SOFTWARE ENGINEERING
(15B11CI513)

Credits :- 4 **Contact Hours :-** 3-1-0

Project Scheduling

Project Scheduling

- Schedule converts action plan into operating time table
- Basis for monitoring and controlling project
- Scheduling is more important in projects than in production, because unique nature
- Sometimes customer specified/approved requirement.
- Based on Work Breakdown Structure (WBS)

Activity Planning

- Effort estimation
  - For whole project
  - For individual activity
- Detailed plan
  - Starting of each activity
  - End of each activity
  - Risks

Project Vs Activity

- A project is composed of a number of related activities
- A project may start when at least one of its activities is ready to start
- A project will be completed when all of its activities have been completed

Cont…

- An activity should have a duration that can be forecasted
- An activity must have a clear start and a clear stop
- Each activity should have some ‘deliverables’ for ease of monitoring
- Some activities may require that other activities are completed before they can begin

Activity Planning

- A project plan is a schedule of activities indicating the start and stop for each activity
  - Also provide the project and resource schedules

Cont…

- During planning, managers consider:
  - Resource availability
  - Resource allocation
  - Staff responsibility
  - Project Monitoring
  - Cash flow forecasting
  - Re-planning of the project towards the pre-defined goal

Objectives of Activity Planning

- Feasibility assessment
  - Time and resource constraints
- Resource allocation
  - Timescale and resource availability
- Detailed costing
  - Cost and their timing
- Motivation
- Co-ordination

Cont…

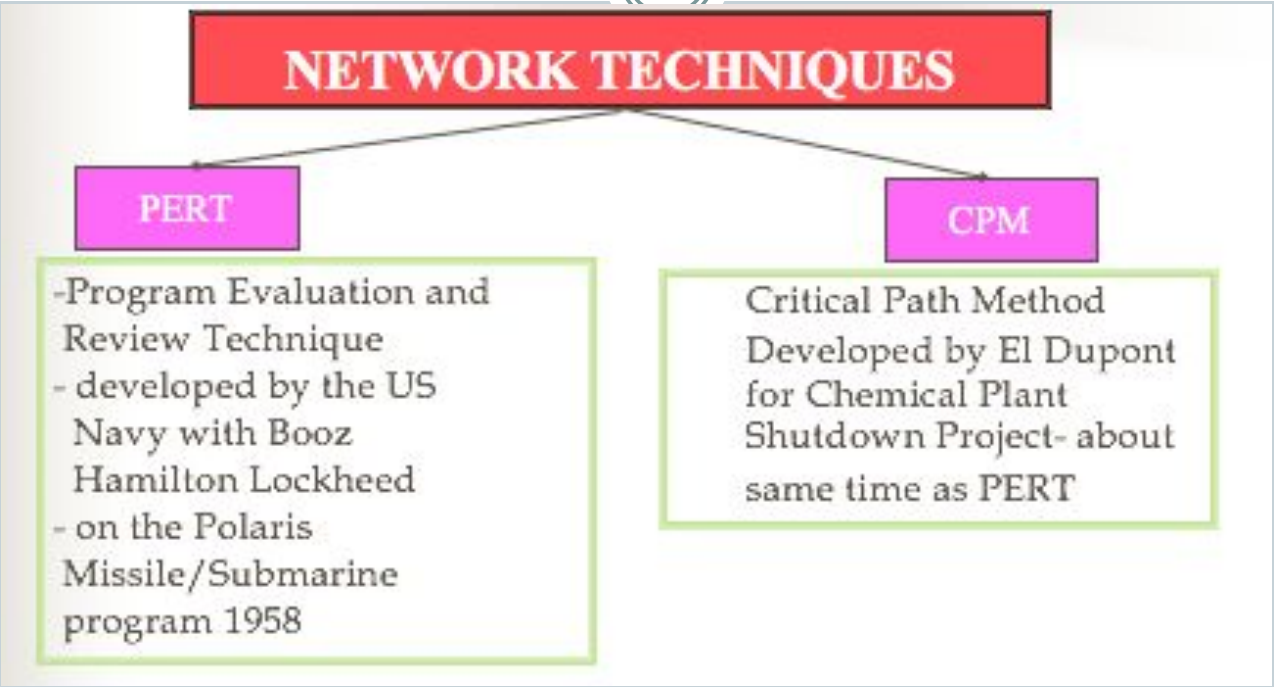
- Activity Planning and scheduling techniques leads to
  - Completing the project in a min. time and at an acceptable cost
  - Activities in parallel

Different Levels of Plans

- Project Schedule: a plan that shows
  - What are activities
  - Order of activities
  - Dates when each activity should start and stop
  - When and how much of the resources will be required
- Activity Plan: a plan that describes
  - how each activity will be undertaken

Activity networks

Network Planning Model



- Both use same calculations, almost similar
- Main difference is probabilistic and deterministic in time estimation
- Gantt Chart also used in scheduling

NETWORK

- Graphical portrayal of activities and event
- Shows dependency relationships between tasks/activities in a project
- Clearly shows tasks that must precede (precedence) or follow (succeeding) other tasks in a logical manner
- Clear representation of plan – a powerful tool for planning and controlling project

Example of Simple Network – Survey

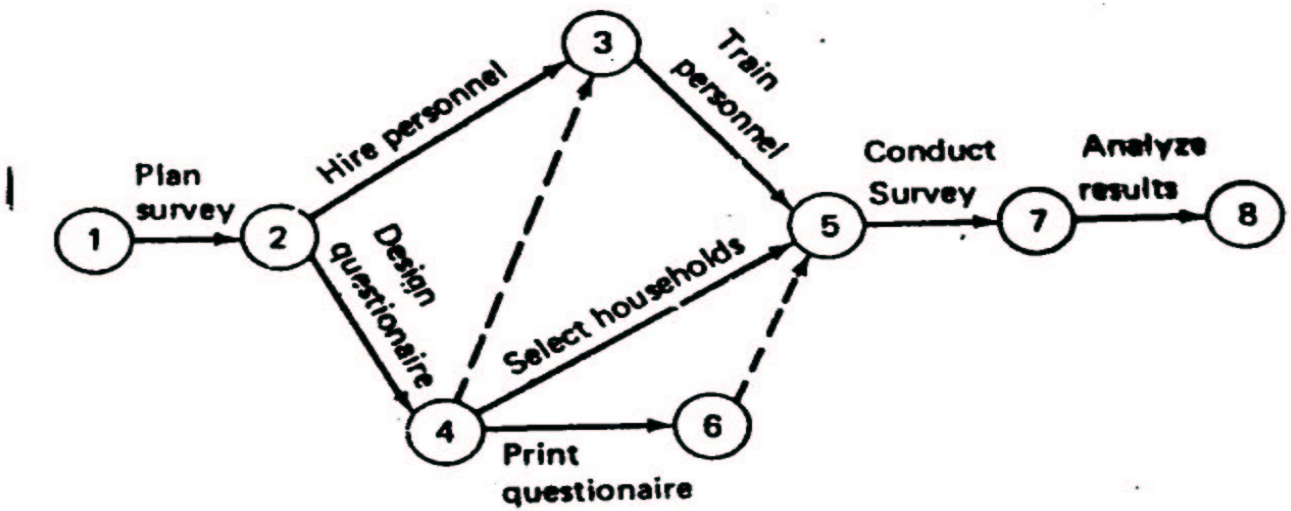


Figure 2-18

Example of Network – More Complex

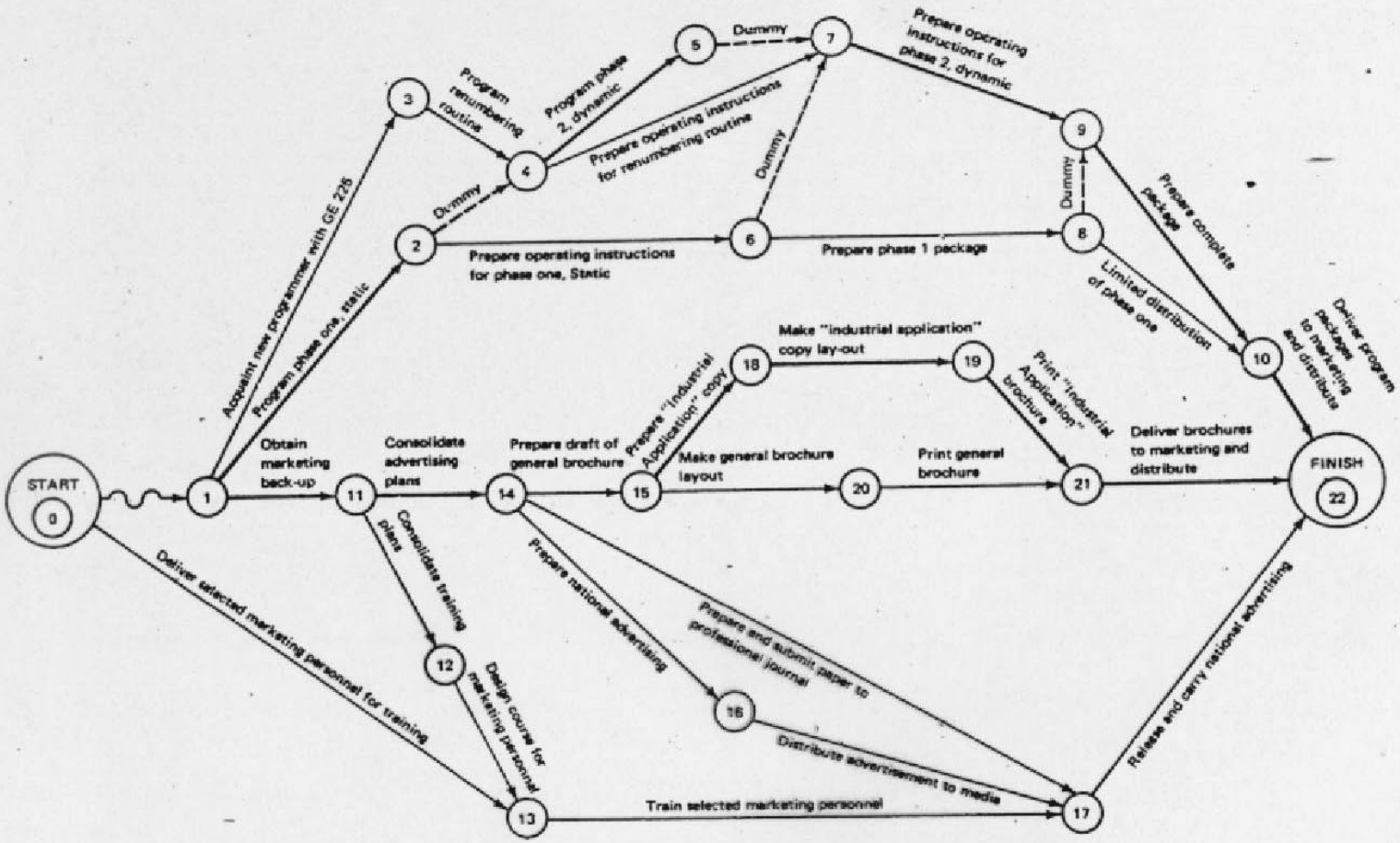
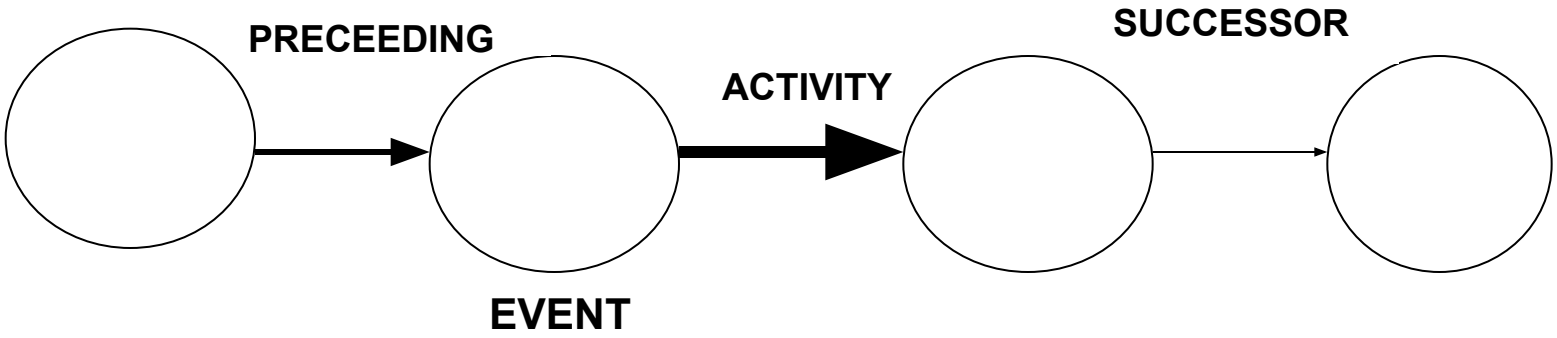


Figure 2-19 Network for the development and marketing of a new computer program.

DEFINITION OF TERMS IN A NETWORK

- **Activity :** any portions of project (tasks) which required by project, uses up resource and consumes time – may involve labor, paper work, contractual negotiations, machinery operations Activity on Arrow (AOA) showed as arrow, AON – Activity on Node
- **Event :** beginning or ending points of one or more activities, instantaneous point in time, also called 'nodes'
- **Network** : Combination of all project activities and the events



Emphasis on Logic in Network Construction

- Construction of network should be based on logical or technical dependencies among activities
- Example - before activity 'Approve Drawing' can be started the activity 'Prepare Drawing' must be completed
- Common error – build network on the basis of time logic (a feeling for proper sequence) see example below

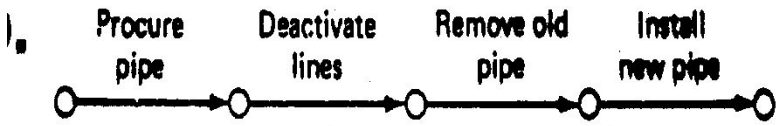


Figure 2-5a

WRONG !!!

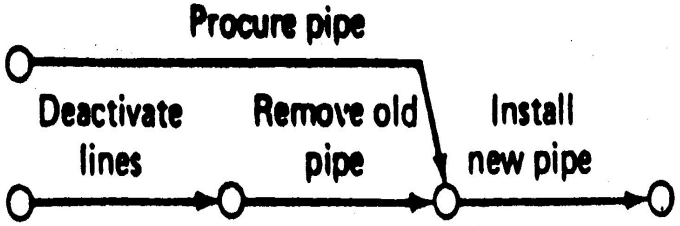


Figure 2-5b

CORRECT ✔

PERT

- **Project Evaluation and Review Technique (PERT)** is a procedure through which activities of a project are represented in its appropriate sequence and timing.
- It is a scheduling technique used to schedule, organize and integrate tasks within a project
- PERT is basically a mechanism for management planning and control which provides blueprint for a particular project
- In this technique, a PERT Chart is made which represent a schedule for all the specified tasks in the project

CPM

- CPM is a technique which is used for the projects where the time needed for completion of project is already known.
- It is majorly used for determining the approximate time within which a project can be completed.
- Critical path is the largest path in project management which always provide minimum time taken for completion of project

Example 1- A simple network

Consider the list of four activities for making a simple product:

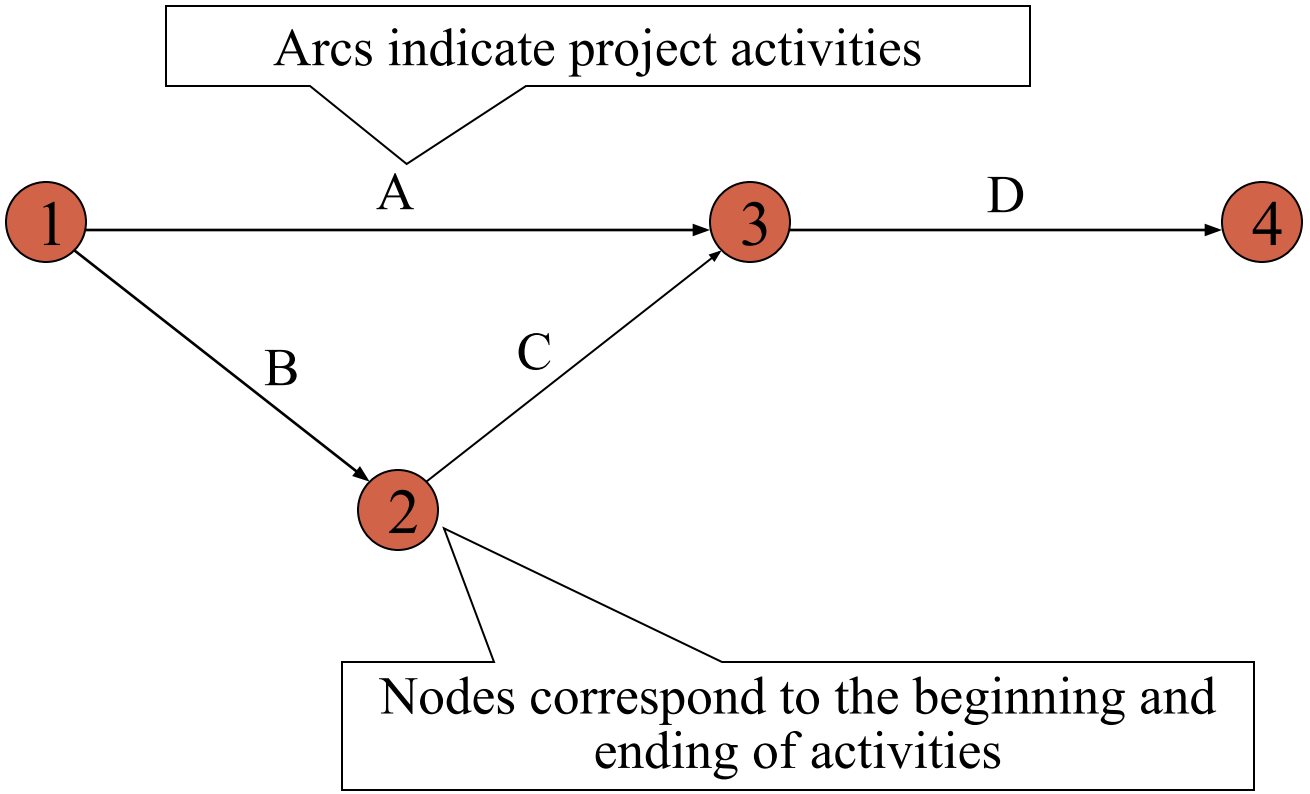
Activity	Description	Immediate predecessors
A	Buy Plastic Body	-
B	Design Component	-
C	Make Component	B
D	Assemble product	A,C

Immediate predecessors for a particular activity are the activities that, when completed, enable the start of the activity in question.

Sequence of activities

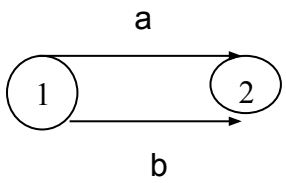
- Can start work on activities A and B anytime, since neither of these activities depends upon the completion of prior activities.
- Activity C cannot be started until activity B has been completed
- Activity D cannot be started until both activities A and C have been completed.
- The graphical representation (next slide) is referred to as the PERT/CPM network

Network of Four Activities

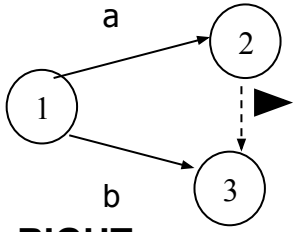


EXAMPLES OF THE USE OF DUMMYACTIVITY

Network concurrent activities

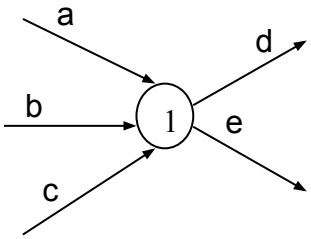


WRONG!!!

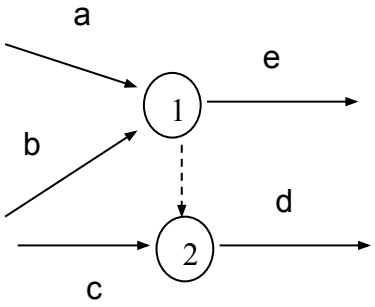


RIGHT ✔

Activity c not required for e



WRONG !!!



RIGHT ✔

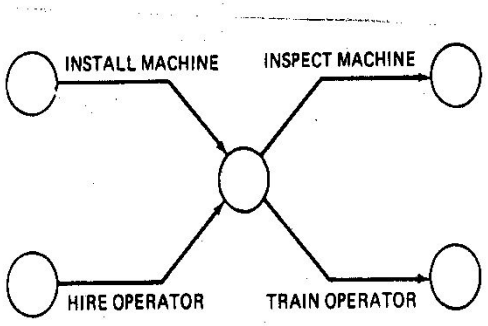


Figure 2-16

WRONG !

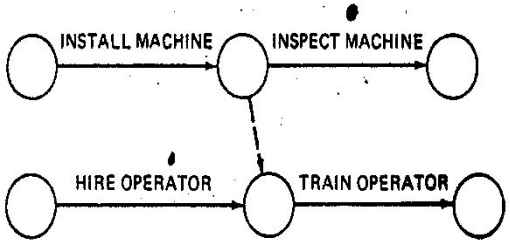
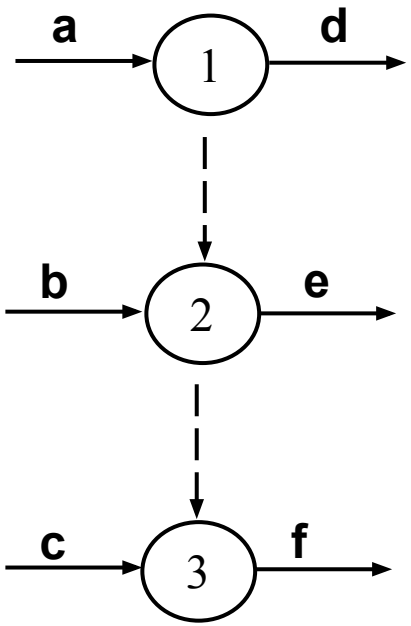


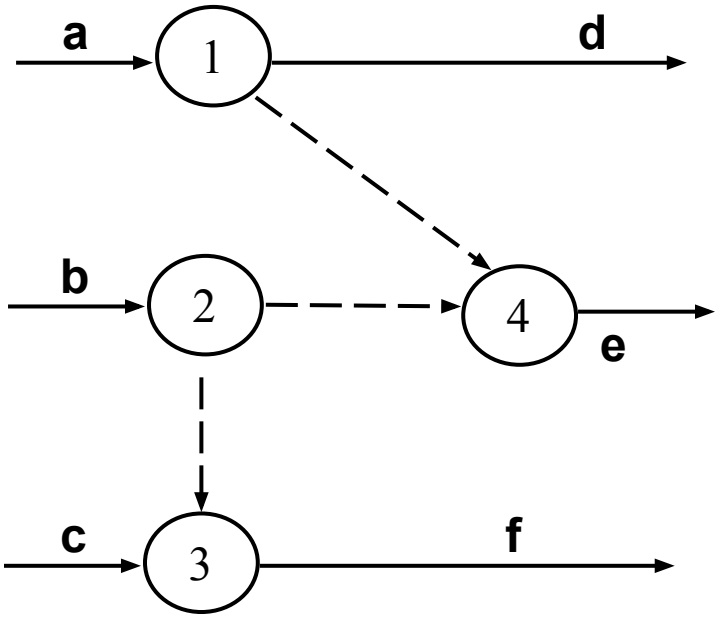
Figure 2-17

RIGHT ✔

WRONG!!!

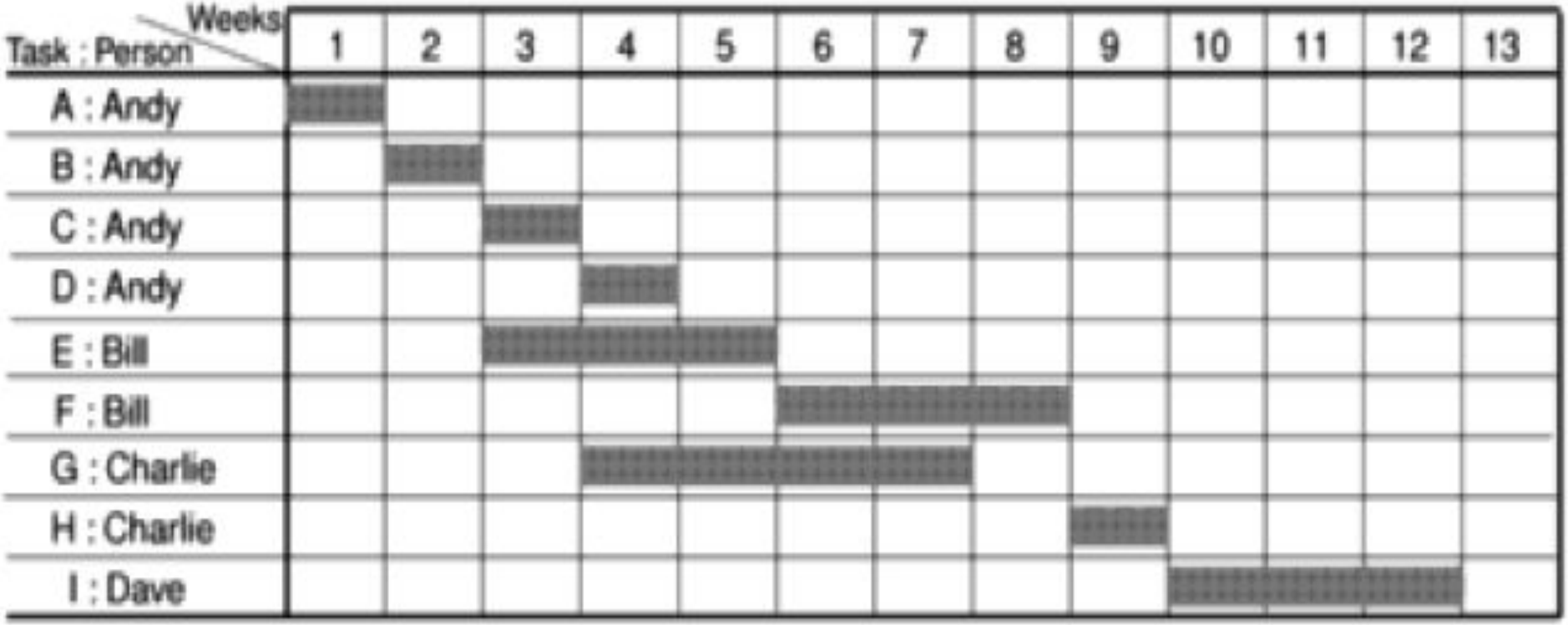


RIGHT!!!



a precedes **d.**
a and **b** precede **e,**
b and **c** precede **f** (**a** does not precede **f**)

Simple sequencing



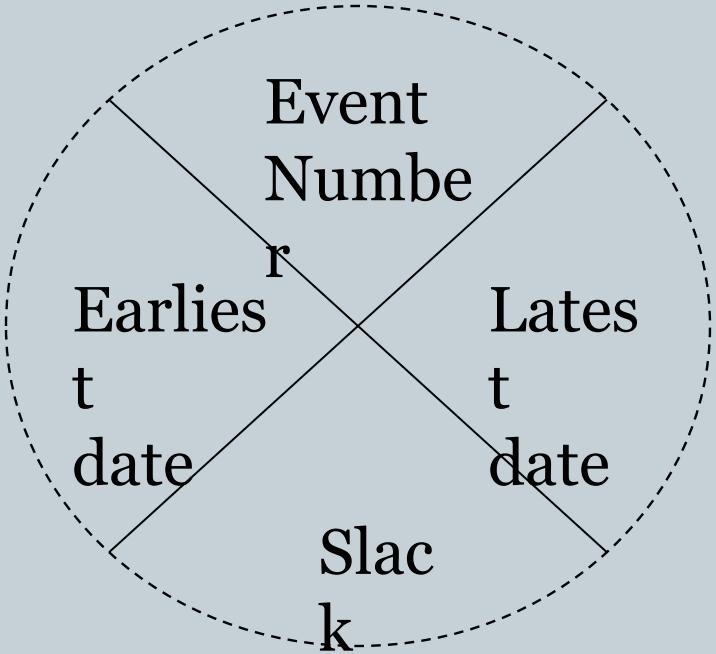
Activity key:

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 testing

CPM Network

- A project network should have only one start node
- A project network should have only one end node
- A link has duration
- Nodes have no duration
- Precedents are immediate preceding activities
- Time moves from Left to Right
- Nodes are numbered sequentially
- A network should not contain loops
  - Leads to an impossible sequence
- A network should not contain dangles

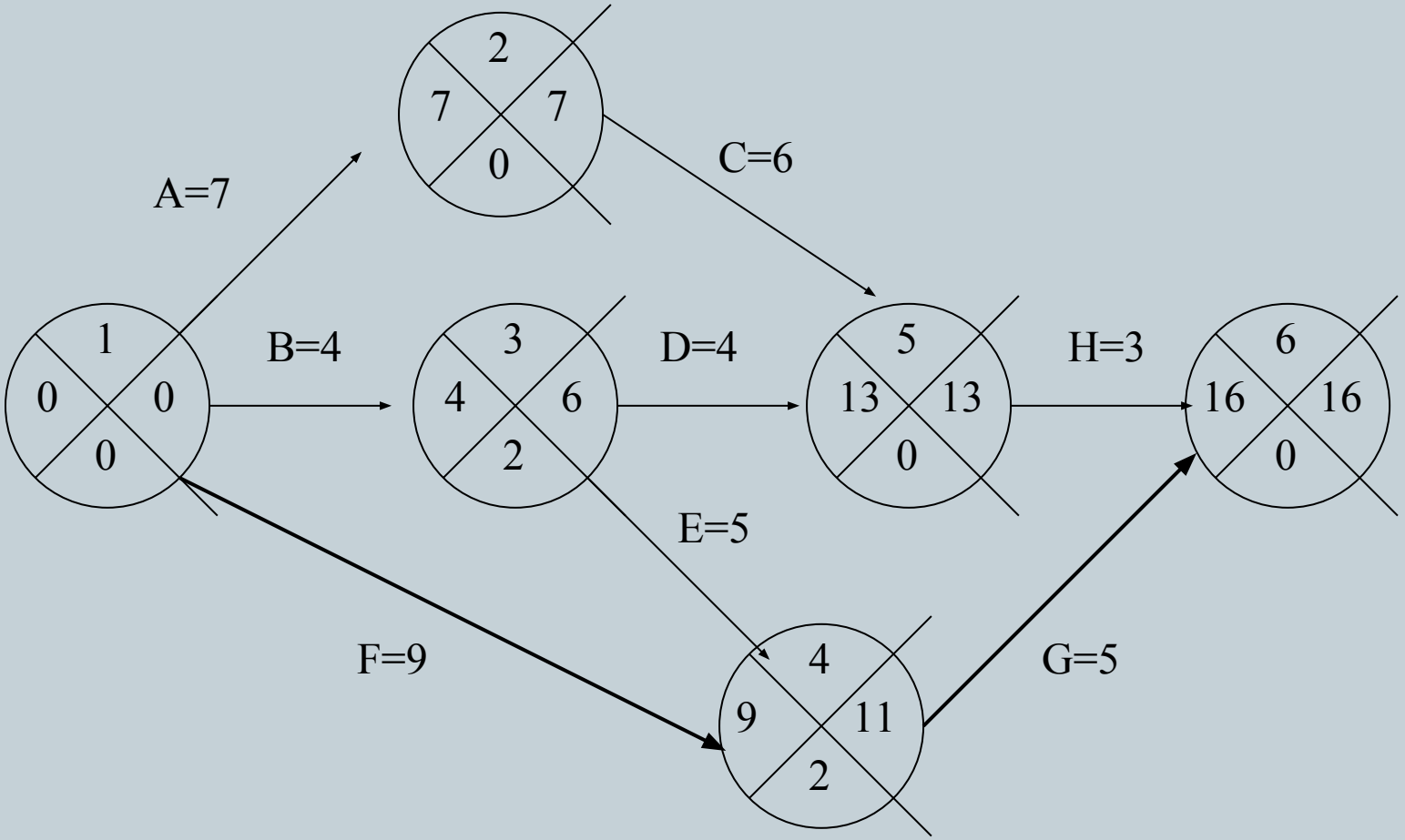
CPM Convention



Example to construct a CPM

Id.	Activity Name	Duration (weeks)	Precedents
A	Hardware selection	7	
B	Software design	4	
C	Hardware Installation	6	A
D	Coding	4	B
E	Data Preparation	5	B
F	User Documentation	9	
G	User Training	5	E,F
H	System Installation	3	C,D

Cont...



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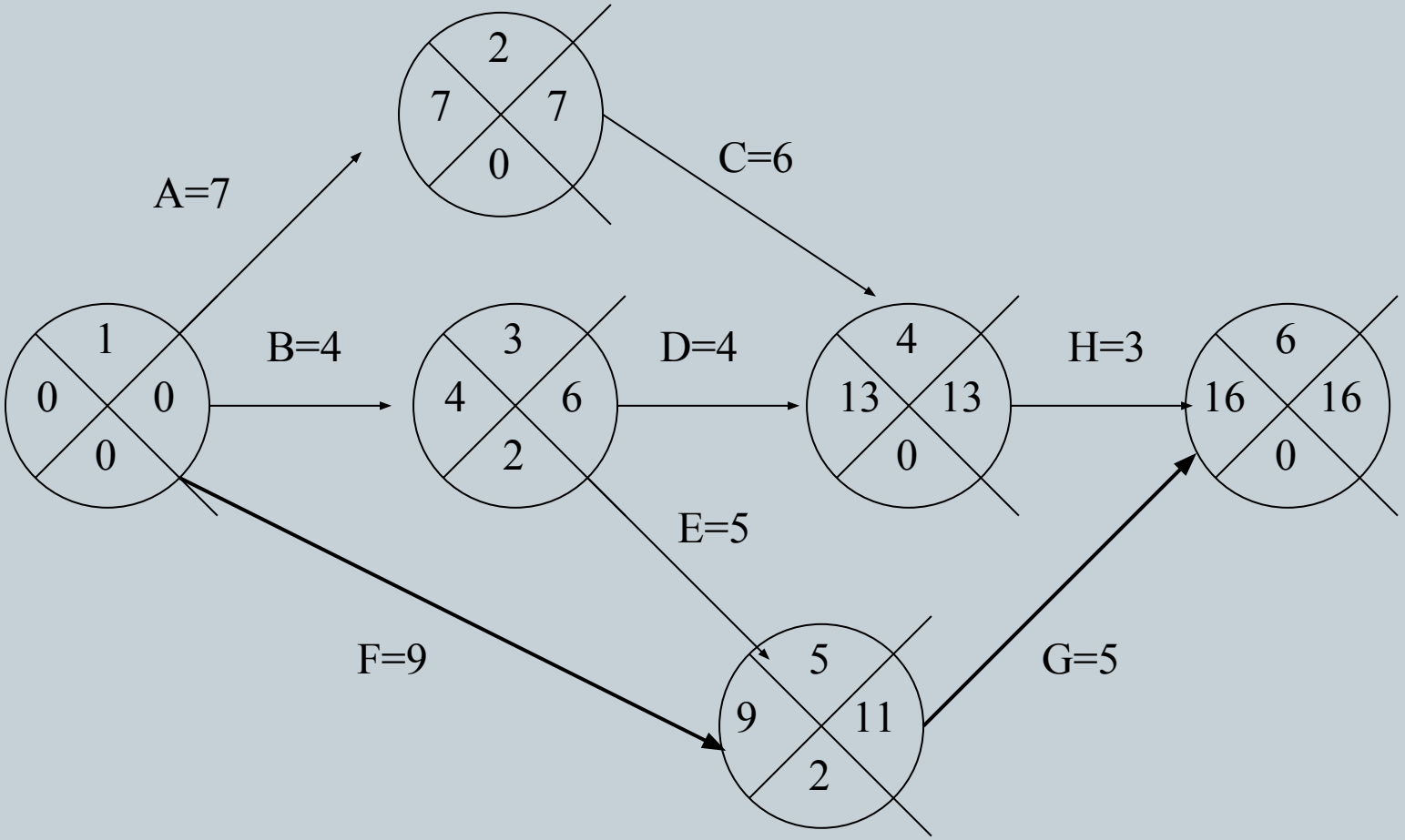


Critical Path

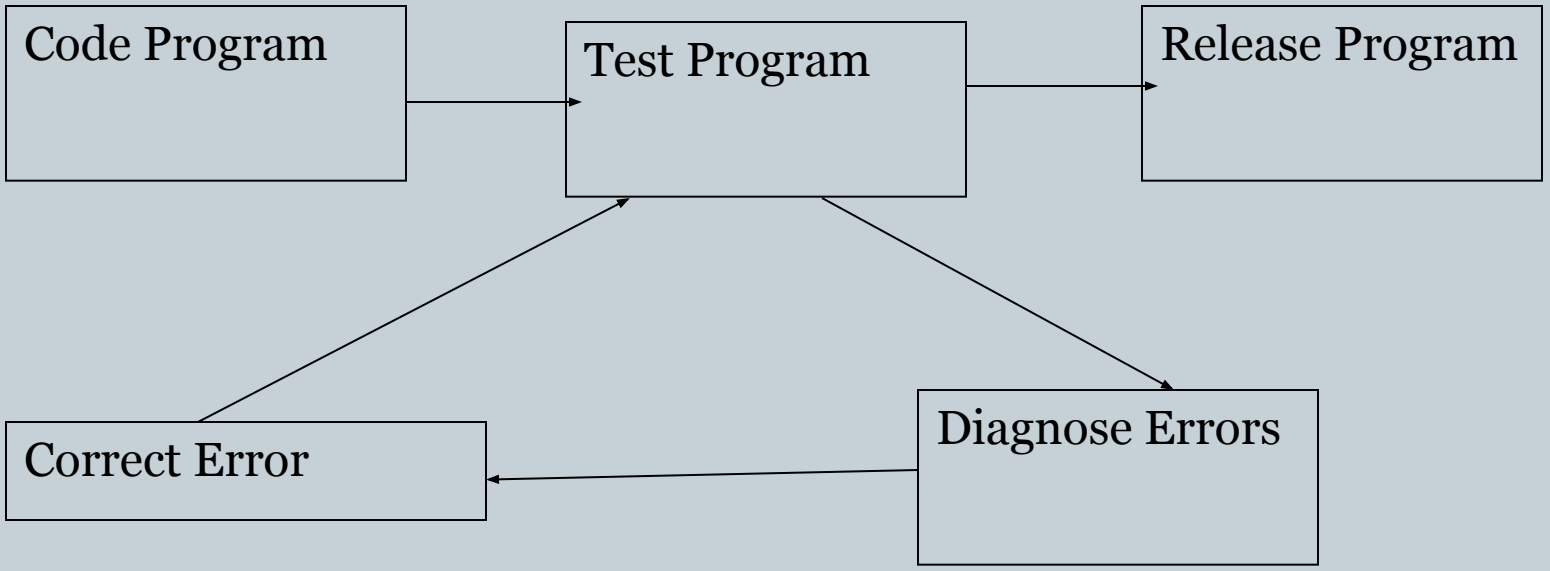
- Any delay in critical path delays the project
- Slack= difference between earliest and latest dates
- Any event with slack 0 is critical.
  - Path joining these events is critical path
- Activity float
  - Float=difference in earliest finish and it's latest start

Adding the time dimension

- Critical path approach is concerned with:
  - Project completed as quickly as possible
  - Identifying activities leads to delay project or later activities start date, if delayed.
- Forward pass
  - Earliest dates of activities
- Backward pass
  - Latest start dates and the critical path

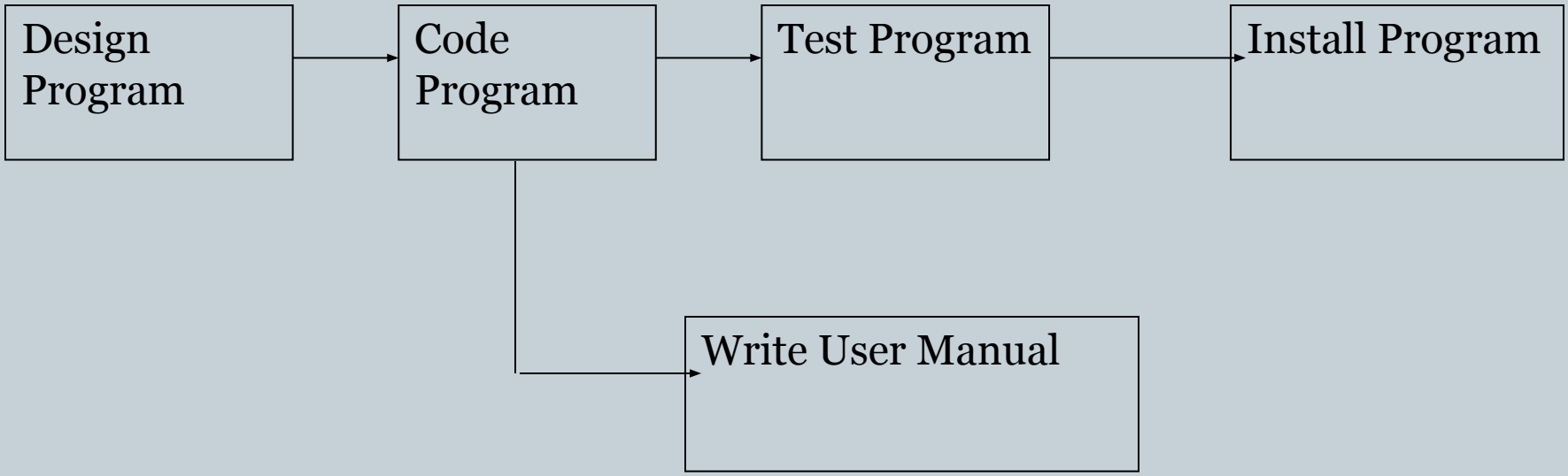
Cont…

- Loop representing impossible sequencing



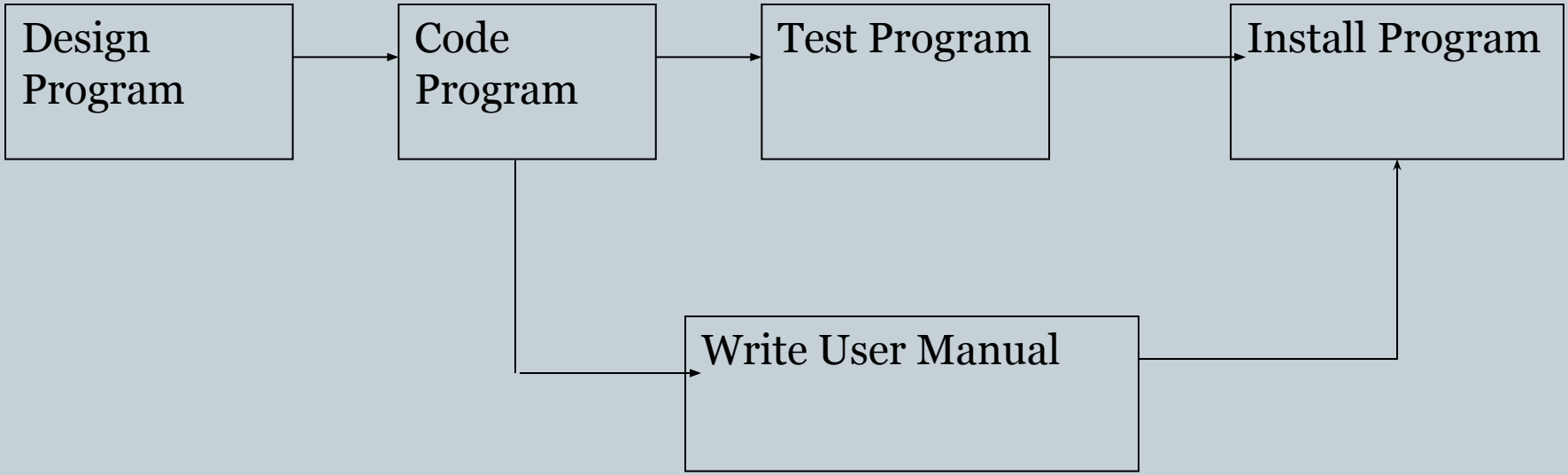
Cont…

- Dangling activities indicate errors in logic



Cont…

- Solution is:
  - Remove dangle activities
  - If that is a part of project => re-draw the network



Significance of critical path

- During planning stage
  - Shortening the critical path will reduce the overall project duration
- During management stage
  - Pay more attention to those activities which fall in the critical path

Risk Management

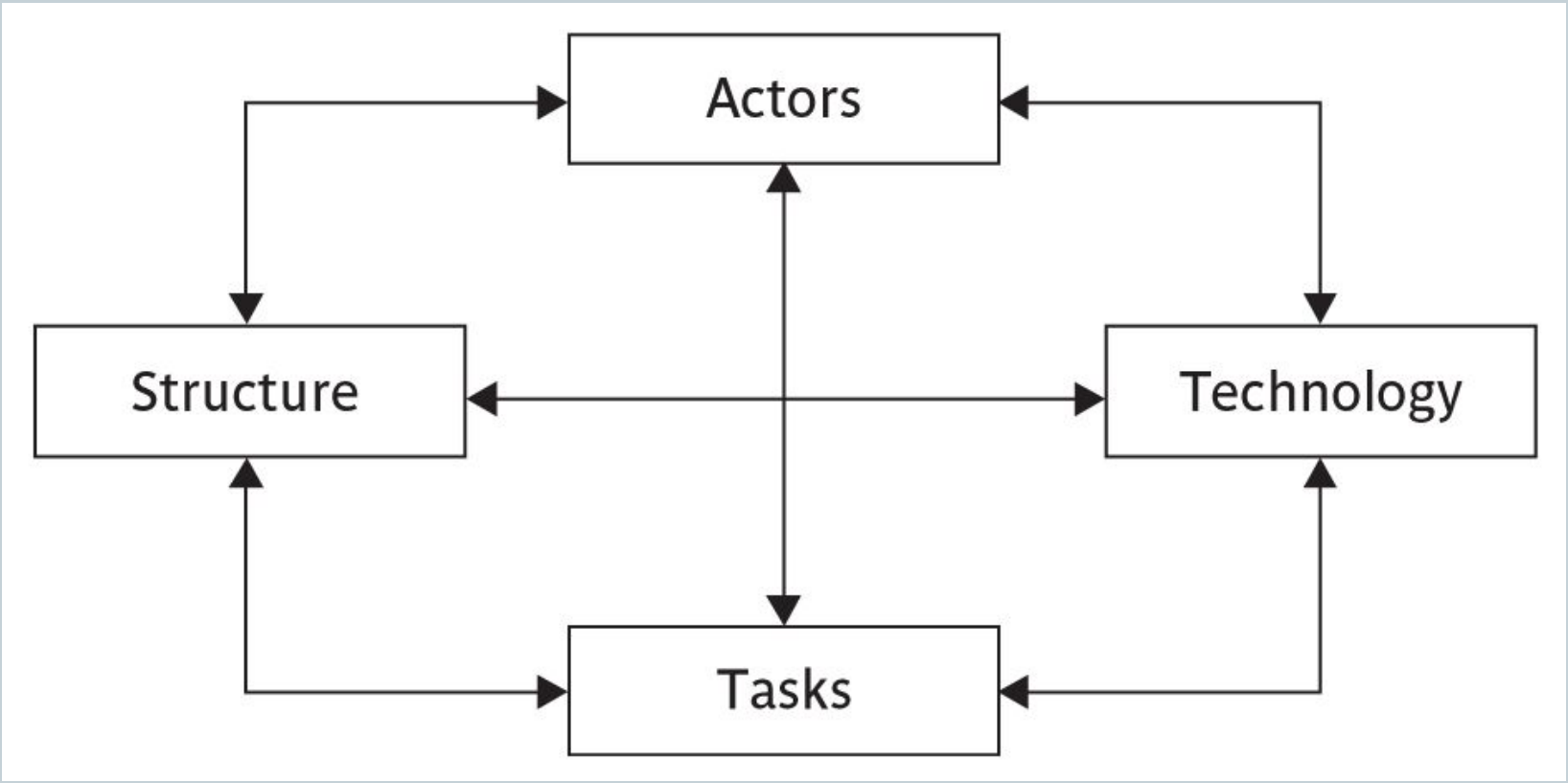
Risk

- An uncertain event or condition that,
  - if it occurs, has a
    - positive or
    - negative effect on a project's objectives.
- Risk relates to future
- It involves cause and effect

Risk Categorization

- Risk management is considering uncertainty remaining after a plan has been formulated.
- Project risks
- Business risks

Cont…



Nature of risk

- Estimation Errors
- Planning assumptions
- Eventualities
  - Unexpected events

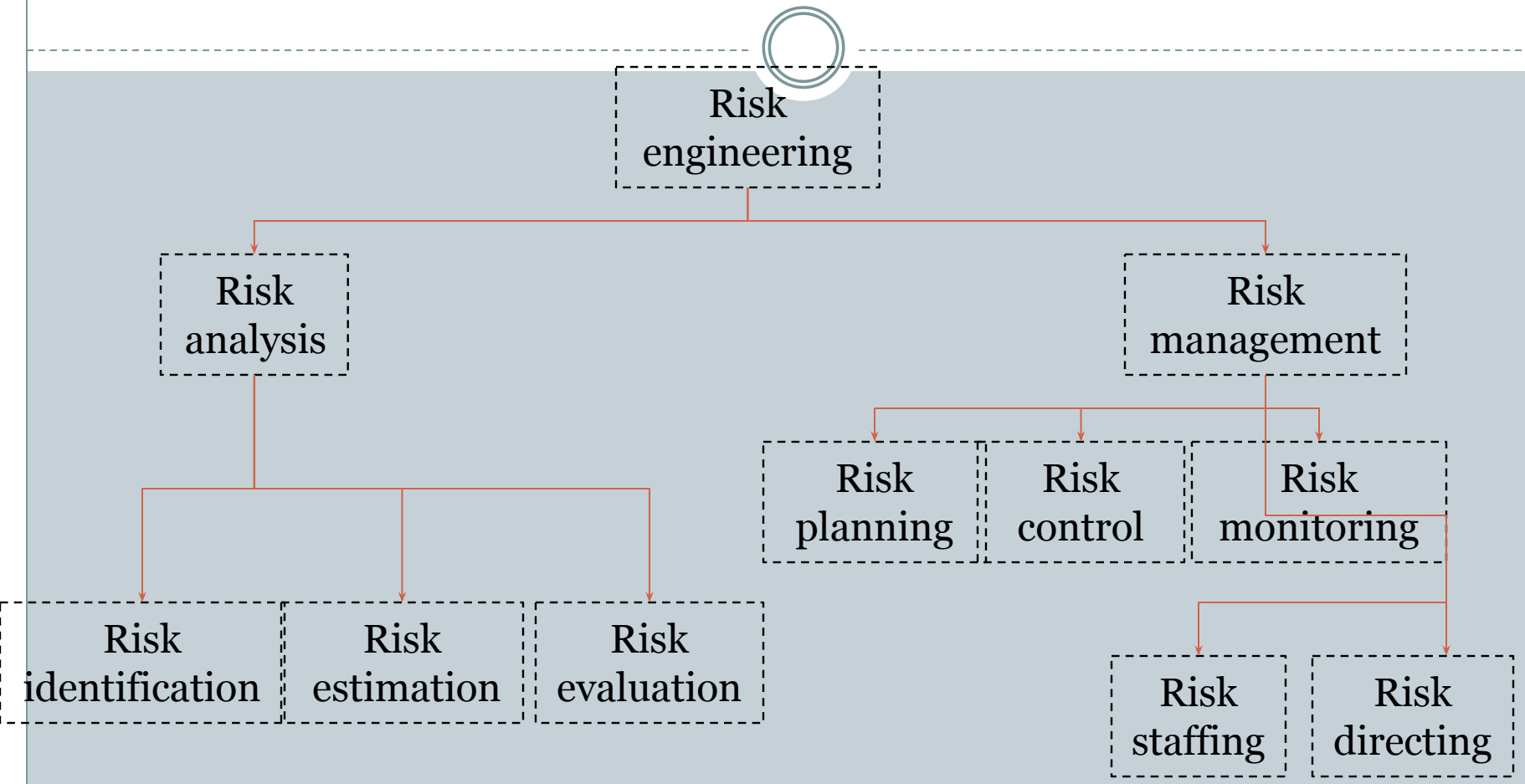
Risk Management

- Risk Identification
  - Checklist
  - Brainstorming
- Risk Estimation
  - Likelihood
  - Impact
- Risk Evaluation
- Risk Planning

Cont…

- Risk Control
  - Aspects of quality control
- Risk Monitoring
- Risk directing and
- Risk staffing

Cont...


Risk engineering
Risk analysis
Risk management
Risk identification
Risk estimation
Risk evaluation
Risk planning
Risk control
Risk monitoring
Risk staffing
Risk directing

Evaluating risks to the scheduling

Using PERT

- Most likely time (m)
  - Normal condition time
- Optimistic time (a)
  - Shortest time
- Pessimistic time (b)
  - Worst possible time

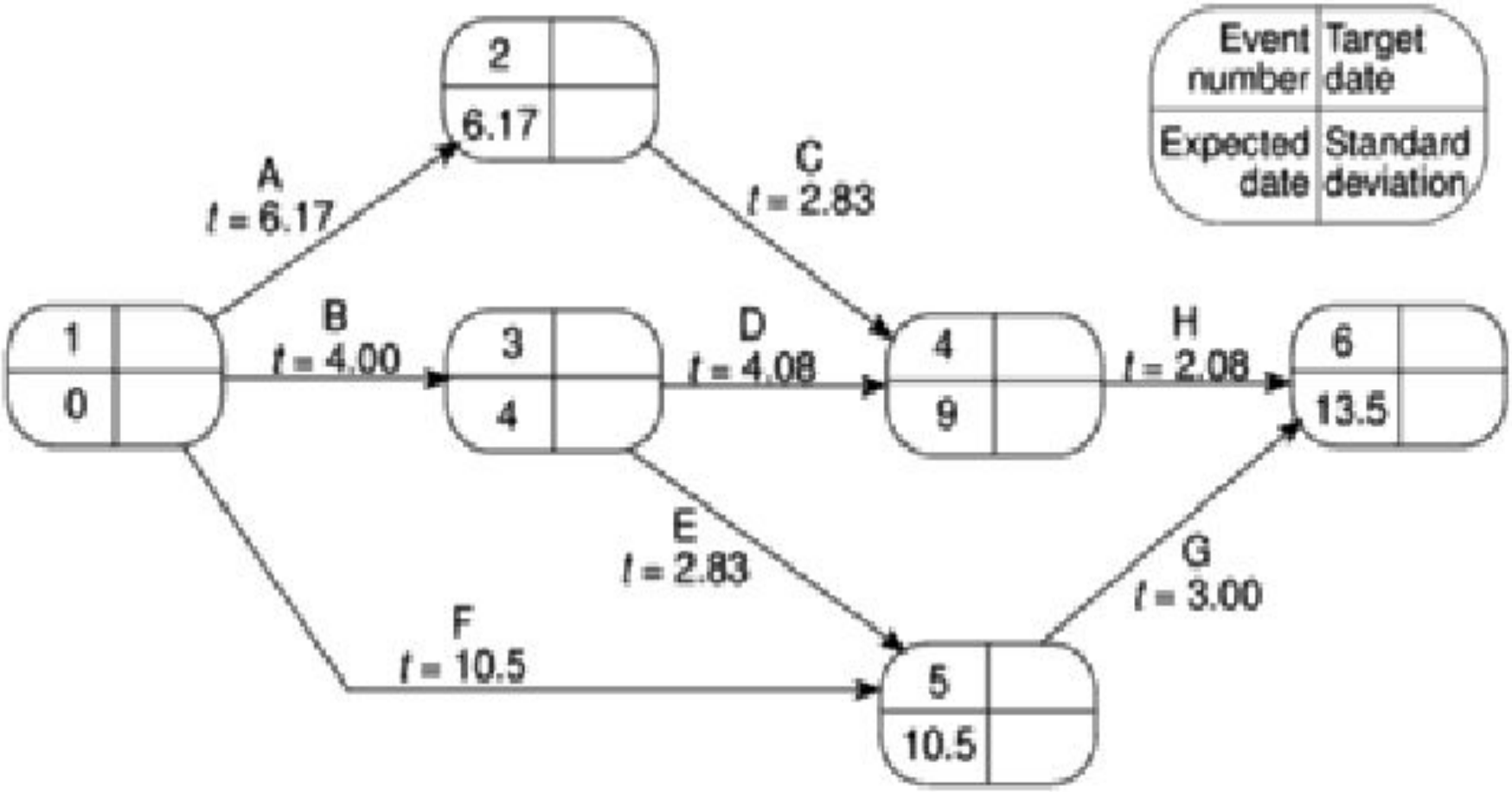
- Single expected duration(t_e)

$$t_e = (a+4m+b)/6$$

Using expected duration

Activity	Activity durations (weeks)		
	Optimistic (a)	Most likely (m)	Pessimistic (b)
A	5	6	8
B	3	4	5
C	2	3	3
D	3.5	4	5
E	1	3	4
F	8	10	15
G	2	3	4
H	2	2	2.5

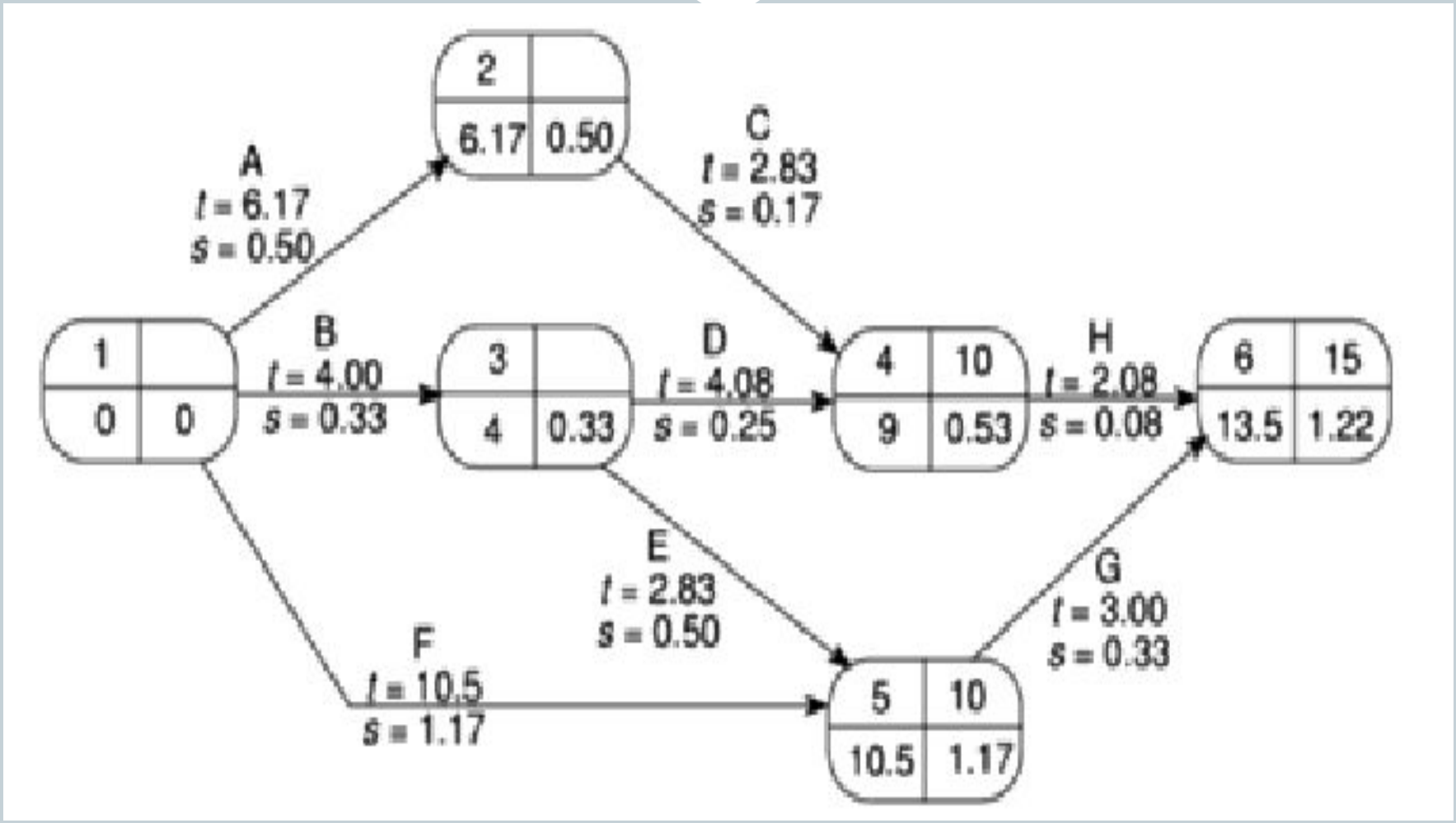
Cont…


Event number
Target date
Expected date
Standard deviation
1
0
2
6.17
3
4
4
9
5
10.5
6
13.5
A
t = 6.17
B
t = 4.00
C
t = 2.83
D
t = 4.08
E
t = 2.83
F
t = 10.5
G
t = 3.00
H
t = 2.08

- Standard Deviation(s):
- S=(b-a)/6

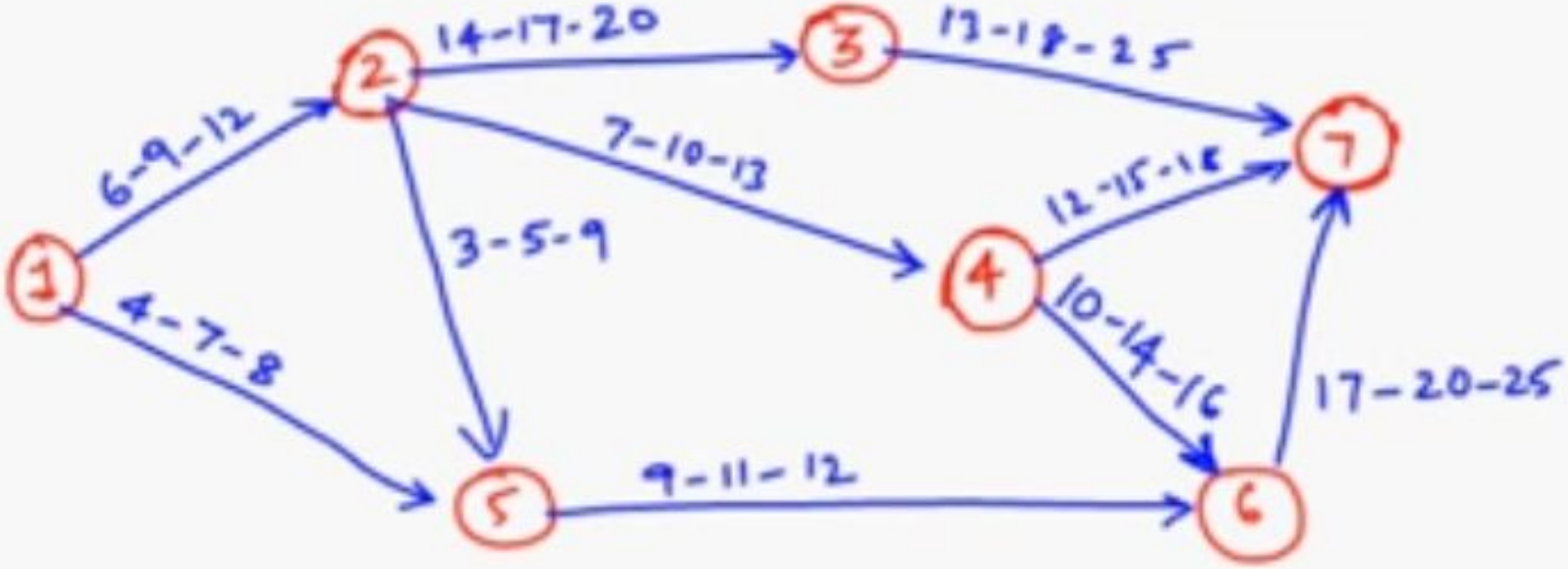
Activity	Activity durations (weeks				
	Optimistic (a)	Most likely (m)	Pessimistic (b)	Expected (t_e)	Standard deviation (s)
A	5	6	8	6.17	0.50
B	3	4	5	4.00	0.33
C	2	3	3	2.83	0.17
D	3.5	4	5	4.08	0.25
E	1	3	4	2.83	0.50
F	8	10	15	10.50	1.17
G	2	3	4	3.00	0.33
H	2	2	2.5	2.08	0.08

Cont…


2
6.17 0.50
A
t = 6.17
s = 0.50
C
t = 2.83
s = 0.17
1
0 0
B
t = 4.00
s = 0.33
3
4 0.33
D
t = 4.08
s = 0.25
4 10
9 0.53
H
t = 2.08
s = 0.08
6 15
13.5 1.22
E
t = 2.83
s = 0.50
G
t = 3.00
s = 0.33
F
t = 10.5
s = 1.17
5 10
10.5 1.17

- Calculating the Z value:

$$Z=(T-t_e)/s$$



For each activity of the network, the three time estimates to, tm and tp are given along the arrows in the to-tm-tp order. Determine variance and expected time for each activity.

For each activity of the network, the three time estimates t_o, t_m and t_p are given along the arrows in the t_o-t_m-t_p order. Determine variance and expected time for each activity.

$\frac{40}{6} = 6\frac{4}{6} = 6.67$ $\frac{82}{7} = 11.66$ $\frac{90}{6} = 15$ $\frac{110}{6} = 18.3$ $\frac{65}{6} = 10.8$ $\frac{32}{6} = 5.33$ $\frac{102}{6} = 17$

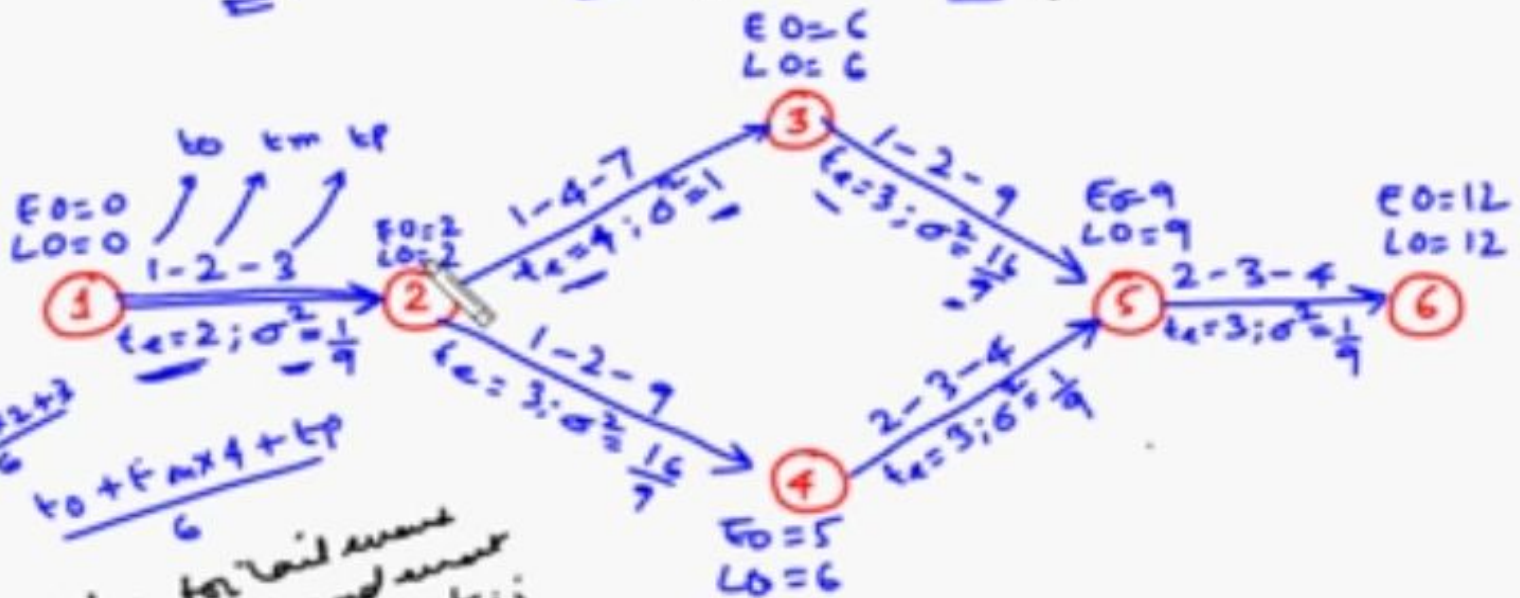
Activity	t_o	t_m	t_p	σ^2	t_e
1-2	6	9	12	1	9
1-5	4	7	8	0.44	6.67
2-3	14	17	20	1	17
2-4	7	10	13	1	10
2-5	3	5	9	1	5.33
5-6	9	11	12	0.25	10.8
3-7	13	18	25	4	18.3
4-7	12	15	18	1	15
4-6	10	14	16	1	13.66
6-7	17	20	25	1.78	20.33

$\left(\frac{t_p - t_o}{6}\right)^2 = \left(\frac{12-6}{6}\right)^2 = \left(\frac{6}{6}\right)^2 = 1^2 = 1$ $\left(\frac{8-4}{6}\right)^2 = \left(\frac{4}{6}\right)^2 = \left(\frac{2}{3}\right)^2 \left(\frac{4}{5}\right)^2$

$\left(\frac{20-14}{6}\right)^2 = \left(\frac{6}{6}\right)^2 = 1^2 = 1$ $\left(\frac{13-7}{6}\right)^2 = \left(\frac{6}{6}\right)^2 = 1$

$\frac{122}{6} = 20.33$ $\frac{6+4\times9+12}{6} = \frac{54}{6} = 9$

Consider the network shown. The three time estimates, the expected activity durations and the variances are shown along the arrows. The earliest and latest allowable occurance times for the events are also given. What is the probability of completing the project in ① 12 days ② 14 days ③ 10 days.

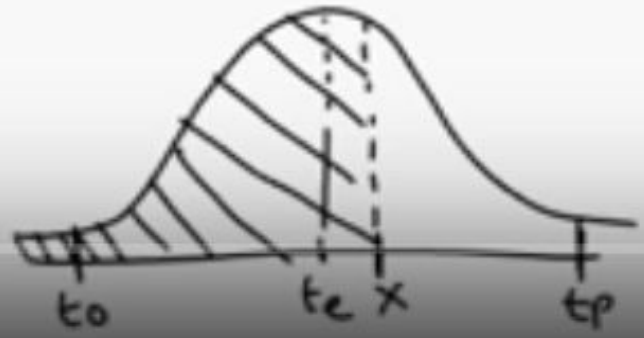


① EO = LO for the last event

② EO = LO for the last event

③ $E_j - E_i = L_j - L_i = t_{ij}$

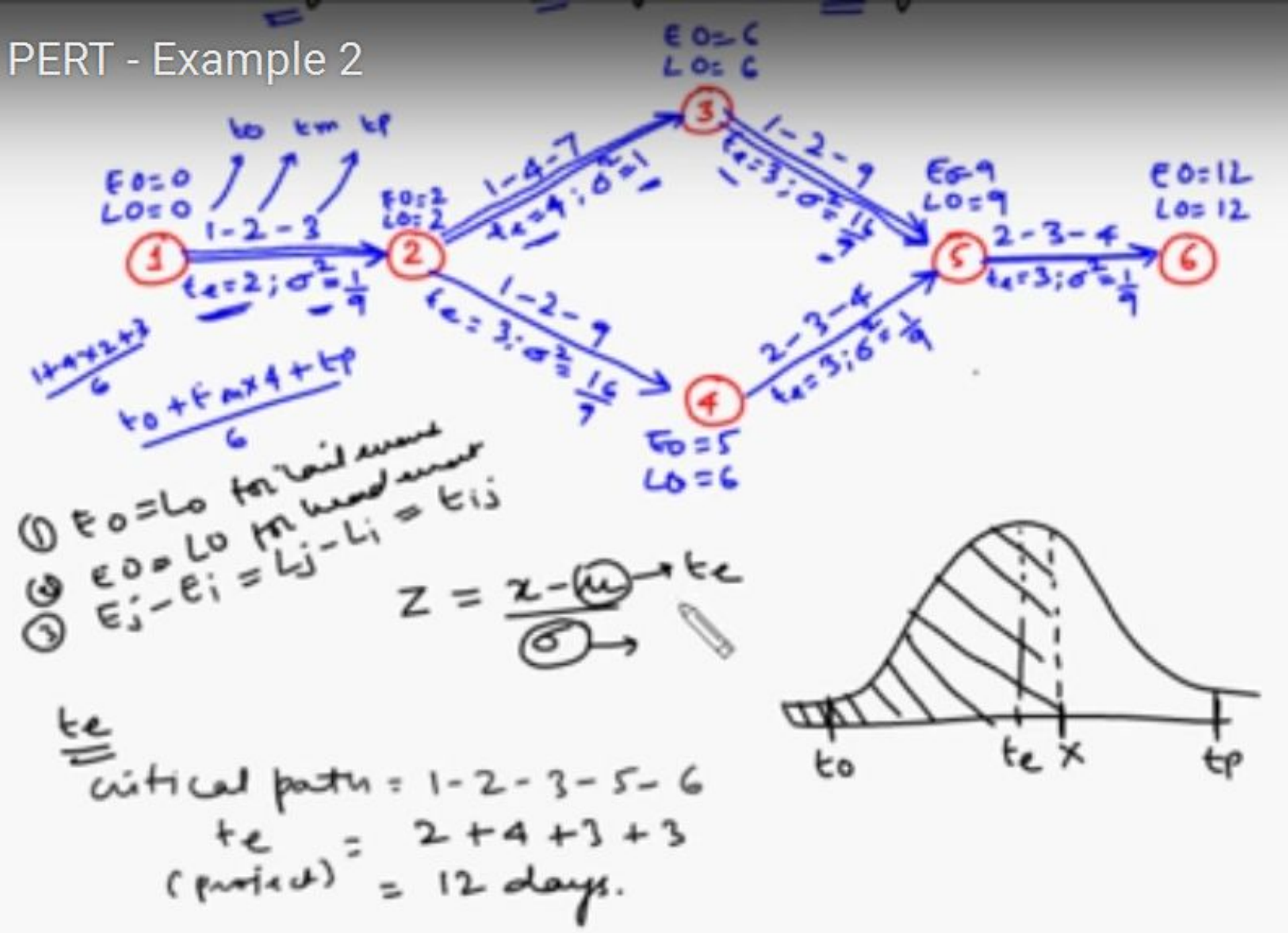
$$Z = \frac{x - \mu}{\sigma} \rightarrow t_e$$



$t_e =$

8:22

PERT - Example 2



① E0 = L0 for critical events
② E0 = L0 for critical events
③ Ej − Ei = Lj − Li = tij

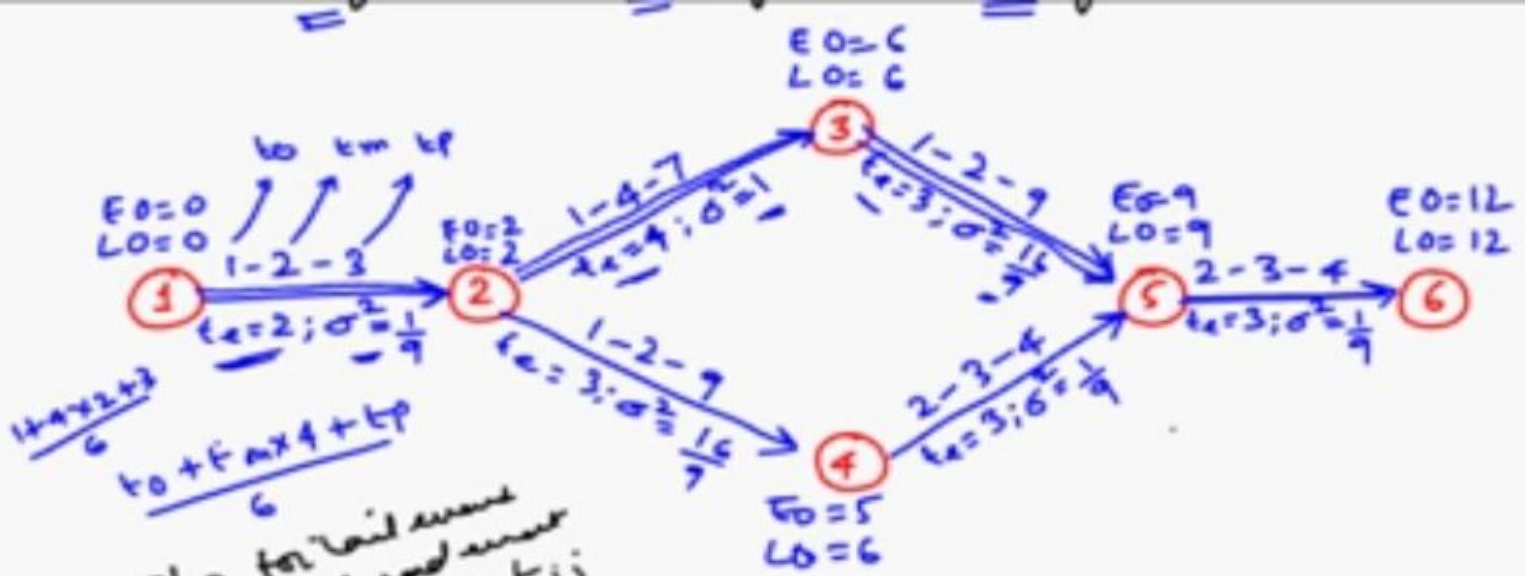
$$Z = \frac{x - \mu}{\sigma} \rightarrow te$$

te

Critical path = 1-2-3-5-6

te = 2 + 4 + 3 + 3

(project) = 12 days.

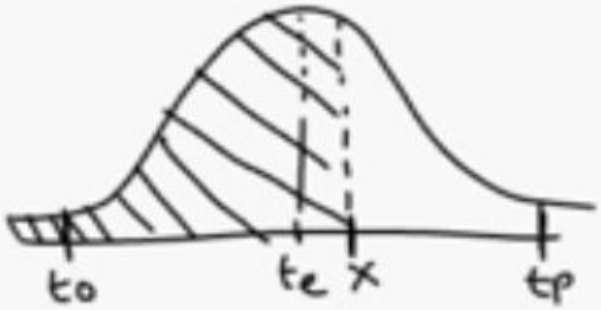


① EO = LO for tail event

② EO = LO for head event

③ $E_j - E_i = L_j - L_i = t_{ij}$

$$Z = \frac{x - \mu \to t_e}{\sigma}$$



t_e

Critical path = 1-2-3-5-6

t_e = 2 + 4 + 3 + 3

(period) = 12 days.

$$\sigma^2 = \sigma^2_{1-2} + \sigma^2_{2-3} + \sigma^2_{3-5} + \sigma^2_{5-6}$$

$$\sigma = \sqrt{\frac{1}{9} + 1 + \frac{16}{9} + \frac{1}{9}}$$

$$\sigma = \sqrt{3}$$

$$= 1.73$$

$$\frac{1}{9} + \frac{1}{1} + \frac{16}{9} + \frac{1}{9}$$

$$= \frac{1 + 9 + 16 + 1}{9}$$

$$= \frac{27}{9}$$

$$= 3$$

$t_e = 12$ days

$\sigma = 1.73$

① 12 days.

$$z = \frac{x - \mu}{\sigma}$$

$$= \frac{12 - 12}{1.73} = 0$$

② 14 days

$$z = \frac{14 - 12}{1.73} = \frac{2}{1.73} = 1.16$$

③ 10 days

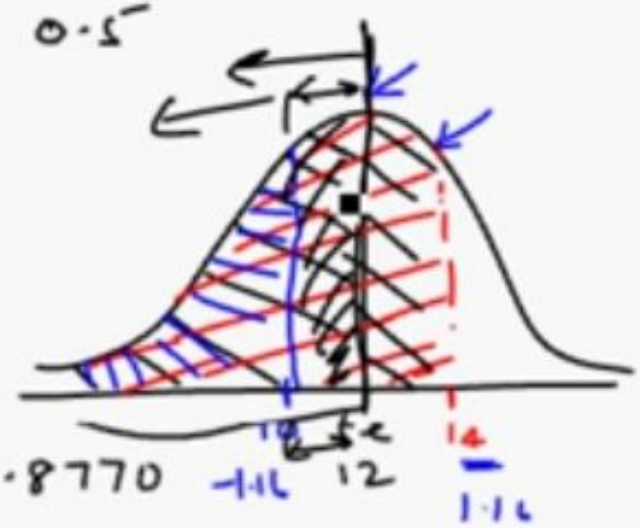
$$z = \frac{10 - 12}{1.73} = \frac{-2}{1.73} = -1.16$$

Normal Distribution

	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993

(1) 12 days ; $Z = 0$; proportion of area = 0.5

probability = 50 %



(2) 14 days ; $Z = 1.16$; proportion of area = 0.8770

probability = 87.7 %

(3) 10 days : $Z = -1.16$:

$0.8770 - 0.5 = 0.3770$

$0.5 - 0.3770 = 0.1230$

probability = 12.3 %

$$\begin{array}{r} 0.^{4}8^{9}700 \\ -\ 0.3770 \\ \hline 0.1230 \end{array}$$