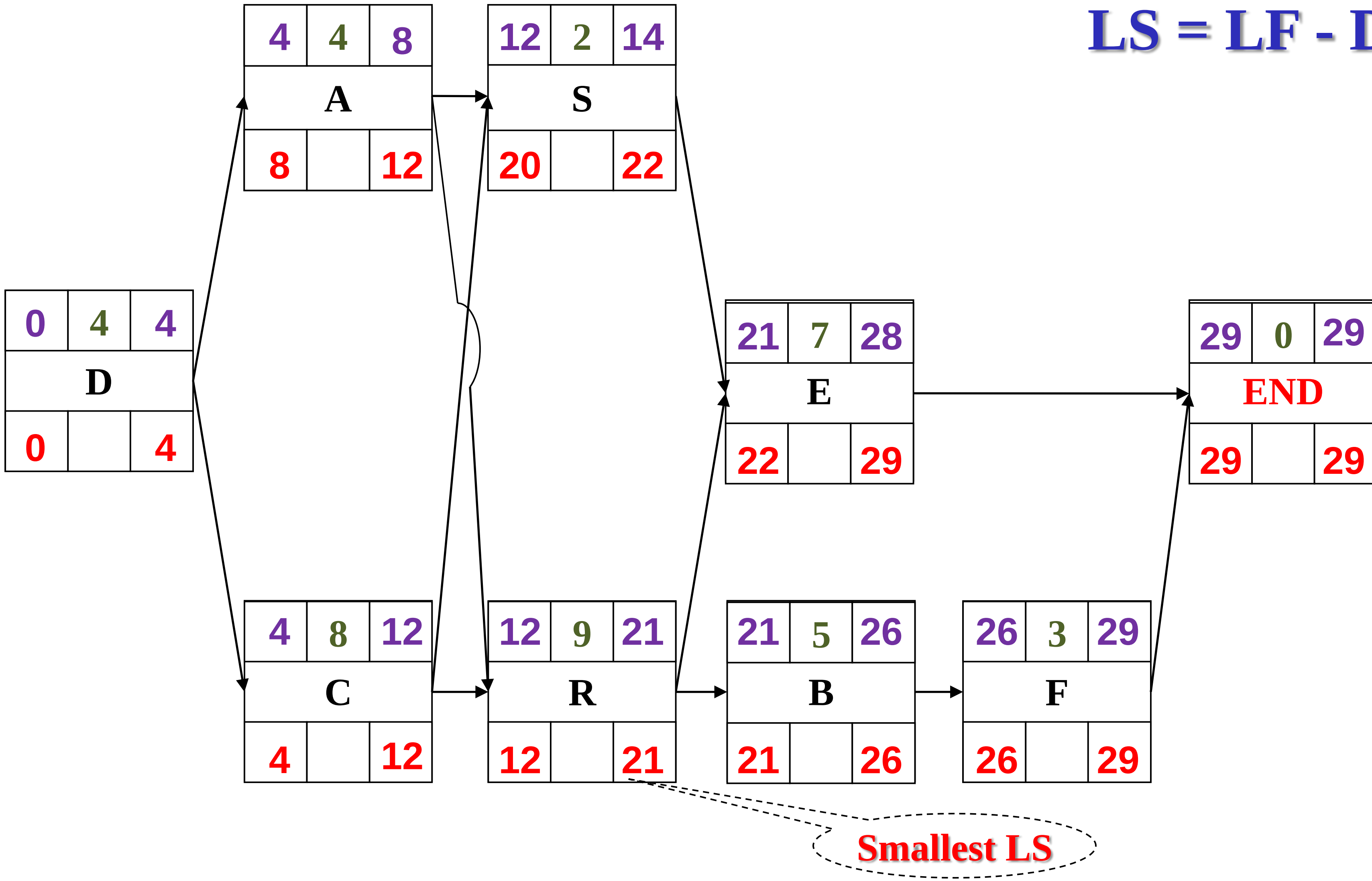
- In case of burst activities LF value is equal to the earliest (or **smallest**) of the LS times of the activities following.

EXAMPL

Calculate the late activity times (LS and LF).

ES	D	EF
Activity ID		FF
LS	TF	LF

$$LS = LF - D$$



FLOAT Time

ES	D	EF
Activity ID		FF
LS	TF	LF

- ***Float*** or leeway *is a measure of the time available for a given activity above and beyond its estimated duration*.
- Two classifications of which are in general usage: ***Total Float*** ***and*** ***Free Float***.

TOTAL FLOAT

ES	D	EF
Activity ID		FF
LS	TF	LF

- The total float of an activity is obtained by subtracting its ES time from its LS time. Subtracting the EF from the LF gives the same result.

Total float (TF) = LS - ES = LF - EF

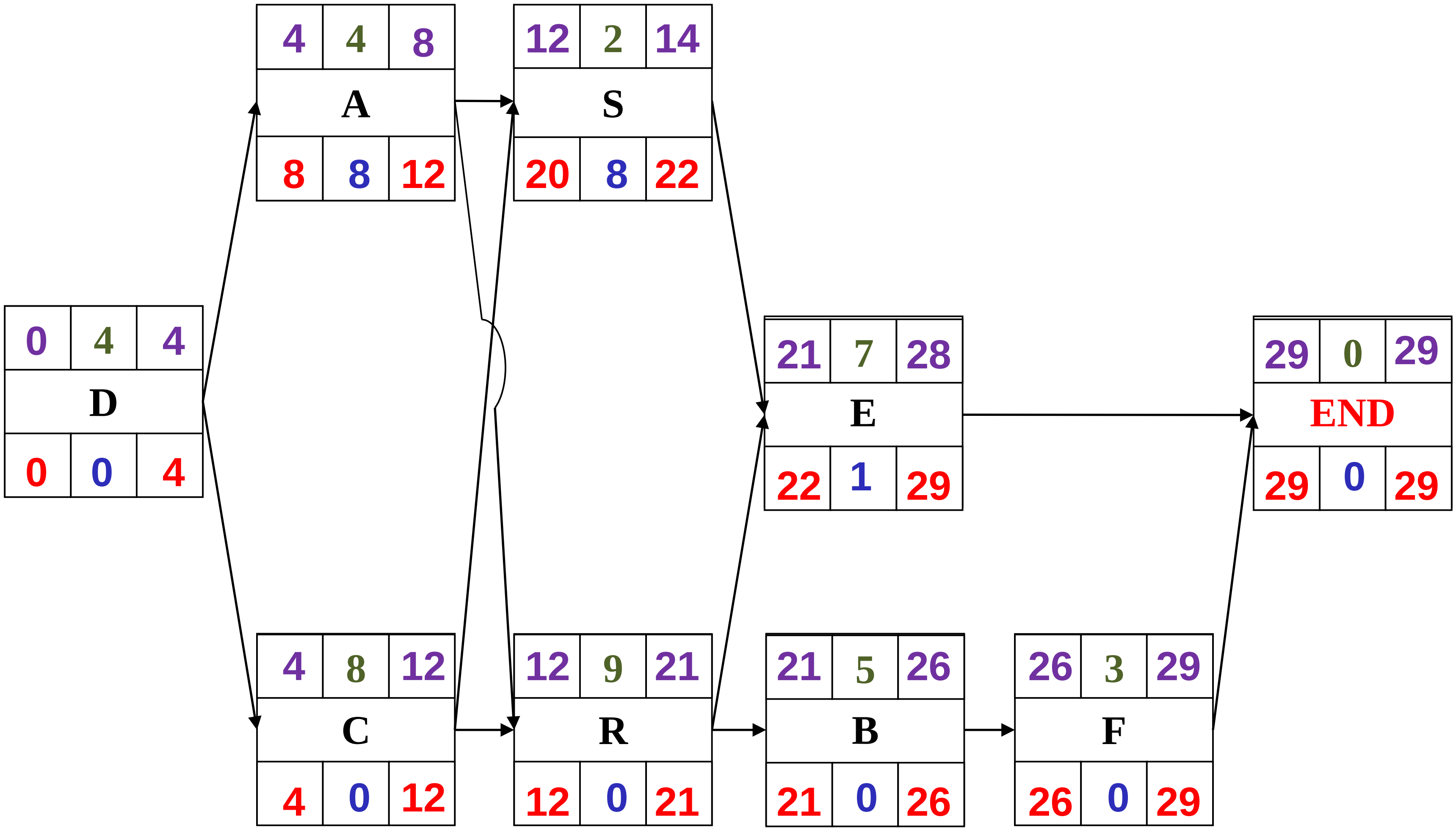
- An activity with **zero** total float has **no spare time** and is, therefore, one of the operations that controls project completion time.
- Activities with zero total float are called "**critical activities**“.

EXAMPLE

Calculate Total Float for an activity.

ES	D	EF
Activity ID		FF
LS	TF	LF

Total float (TF) = LS - ES = LF - EF



CRITICAL PATH

ES	D	EF
Activity ID		FF
LS	TF	LF

- *Critical activity is quickly identified as one whose two start times at the left of the activity box are equal*. Also equal are the two finish times at the right of the activity box.

- *The critical activities must form a continuous path from project beginning to project end*, this chain of critical activities is ***called*** the ***"critical path".***

- *The critical path is the longest path in the network*.

CRITICAL PATH

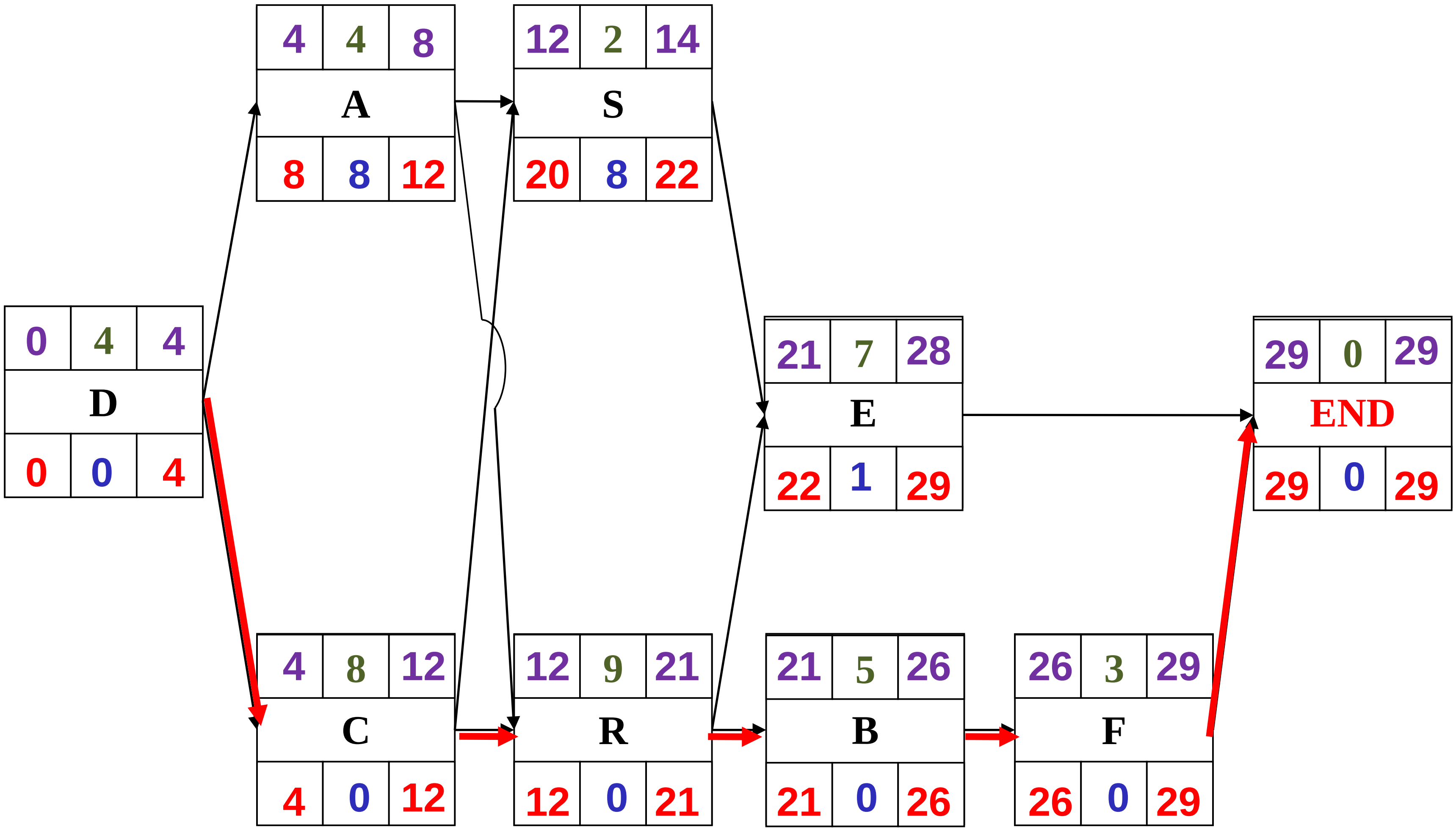
ES	D	EF
Activity ID		FF
LS	TF	LF

- The critical path is normally *indicated* on the diagram in some distinctive way such as *with colors, heavy lines, or double lines*.

- Any delay in the finish date of a critical activity, for whatever reason, automatically prolongs project completion by the same amount.

CRITICAL PATH

ES	D	EF
Activity ID		FF
LS	TF	LF



ES	D	EF
Activity ID		FF
LS	TF	LF

FREE FLOAT

- *The free float of an activity is the amount of time by which the completion of that activity can be deferred without delaying the early start of the following activities.*

- ***The free float of an activity is found by subtracting its earliest finish time from the earliest start time of the activities directly following.***

- **FF** = *The smallest of the ES value of those activities immediately following - EF of the activity.*

  = *the smallest of the earliest start time of the successor activities minus the earliest finish time of the activity in question.*

$$FF_i = Min.\ (ES_j) - EF_i$$

CALENDAR-DATE SCHEDULE

ES	D	EF
Activity ID		FF
LS	TF	LF

- Activity times (ES, EF, LS, LF) obtained from previous calculations are expressed in terms of expired ***working days.***

- For purposes of project directing, monitoring and control, it is necessary to convert these times to ***calendar dates*** on which each activity is expected to start and finish.

- This is done with the aid of a ***calendar*** on which the working days are numbered consecutively, starting with number 1 on the anticipated start date and skipping weekends and holidays.

■ *Advantages and disadvantages of network diagram*

Advantages

- Show precedence well
- Reveal interdependencies not shown in other techniques
- Ability to calculate critical path
- Ability to perform “what if” exercises

Disadvantages

- Default model assumes resources are unlimited
- You need to incorporate this yourself (Resource Dependencies) when determining the “real” Critical Path
- Difficult to follow on large projects

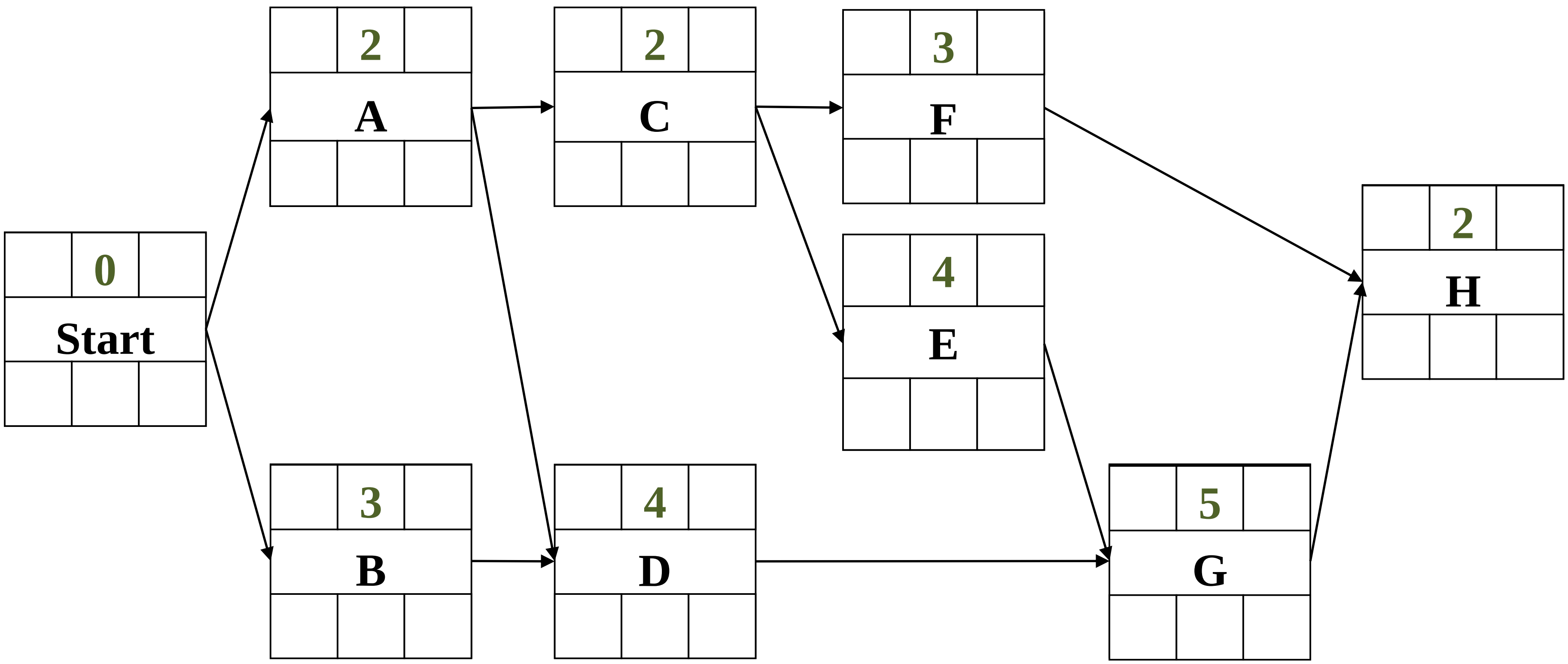
Example 2: Milwaukee Paper Manufacturing's

Activity	*Description*	*Immediate Predecessors*	*Time (weeks)*
A	*Build internal components*	—	*2*
B	*Modify roof and floor*	—	*3*
C	*Construct collection stack*	*A*	*2*
D	*Pour concrete and install frame*	*A, B*	*4*
E	*Build high-temperature burner*	*C*	*4*
F	*Install pollution control system*	*C*	*3*
G	*Install air pollution device*	*D, E*	*5*
H	*Inspect and test*	*F, G*	*2*

Table 3.2 (Frome Heizer/Render; Operation Management)

Example 2: Milwaukee Paper Manufacturing's

Activit y	Description	Immediate Predecessors	Time (weeks)
A	*Build internal components*	—	*2*
B	*Modify roof and floor*	—	*3*
C	*Construct collection stack*	*A*	*2*
D	*Pour concrete and install frame*	*A, B*	*4*
E	*Build high-temperature burner*	*C*	*4*
F	*Install pollution control system*	*C*	*3*
G	*Install air pollution device*	*D, E*	*5*
H	*Inspect and test*	*F, G*	*2*

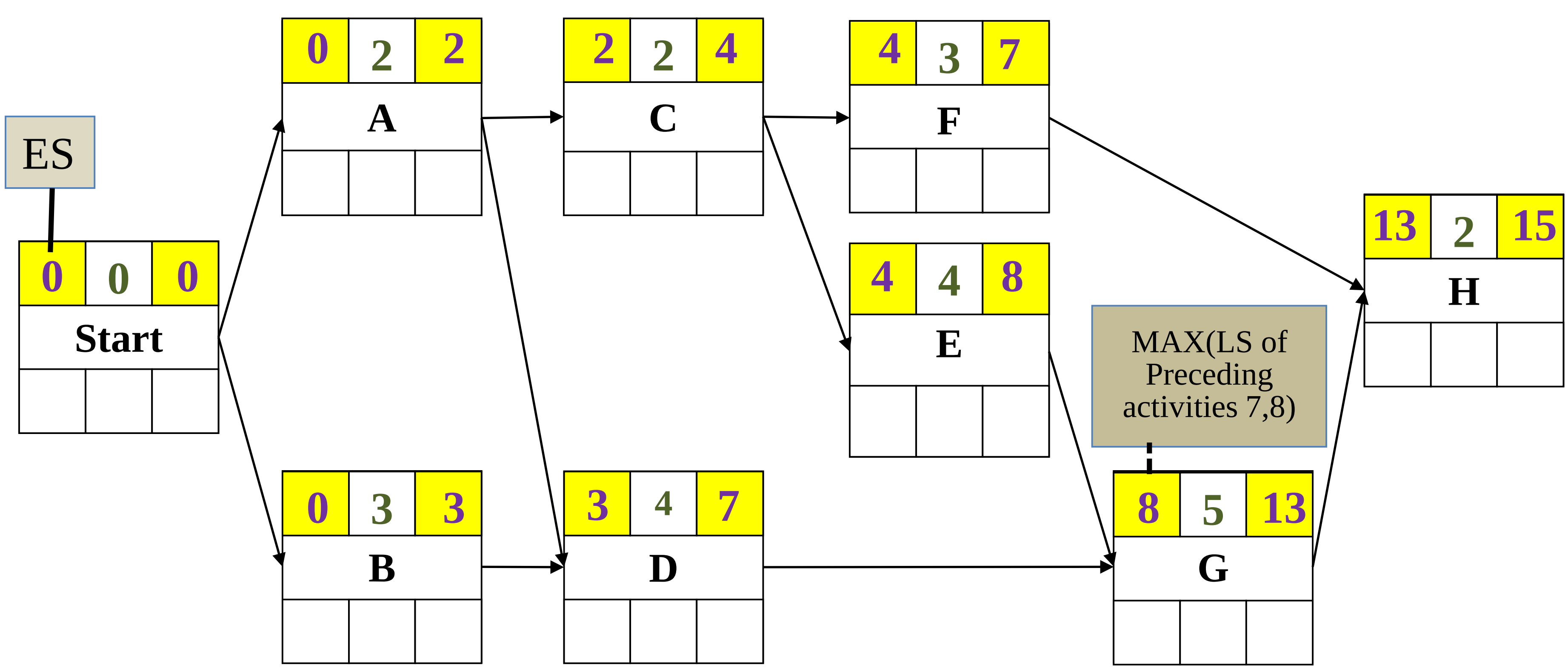


Example 2: Milwaukee Paper Manufacturing's

ES/EF calculation

EF = ES + Activity time

Activity	Description	Immediate Predecessors	Time (weeks)
A	Build internal components	—	2
B	Modify roof and floor	—	3
C	Construct collection stack	A	2
D	Pour concrete and install frame	A, B	4
E	Build high-temperature burner	C	4
F	Install pollution control system	C	3
G	Install air pollution device	D, E	5
H	Inspect and test	F, G	2

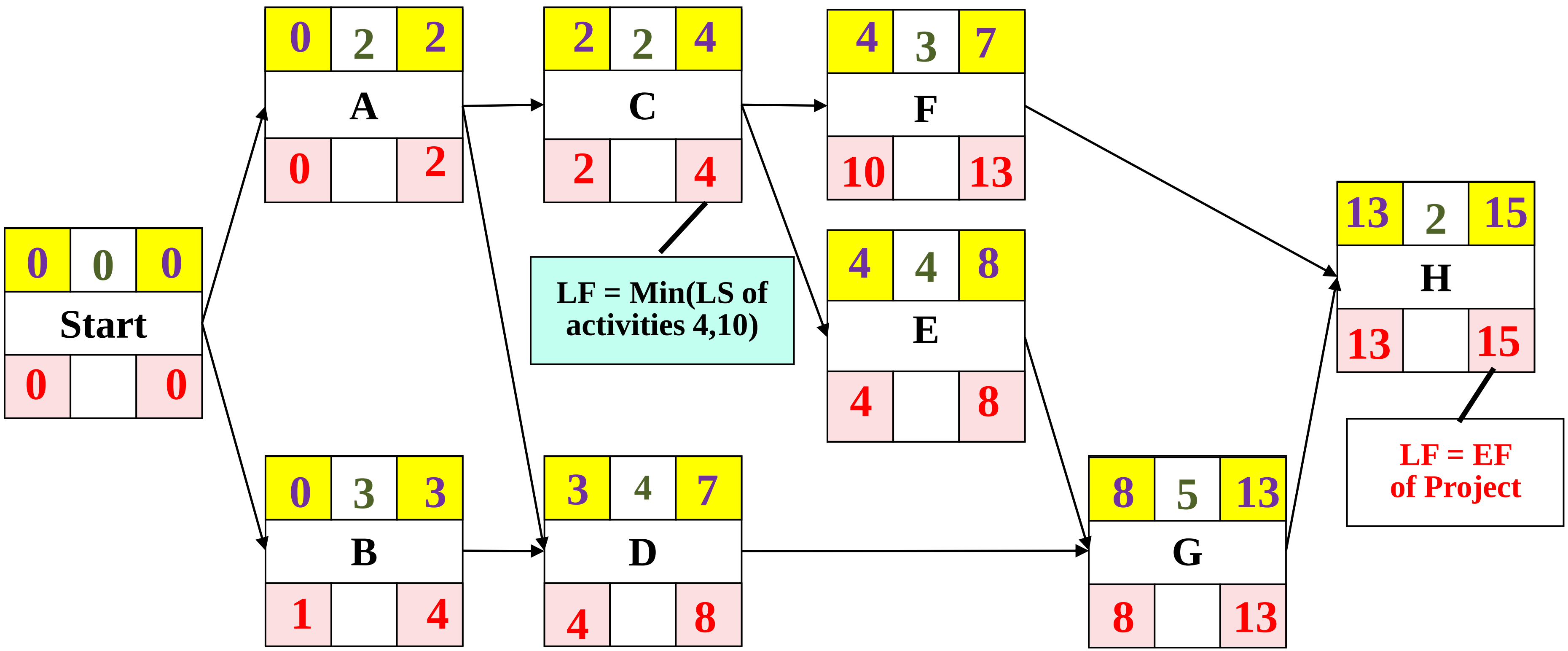


Example 2: Milwaukee Paper Manufacturing's

LS/LF calculation

LS = LF - Activity time

Activity	Description	Immediate Predecessors	Time (weeks)
A	Build internal components	—	2
B	Modify roof and floor	—	3
C	Construct collection stack	A	2
D	Pour concrete and install frame	A, B	4
E	Build high-temperature burner	C	4
F	Install pollution control system	C	3
G	Install air pollution device	D, E	5
H	Inspect and test	F, G	2

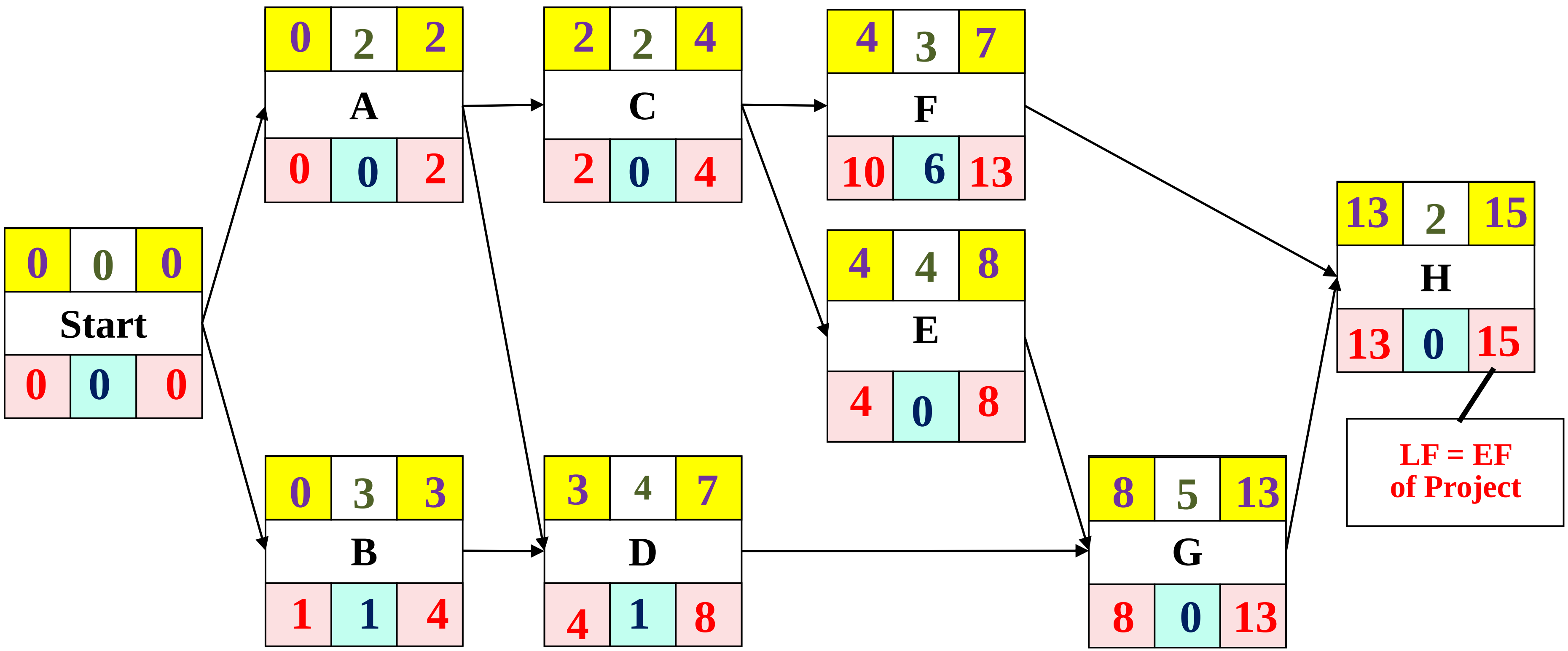


Example 2: Milwaukee Paper Manufacturing's

Total Float calculation

Slack = LS – ES   or
Slack = LF – EF

Activity	Description	Immediate Predecessors	Time (weeks)
A	Build internal components	—	2
B	Modify roof and floor	—	3
C	Construct collection stack	A	2
D	Pour concrete and install frame	A, B	4
E	Build high-temperature burner	C	4
F	Install pollution control system	C	3
G	Install air pollution device	D, E	5
H	Inspect and test	F, G	2



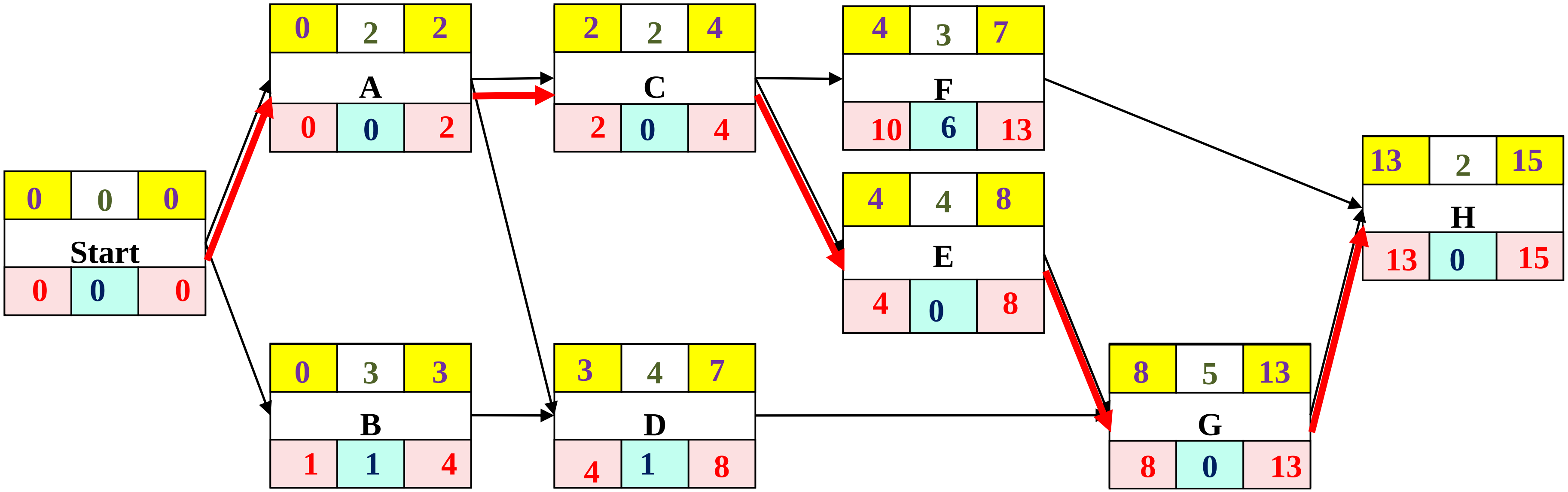
Example 2: Milwaukee Paper Manufacturing's

Computing Slack Time (Float Time)

Activity	Earliest Start ES	Earliest Finish EF	Latest Start LS	Latest Finish LF	Slack LS – ES	On Critical Path
A	0	2	0	2	0	Yes
B	0	3	1	4	**1**	No
C	2	4	2	4	0	Yes
D	3	7	4	8	**1**	No
E	4	8	4	8	0	Yes
F	4	7	10	13	**6**	No
G	8	13	8	13	0	Yes
H	13	15	13	15	0	Yes

Example 2: Milwaukee Paper Manufacturing's

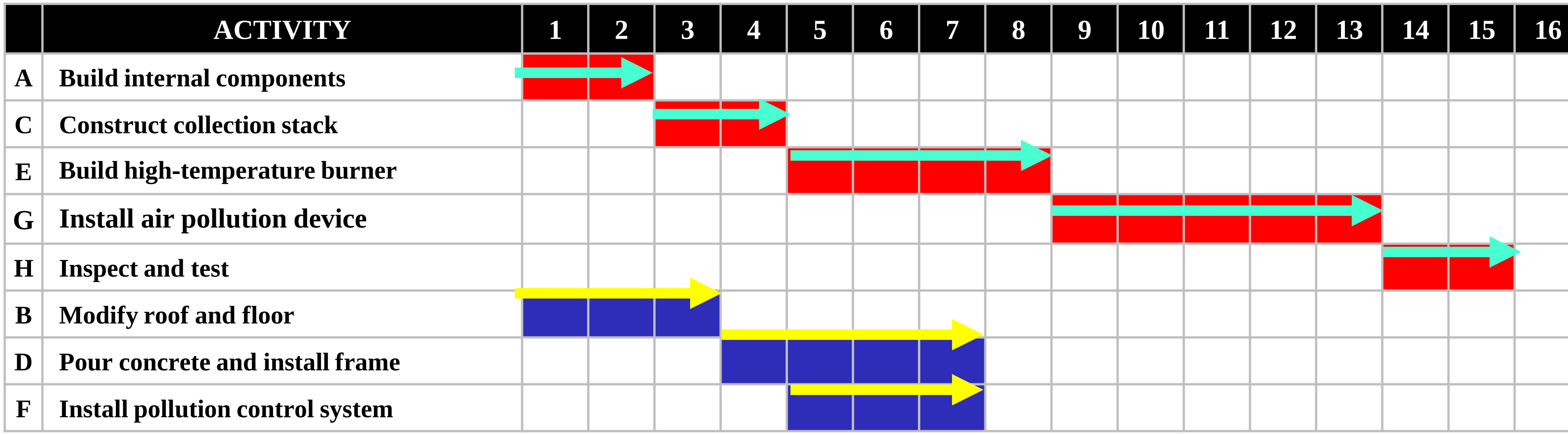
Critical Path for Milwaukee Paper: A, C, E, G, H



Activity	Duration	ES	EF	LS	LF	TF	FF	CP
A	2	0	2	0	2	0	0	Y
B	3	0	3	1	4	1	0	N
C	2	2	4	2	4	0	0	Y
D	4	3	7	4	8	1	1	N
E	4	4	8	4	8	0	0	Y
F	3	4	7	10	13	6	6	N
G	5	8	13	8	13	0	0	Y
H	2	13	15	13	15	0	0	Y

Example 2: Milwaukee Paper Manufacturing's

ES –EF <u>GANTT CHART SCHEDULE</u>



LS –LF <u>GANTT CHART SCHEDULE</u>