

Software Engineering

Project Scheduling and Tracking

❑ Why project scheduling

- **Interdependency** task gular moddhe relaton . amon hote pare akti tasker output onno aktir input hisebe kaj kortese
 - Relation among tasks
 - Output of a task may be input of another task
- **Assessing progress**


❑ **Root causes of late delivery of a software**

- Unrealistic deadline
 - Established by someone outside the software development group
 - Forced to the group
- Changing customer requirements
 - Schedule not changed
- Underestimating the effort, resources required
- Unconsidered risks
- Technical difficulties
 - Could not be foreseen in advance
- Human difficulties
 - Could not be foreseen in advance
- Miscommunication among project staff
 - Results in delay

Project Scheduling and Tracking

- ❑ Root causes of late delivery of a software
 - Failure by project management
 - Project is falling behind schedule
 - Lack of action to correct the problem
- ❑ Basic principles of project scheduling
 - Compartmentalization
 - Project is compartmentalized into a number of manageable activities and tasks
 - Product and process are decomposed
 - Interdependency
 - Interdependency among each task must be determined
 - Sequential
 - Parallel
 - Time allocation
 - Allocating some number of work units
 - Assigning start date and completion date
 - Effort validation
 - Defined responsibilities
 - Assigning tasks to specific team members

Project Scheduling and Tracking

- ❑ Basic principles of project scheduling
 - Defined outcomes
 - Work products
 - Defined milestones
- ❑ Degree of rigor
 - Casual
 - Process framework activities
 - Minimum task set
 - Minimized umbrella activities
 - Reduced documentation requirements
 - Structured
 - Process framework activities
 - Umbrella activities necessary to ensure high quality
 - Streamlined documentation
 - Strict
 - Full process
 - All umbrella activities
 - Quick reaction 
 - Emergency situation
 - Only tasks essential to maintain good quality

Project Scheduling and Tracking

□ Defining a task network/activity network

- Graphic representation of the task flow for a project
- Depicts major software engineering tasks

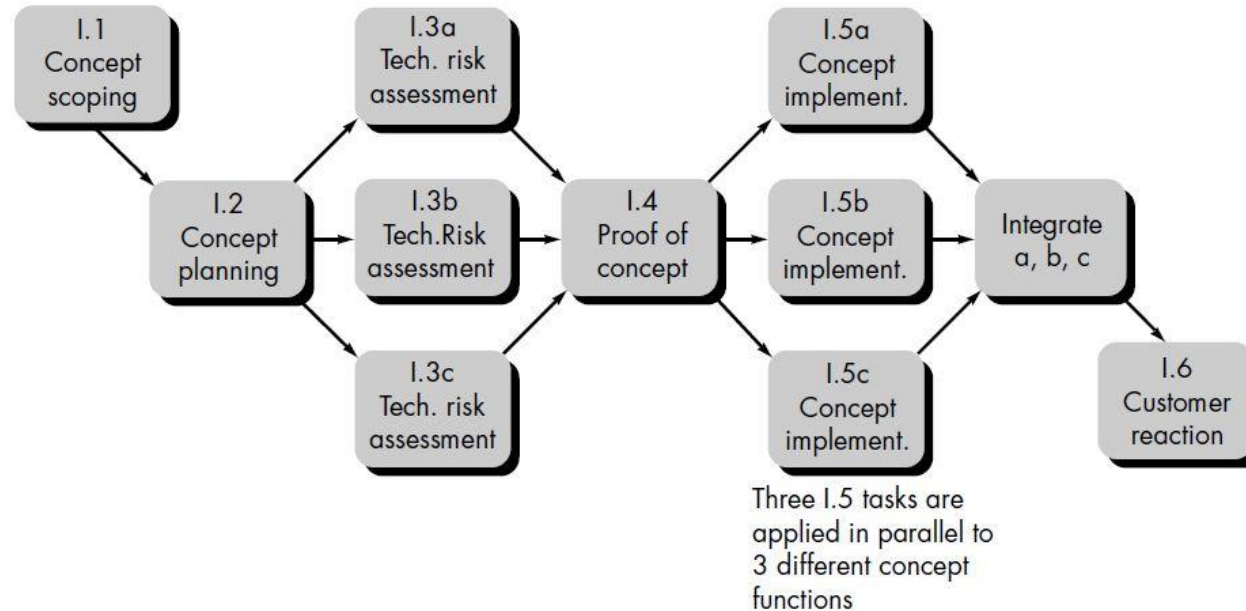


Figure 1: A task network for concept development

Project Scheduling and Tracking

□ Timeline chart/Gantt chart

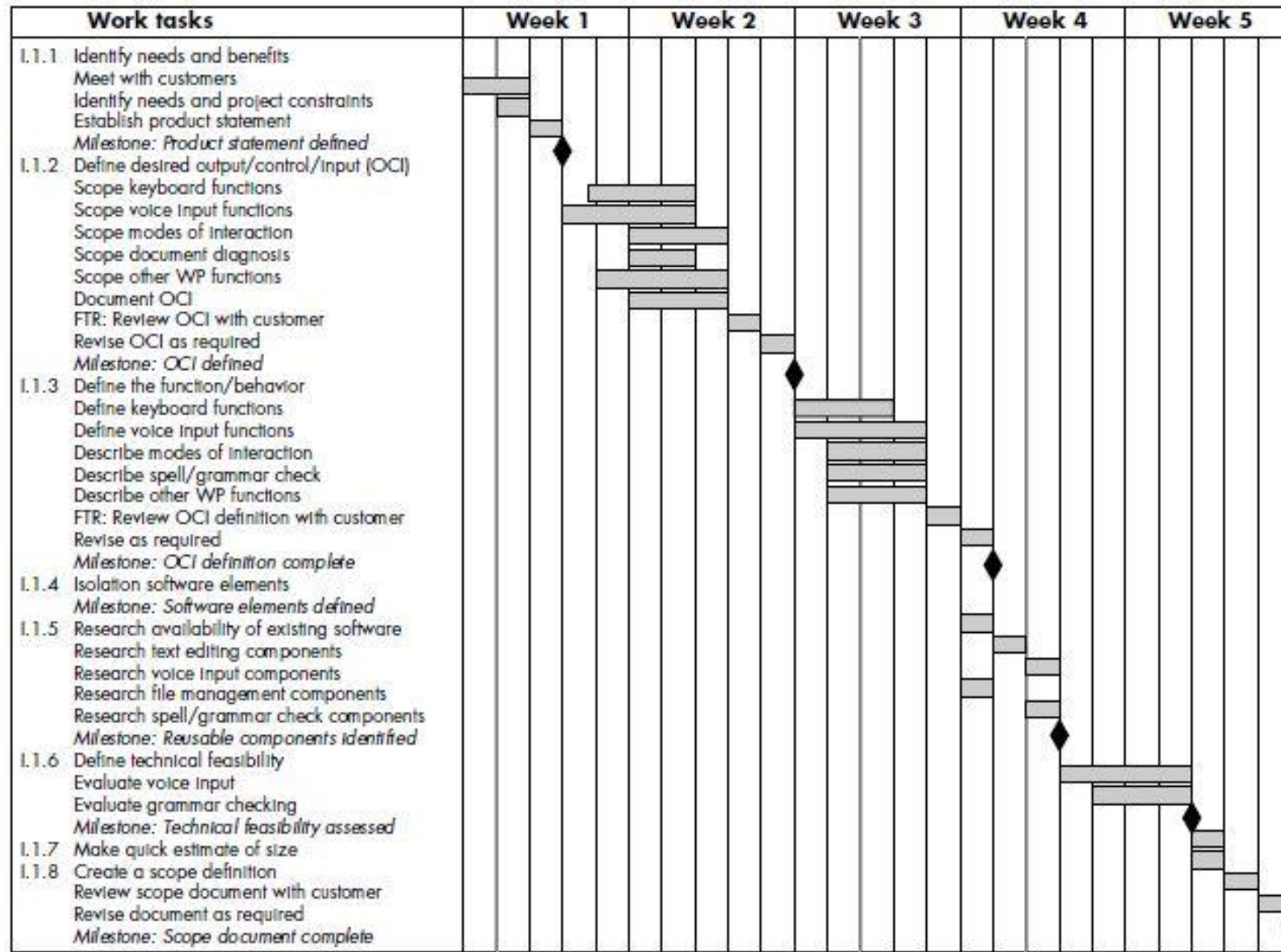


Figure 2: An example timeline chart

Project Scheduling and Tracking

❑ CPM (Critical Path Method)

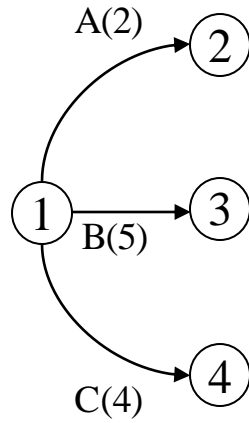
- Unique Start (tail)
- Unique End (head)

Activity	Immediate Predecessor(s)	Duration (Months)
A	---	2
B	---	5
C	---	4
D	B	5
E	A	7
F	A	3
G	B	3
H	C,D	6
I	C,D	2
J	E	5
K	F,G,H	4
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M	I	12
N	J,K	8

Project Scheduling and Tracking

❑ CPM (Critical Path Method)

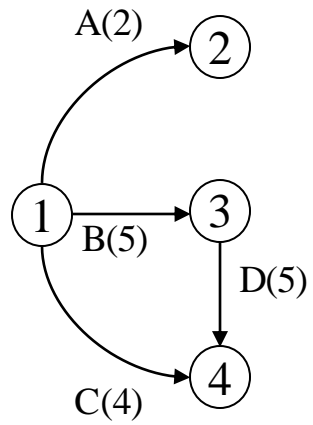
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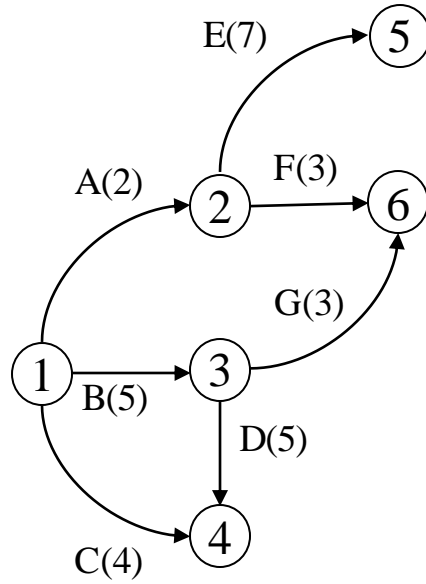
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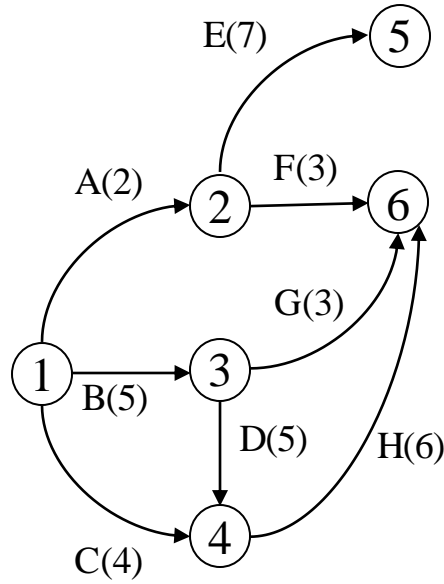
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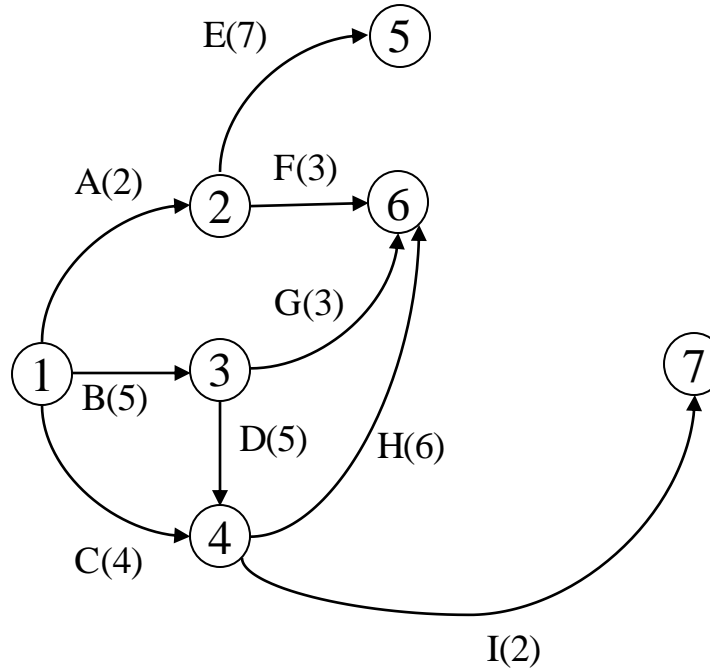
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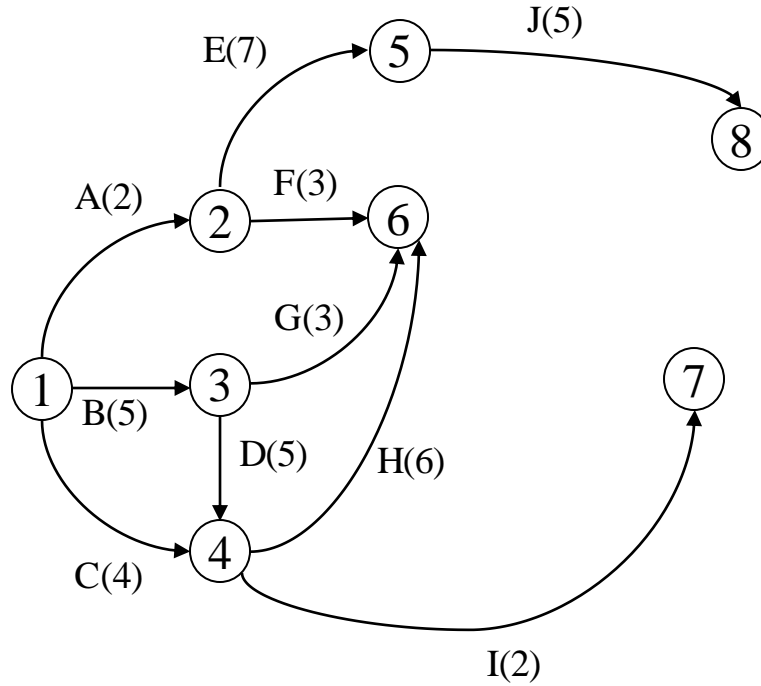
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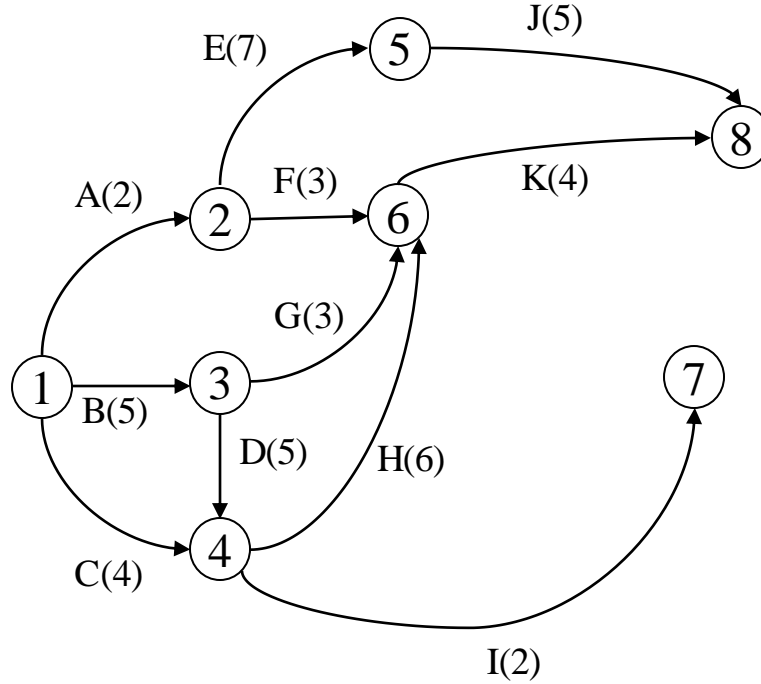
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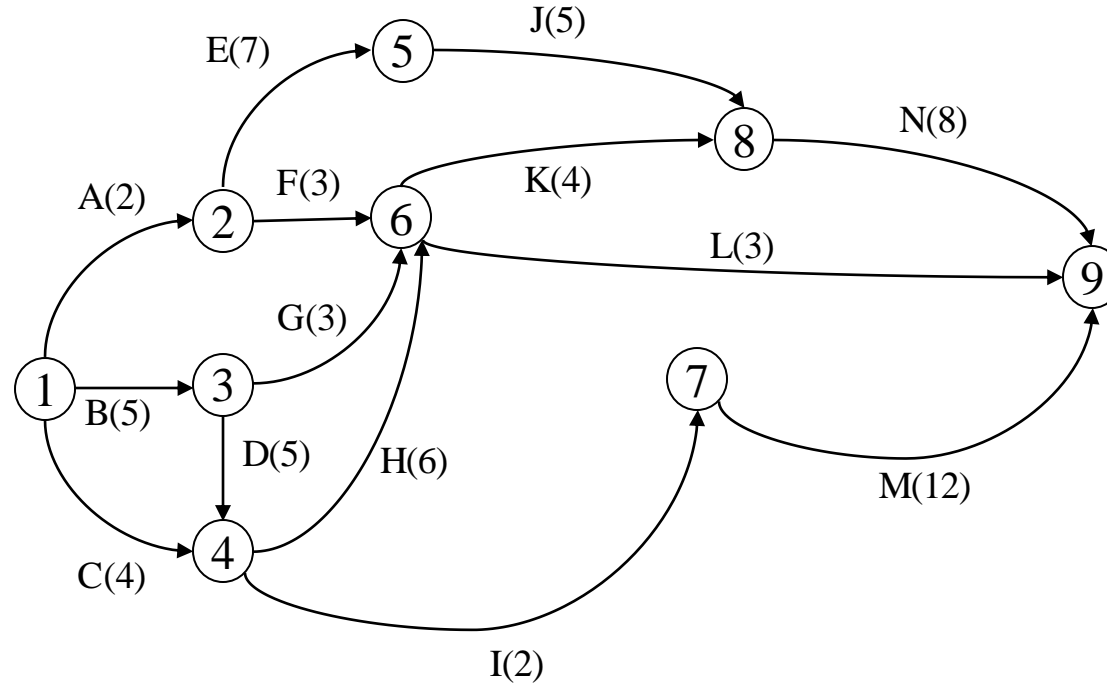
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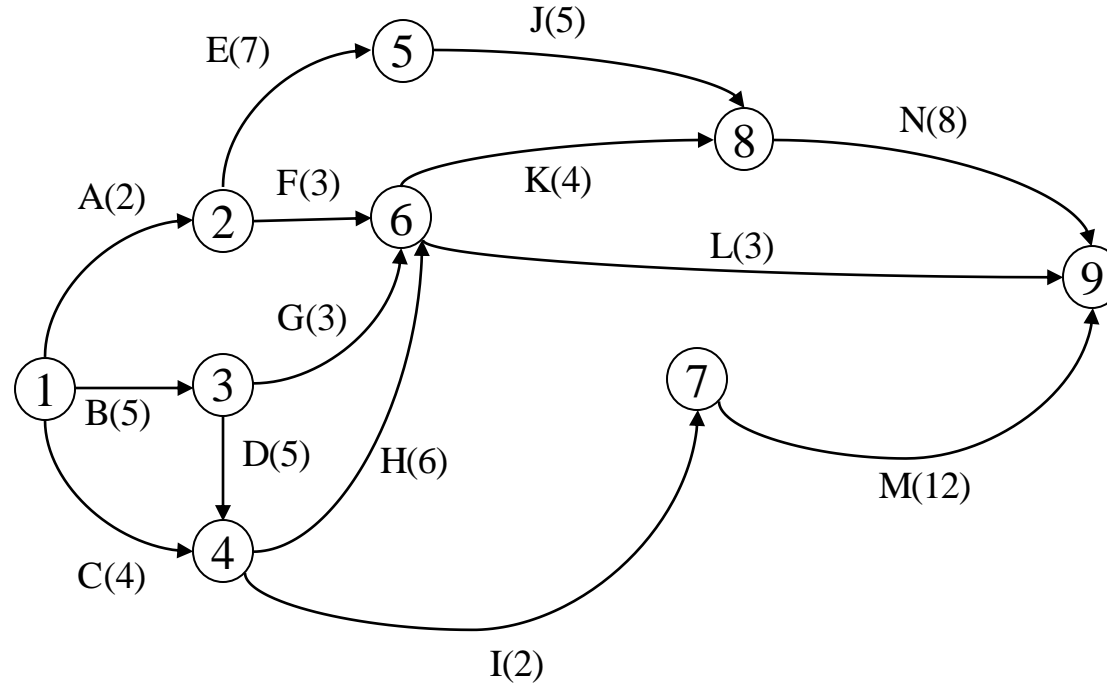


Figure 3: CPM Network

Project Scheduling and Tracking

□ CPM (Critical Path Method)

■ Critical Path

- › Longest distance between start and end
- › Earliest Start time (ES) [forward pass]
 - $ES_j = \text{Max}_i(ES_i + D_{ij})$
- › Latest Completion time (LC) [backward pass]
 - $LC_i = \text{Min}_j(LC_j - D_{ij})$

LC
ES

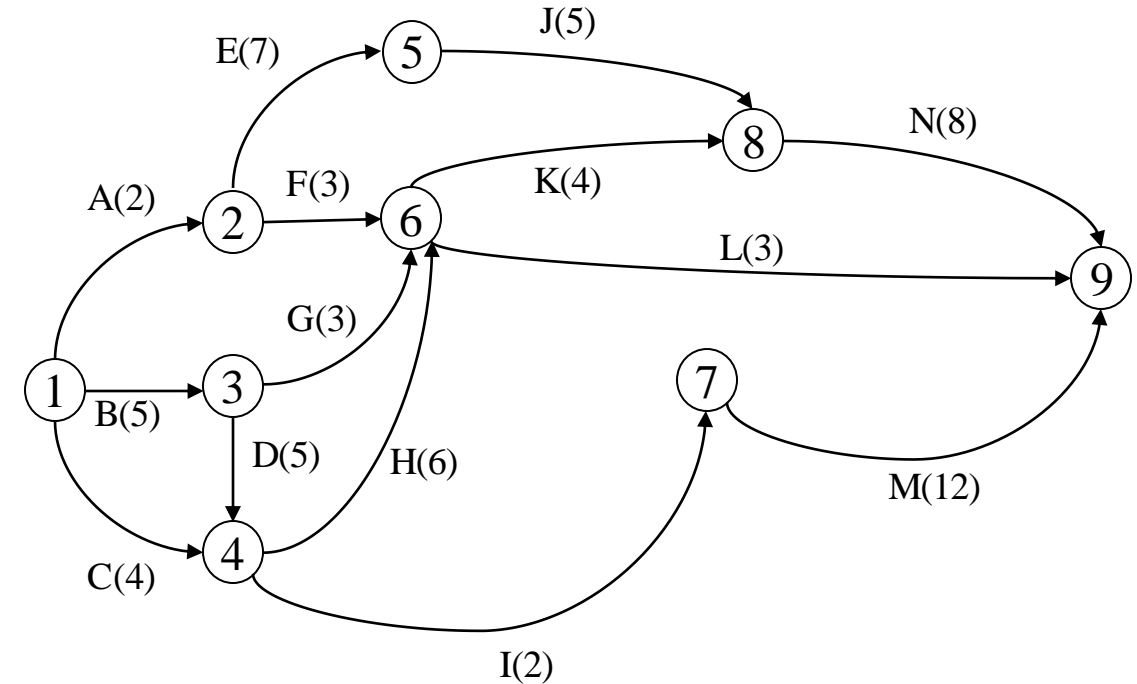


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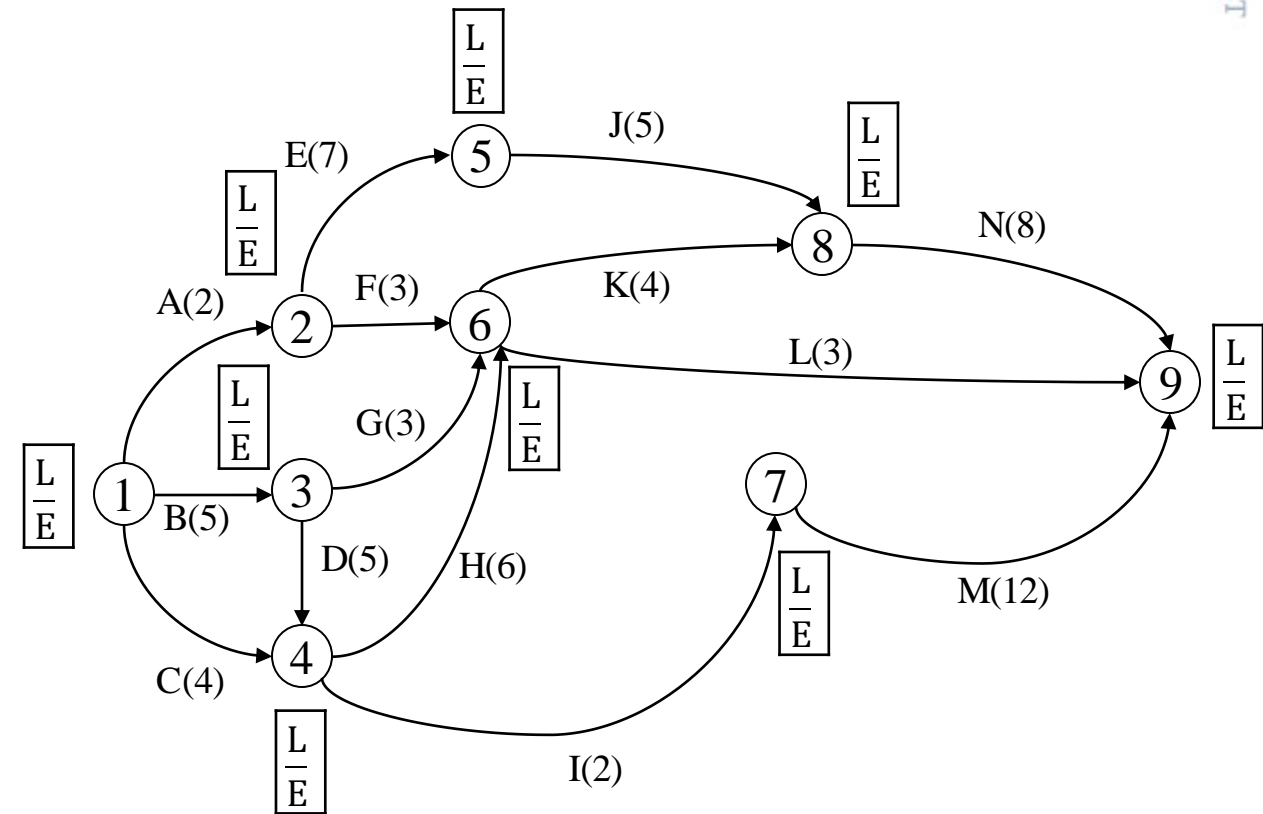
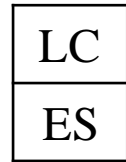


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Project Scheduling and Tracking

□ CPM (Critical Path Method)

■ Critical Path

› ES for Node 1: 0

› ES for Node 2

$$ES = \text{Max}(0 + 2) = 2$$

› ES for Node 3

$$ES = \text{Max}(0 + 5) = 5$$

› ES for **Node 4**

$$ES = \text{Max}(0 + 4, 5 + 5) = 10$$

› ES for Node 5

$$ES = 9$$

› ES for **Node 6**

$$ES = \text{Max}(3 + 2, 3 + 5, 6 + 10) = 16$$

› ES for Node 7

$$ES = 12$$

› ES for **Node 8**

$$ES = \text{Max}(5 + 9, 4 + 16) = 20$$

› ES for **Node 9**

$$ES = \text{Max}(8 + 20, 3 + 16, 12 + 12) = 28$$

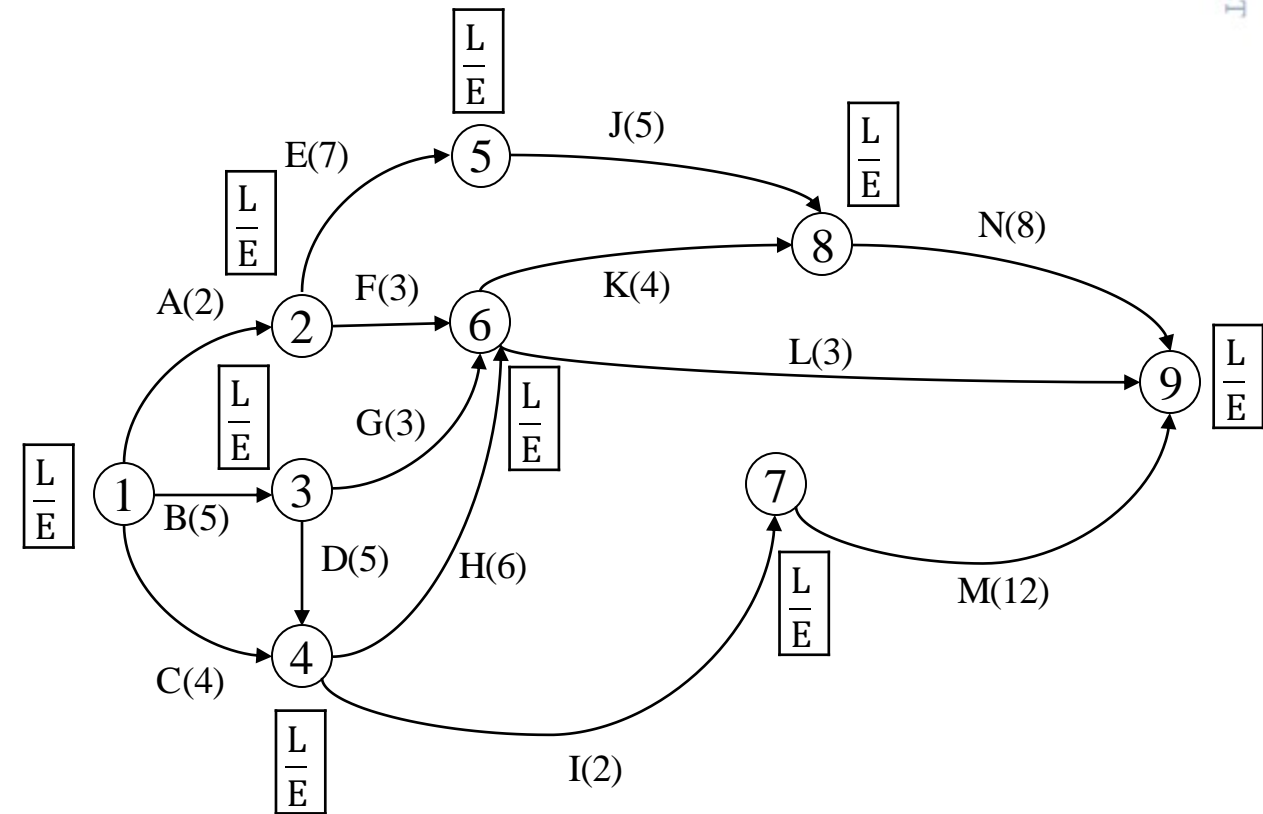


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› ES for Node 7

$$ES = 12$$

› ES for **Node 8**

$$ES = \text{Max}(5 + 9, 4 + 16) = 20$$

› ES for **Node 9**

$$ES = \text{Max}(8 + 20, 3 + 16, 12 + 12) = 28$$

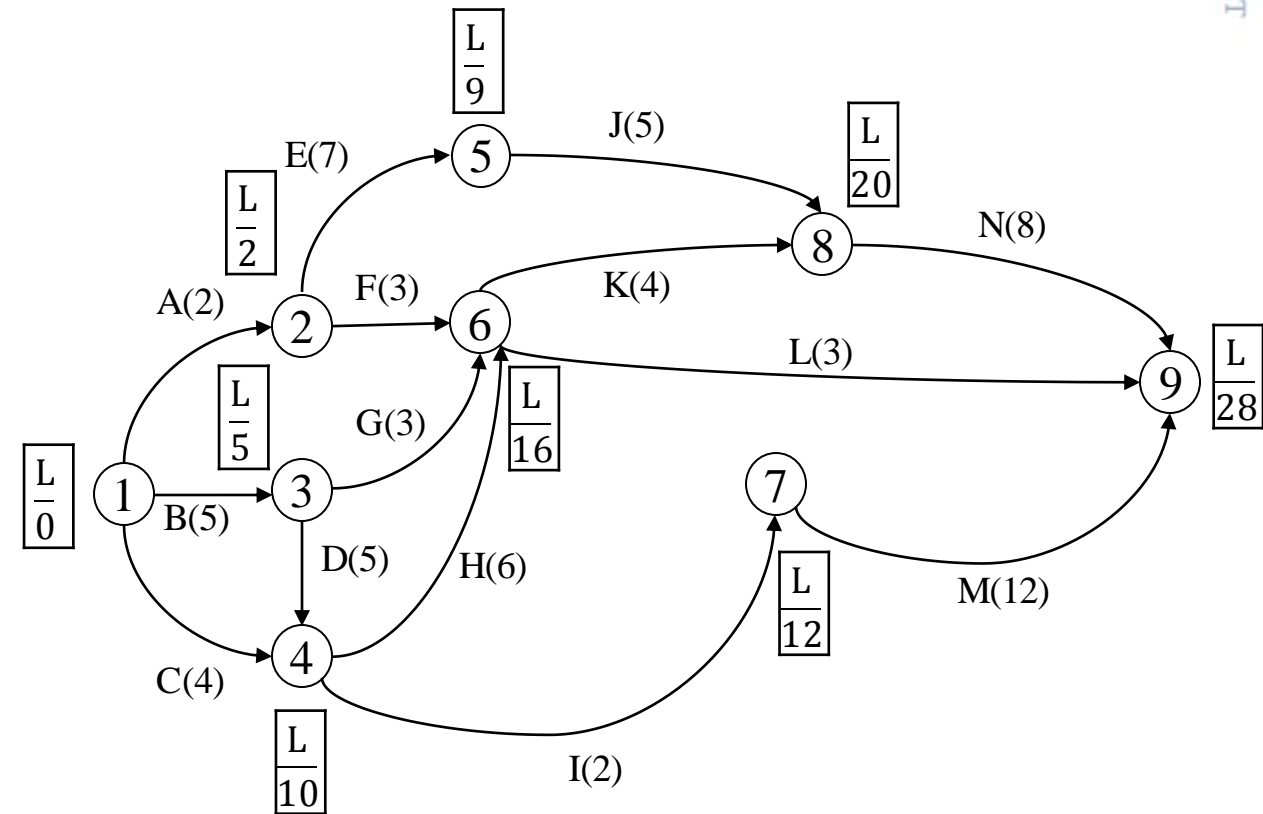


Figure 3: CPM Network

Project Scheduling and Tracking

□ CPM (Critical Path Method)

■ Critical Path

- › LC for Node 9: 28
- › LC for Node 8
 - LC = $\text{Min}(28 - 8) = 20$
- › LC for Node 7
 - LC = 16
- › LC for **Node 6**
 - LC = $\text{Min}(20 - 4, 28 - 3) = 16$
- › LC for Node 5
 - LC = 15
- › LC for **Node 4**
 - LC = $\text{Min}(16 - 6, 16 - 2) = 10$
- › LC for **Node 3**
 - LC = $\text{Min}(16 - 3, 10 - 5) = 5$
- › LC for **Node 2**
 - LC = $\text{Min}(15 - 7, 16 - 3) = 8$
- › LC for **Node 1**
 - LC = $\text{Min}(8 - 2, 5 - 5, 10 - 4) = 0$

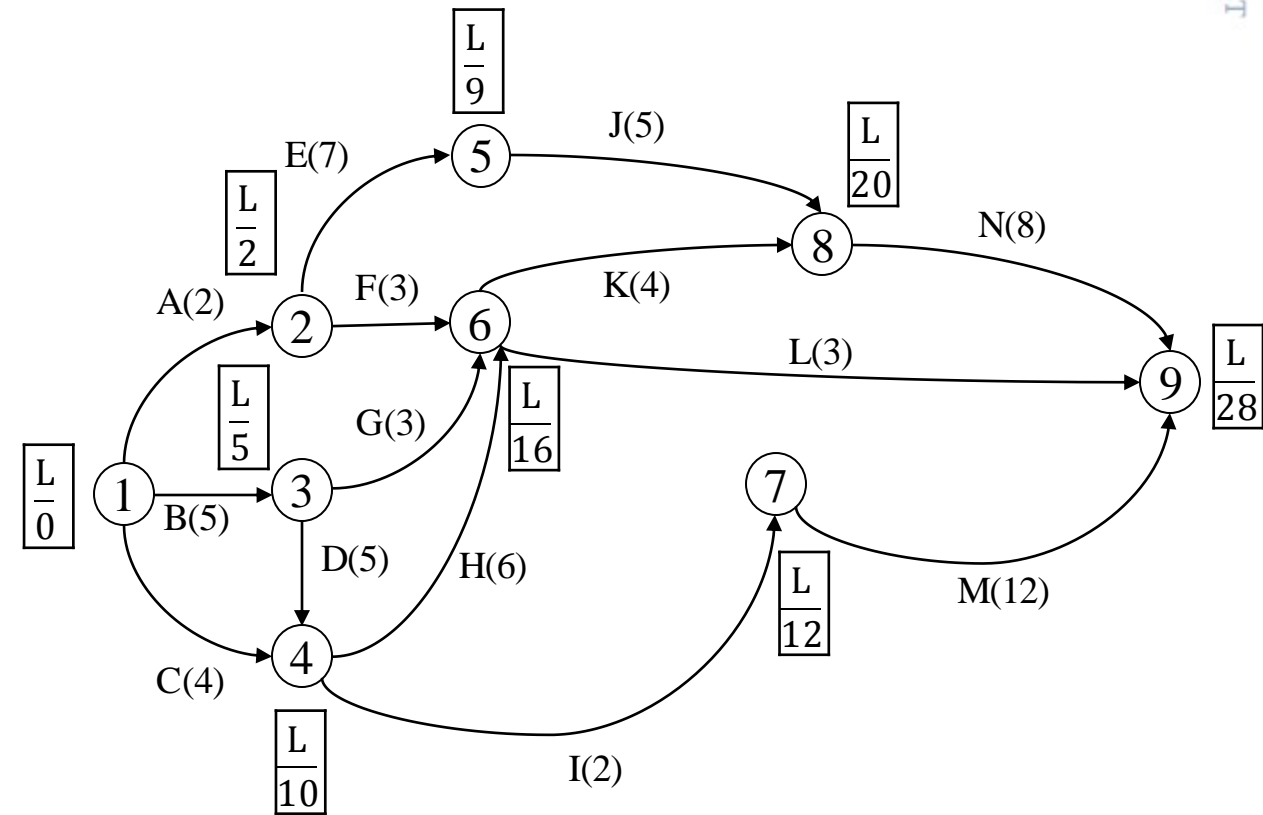


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 - LC = 15
- › LC for **Node 4**
 - LC = $\text{Min}(16 - 6, 16 - 2) = 10$
- › LC for **Node 3**
 - LC = $\text{Min}(16 - 3, 10 - 5) = 5$
- › LC for **Node 2**
 - LC = $\text{Min}(15 - 7, 16 - 3) = 8$
- › LC for **Node 1**
 - LC = $\text{Min}(8 - 2, 5 - 5, 10 - 4) = 0$

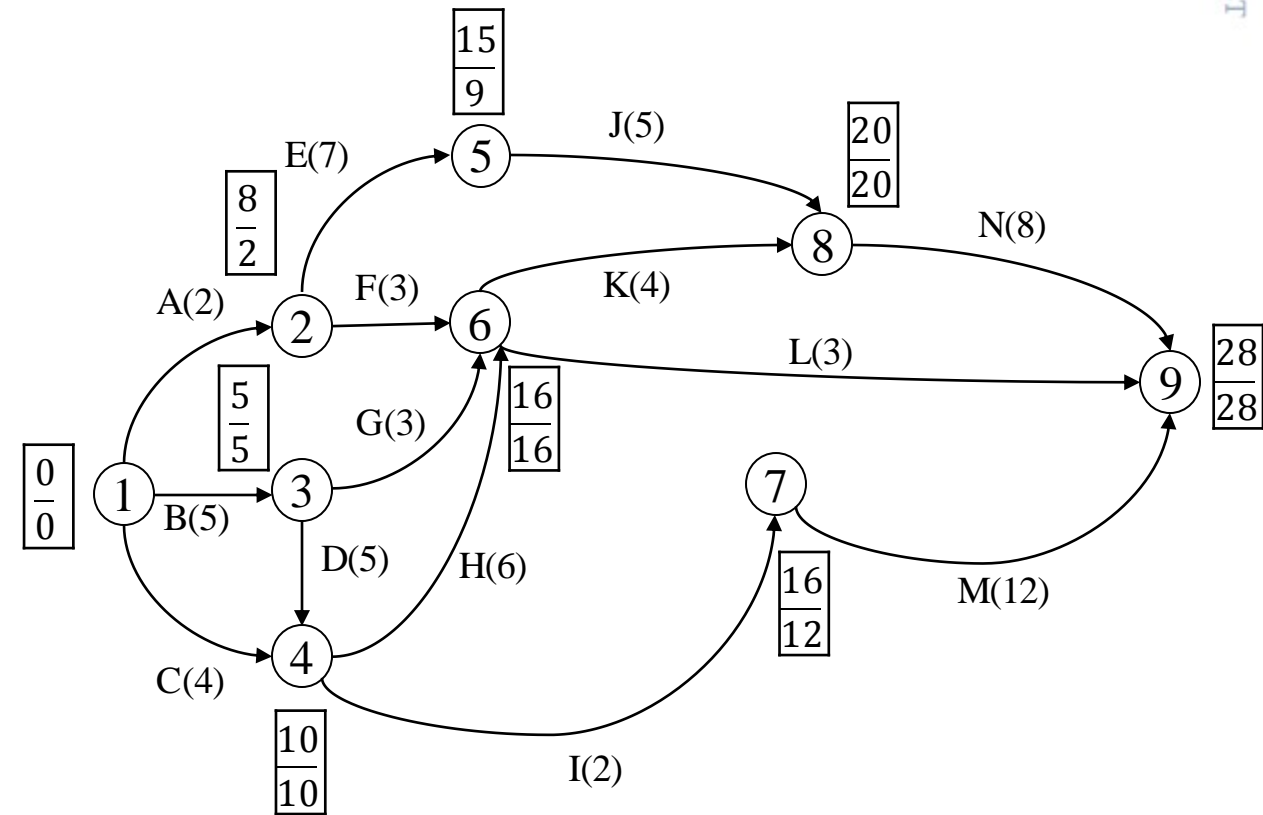


Figure 3: CPM Network

Project Scheduling and Tracking

□ CPM (Critical Path Method)

■ Critical Path

- › $ES_i = LC_i$
- › $ES_j = LC_j$
- › $ES_j - ES_i = LC_j - LC_i = D_{ij}$

- › 1-3
- › 3-4
- › 4-6
- › 6-8
- › 8-9

- › Path
- › 1-3-4-6-8-9
- › B-D-H-K-N

- › Distance (time)
- › 5+5+6+4+8=28 months [expected project completion time]

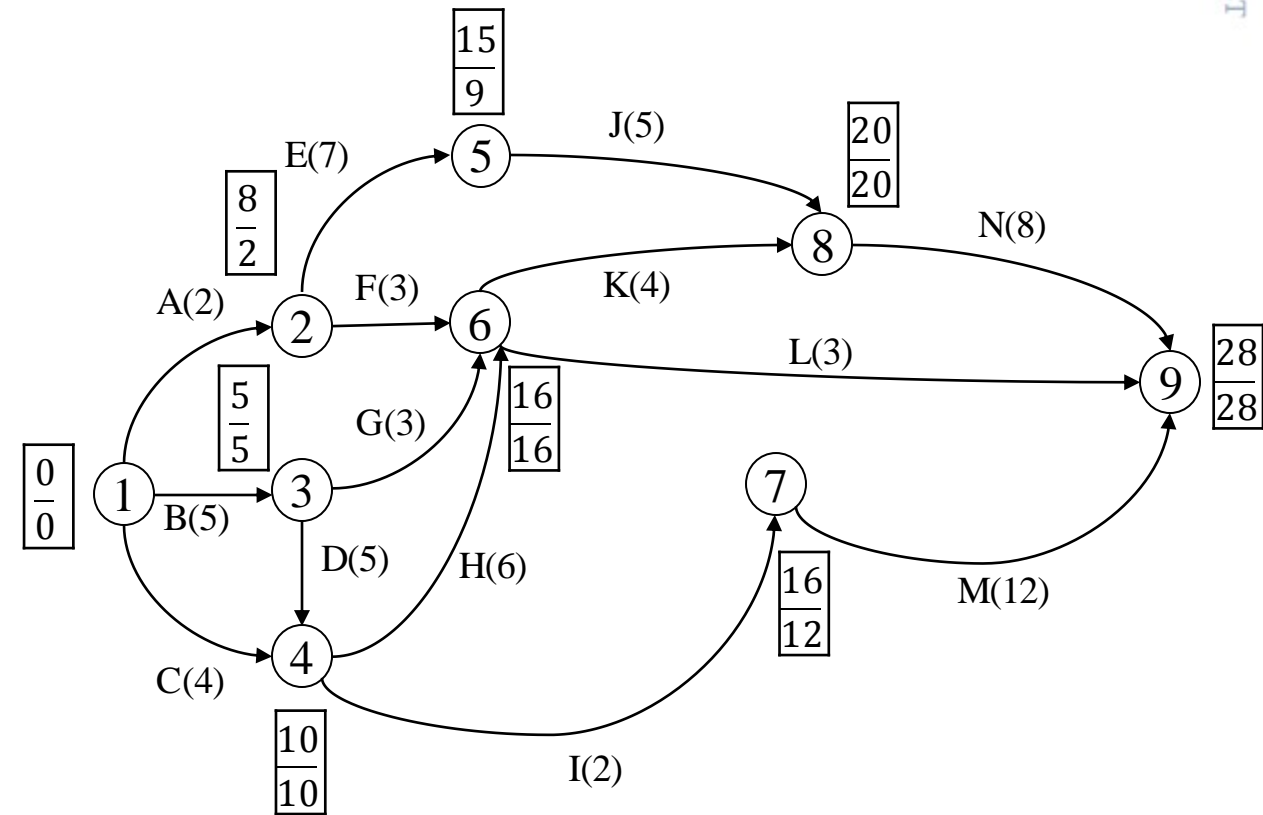


Figure 3: CPM Network

Project Scheduling and Tracking

□ CPM (Critical Path Method)

■ Total floats

eto poriman somoy delay korle kono problem hobena . Project completion time

$$TF_{ij} = LC_j - ES_i - D_{ij}$$

■ Free floats

$$FF_{ij} = ES_j - ES_i - D_{ij}$$

Activity	Duration (Months)	Total Floats	Free Floats
A	2	6 (8-0-2)	0 (2-0-2)
B	5	0 (5-0-5)	0 (5-0-5)
C	4	6 (10-0-4)	6 (10-0-4)
D	5	0 (16-10-6)	0 (16-10-6)
E	7	6 (15-2-7)	0 (9-2-7)
F	3	11 (16-2-3)	11 (16-2-3)
G	3	8 (16-5-3)	8 (16-5-3)

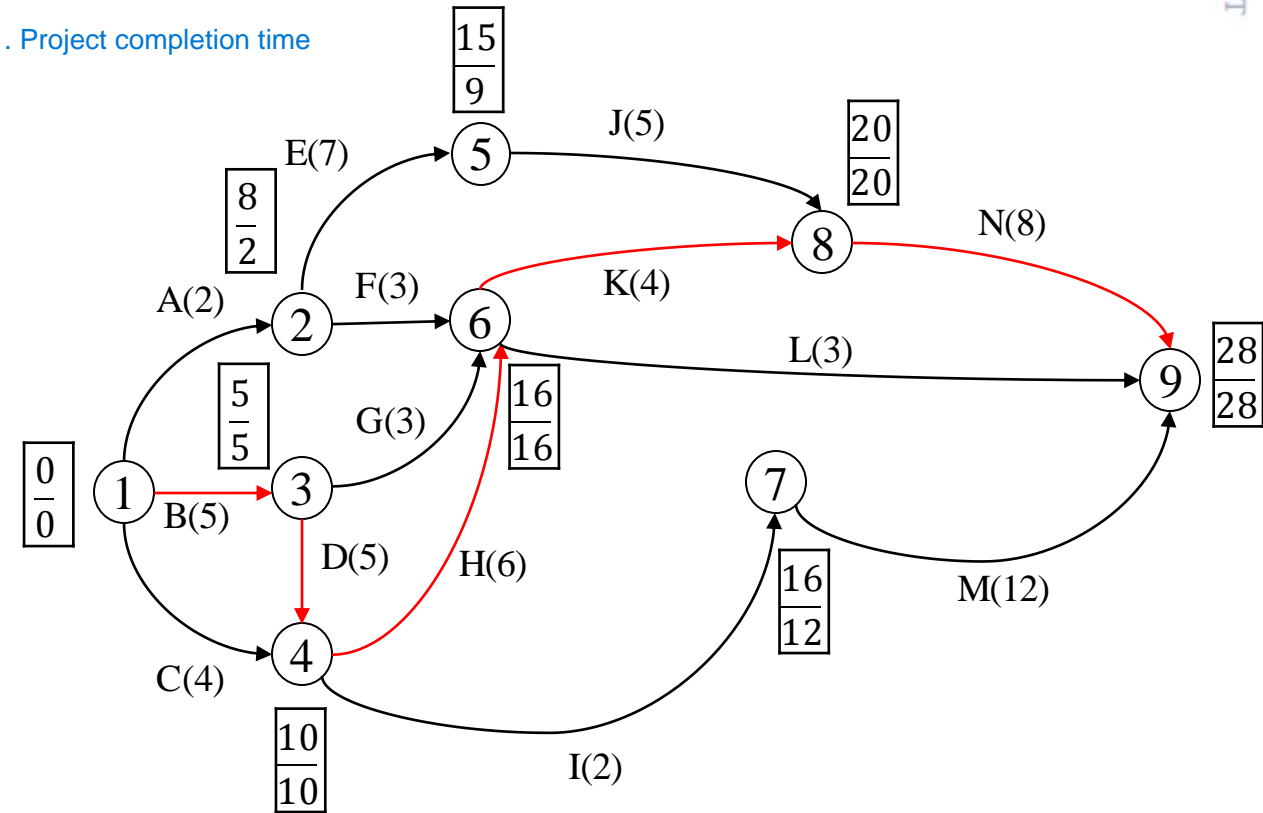


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■ Free floats

$$FF_{ij} = ES_j - ES_i - D_{ij}$$

Activity	Duration (Months)	Total Floats	Free Floats
H	6	0 (16-10-6)	0 (16-10-6)
I	2	4 (16-10-2)	0 (12-10-2)
J	5	6 (20-9-5)	6 (20-9-5)
K	4	0 (20-16-4)	0 (20-16-4)
L	3	9 (28-16-3)	9 (28-16-3)
M	12	4 (28-12-12)	4 (28-12-12)
N	8	0 (28-20-8)	0 (28-20-8)

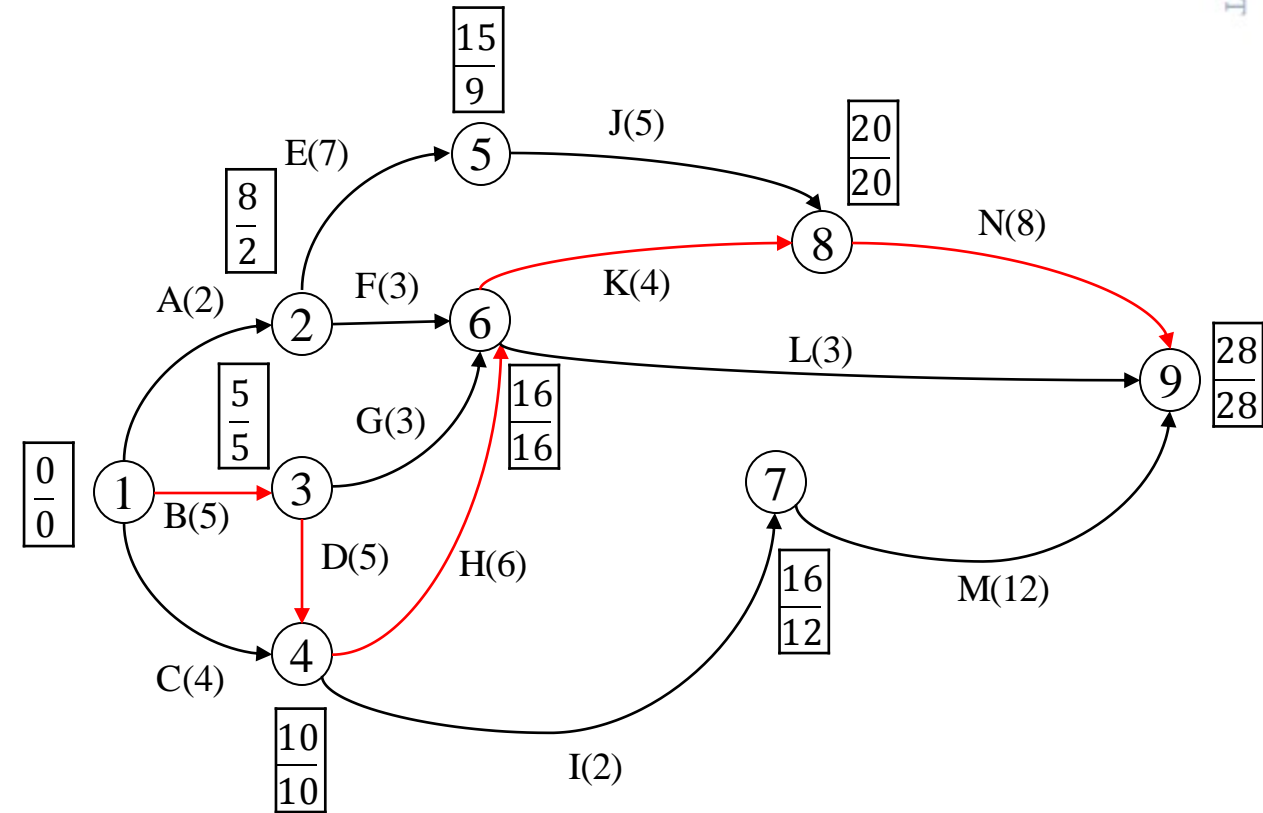


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B	5	0 (5-0-5)	0 (5-0-5)
C	4	6 (10-0-4)	6 (10-0-4)
D	5	0 (16-10-6)	0 (16-10-6)
E	7	6 (15-2-7)	0 (9-2-7)
F	3	11 (16-2-3)	11 (16-2-3)
G	3	8 (16-5-3)	8 (16-5-3)
H	6	0 (16-10-6)	0 (16-10-6)
I	2	4 (16-10-2)	0 (12-10-2)
J	5	6 (20-9-5)	6 (20-9-5)
K	4	0 (20-16-4)	0 (20-16-4)
L	3	9 (28-16-3)	9 (28-16-3)
M	12	4 (28-12-12)	4 (28-12-12)
N	8	0 (28-20-8)	0 (28-20-8)

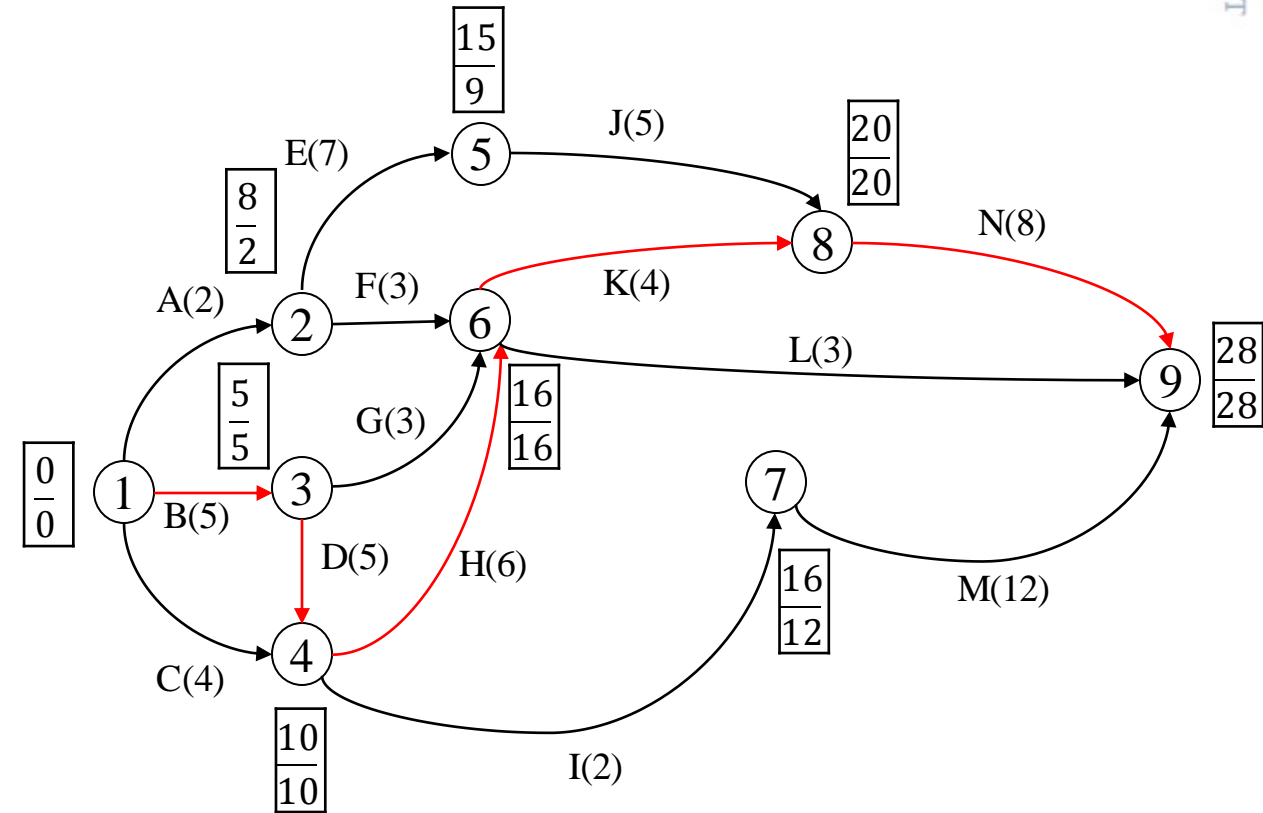


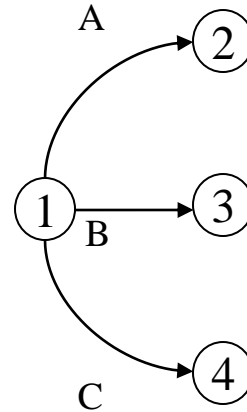
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Project Scheduling and Tracking

❑ PERT (Project Evaluation and Review Technique)

- CPM: Each activity---One estimate
- PERT: Each activity---Three estimates (optimistic, most likely, pessimistic)

Activity	Immediate Predecessor(s)	Duration (Months)		
		O	M	P
A	---	5	6	7
B	---	1	3	5
C	---	1	4	7
D	A	1	2	3
E	B	1	2	9
F	C	1	5	9
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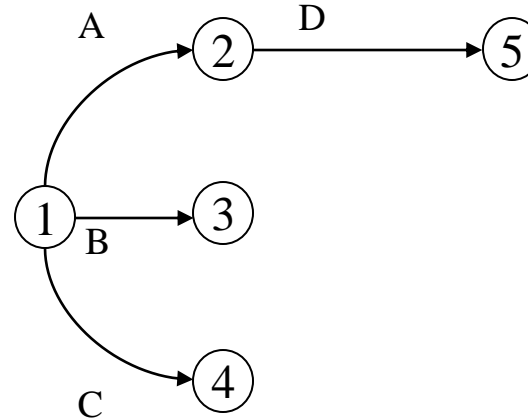


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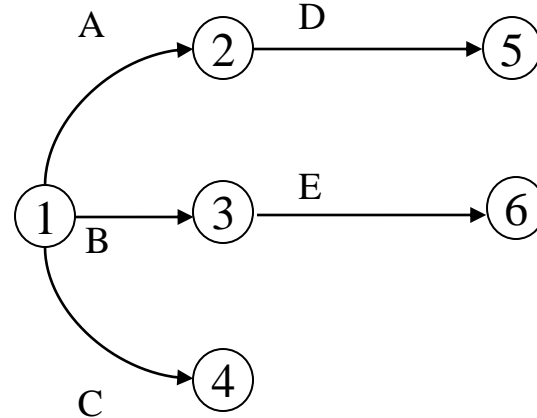


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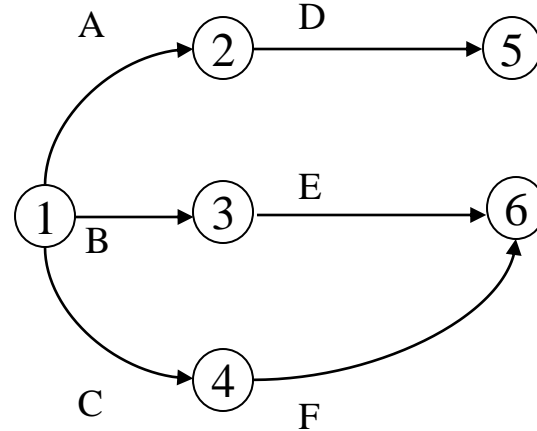


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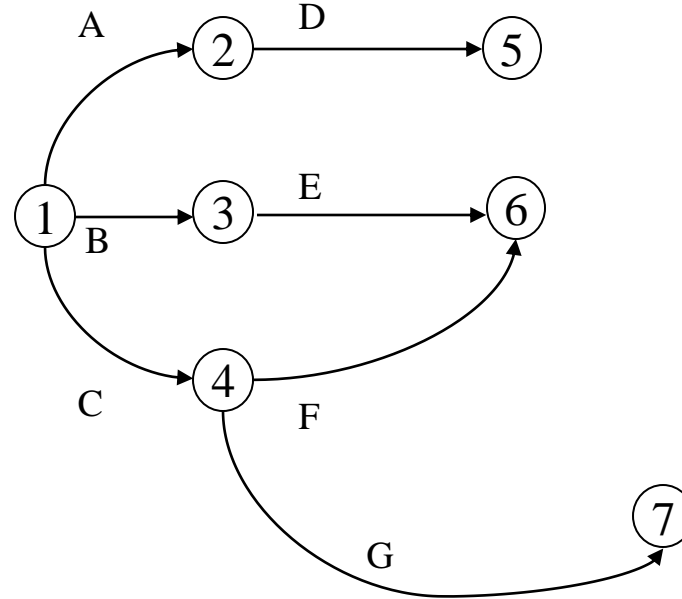


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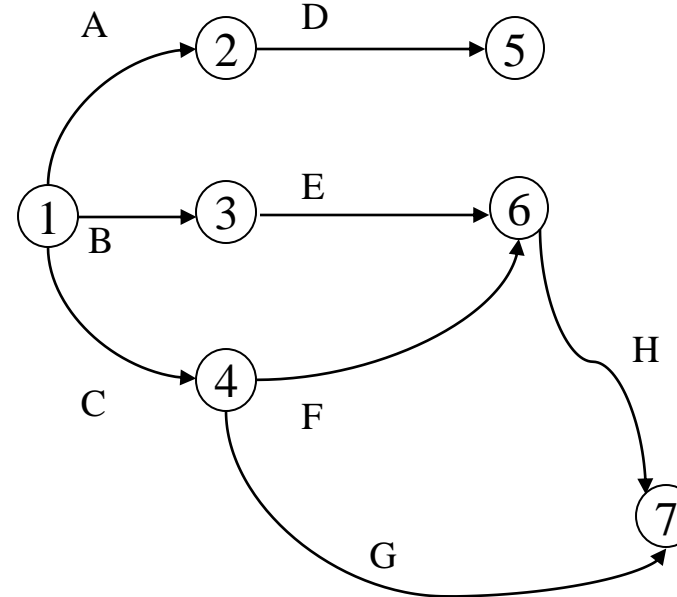


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❑ PERT (Project Evaluation and Review Technique)

- CPM: Each activity---One estimate
- PERT: Each activity---Three estimates (optimistic, most likely, pessimistic)

Activity	Immediate Predecessor(s)	Duration (Months)		
		O	M	P
A	---	5	6	7
B	---	1	3	5
C	---	1	4	7
D	A	1	2	3
E	B	1	2	9
F	C	1	5	9
G	C	2	2	8
H	E,F	4	4	10
I	D	2	5	8
J	H,G	2	2	8

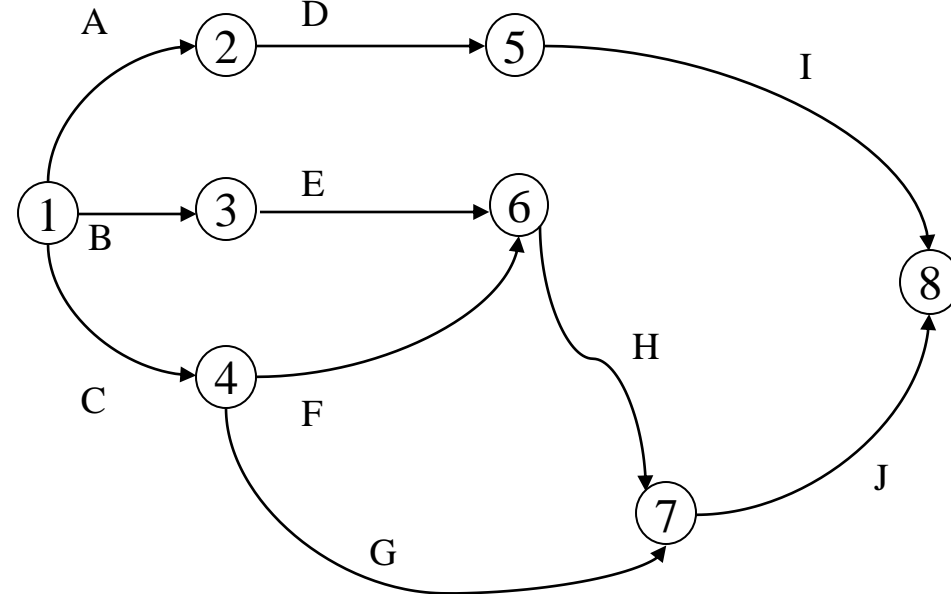


Figure 4: Project Network

Project Scheduling and Tracking

□ PERT (Project Evaluation and Review Technique)

- Mean (expected duration): $t_e = \frac{t_o + 4t_m + t_p}{6}$
- Variance: $\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$

Activity	Immediate Predecessor(s)	Duration (Months)				
		O	M	P	Mean	Variance
A	---	5	6	7	6	0.11
B	---	1	3	5	3	0.44
C	---	1	4	7	4	1.00
D	A	1	2	3	2	0.11
E	B	1	2	9	3	1.78
F	C	1	5	9	5	1.78
G	C	2	2	8	3	1.00
H	E,F	4	4	10	5	1.00
I	D	2	5	8	5	1.00
J	H,G	2	2	8	3	1.00

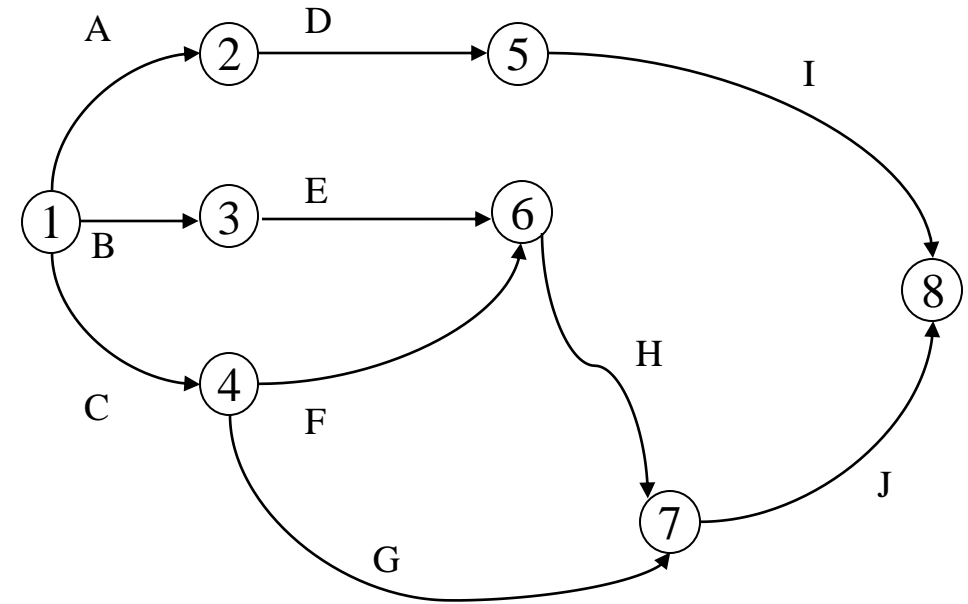


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H	E,F	4	4	10	5	1.00
I	D	2	5	8	5	1.00
J	H,G	2	2	8	3	1.00

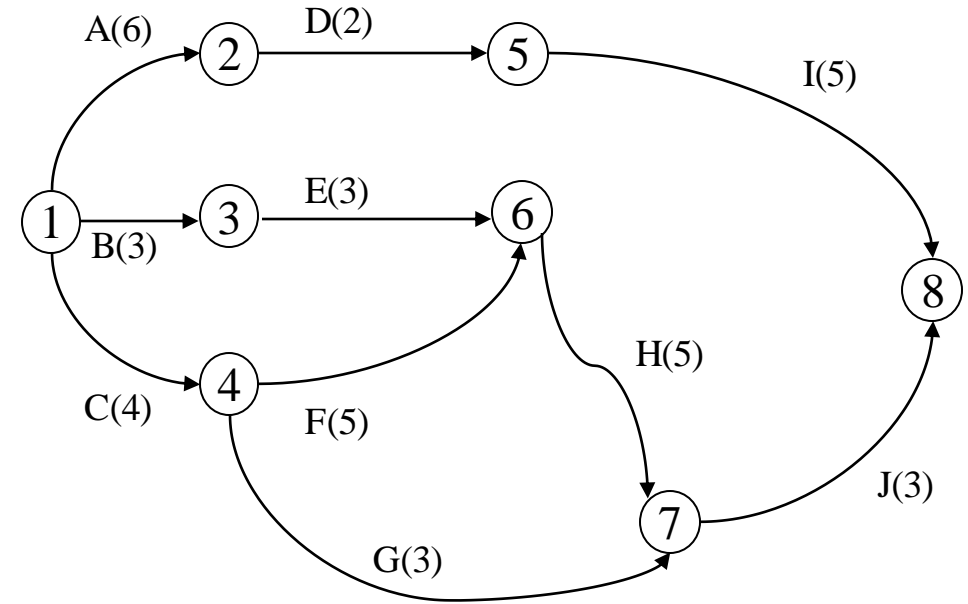


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H	E,F	4	4	10	5	1.00
I	D	2	5	8	5	1.00
J	H,G	2	2	8	3	1.00

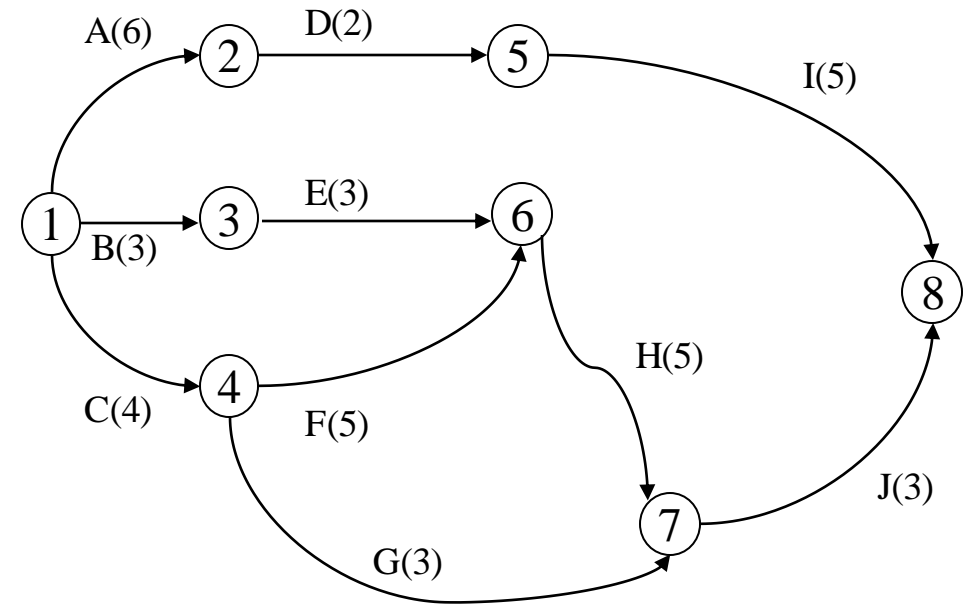


Figure 4: Project Network

Project Scheduling and Tracking

□ PERT (Project Evaluation and Review Technique)

■ Critical Path

- › Longest distance between start and end
- › Earliest Start time (ES) [forward pass]
 - $ES_j = \text{Max}_i(ES_i + D_{ij})$
- › Latest Completion time (LC) [backward pass]
 - $LC_i = \text{Min}_j(LC_j - D_{ij})$

LC
<hr/>
ES

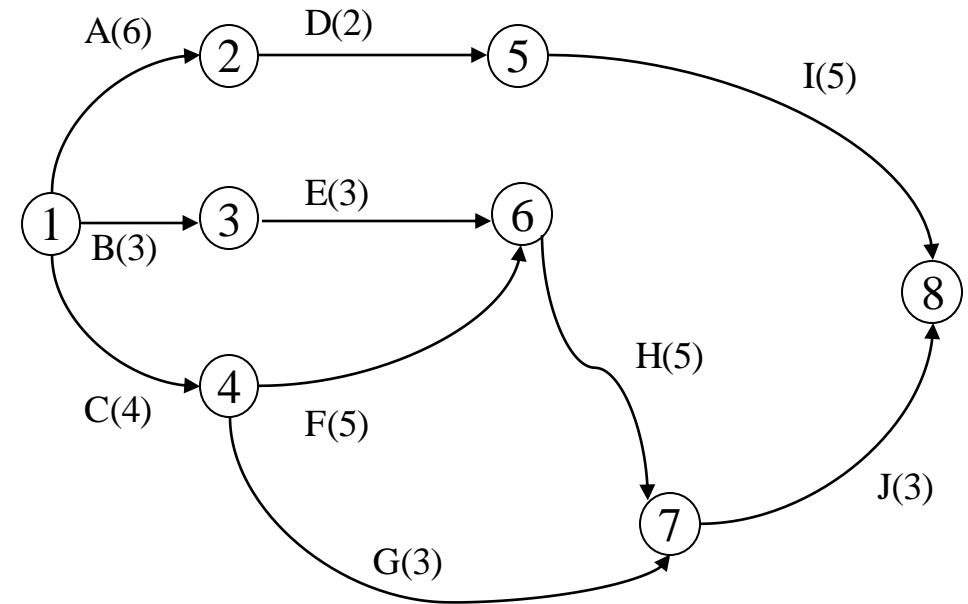


Figure 4: Project Network

Project Scheduling and Tracking

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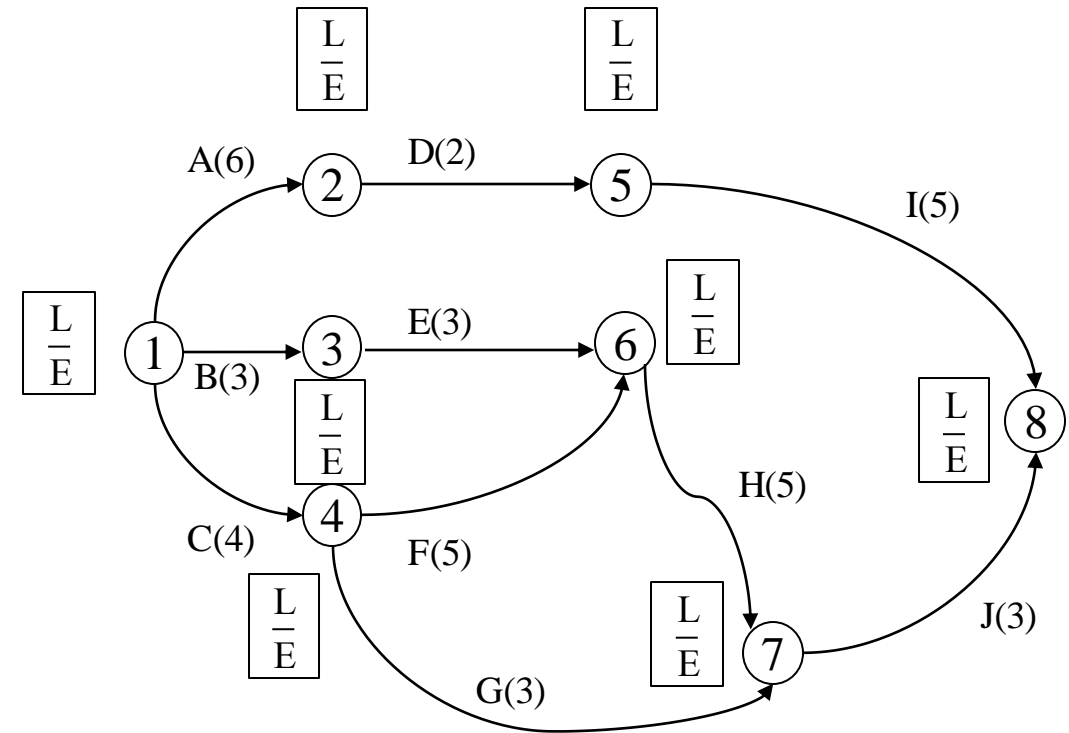
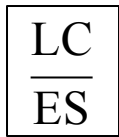


Figure 4: Project Network

Project Scheduling and Tracking

❑ PERT (Project Evaluation and Review Technique)

▪ Critical Path

- › ES for Node 1: 0
- › ES for Node 2: 6
- › ES for Node 3: 3
- › ES for Node 4: 4
- › ES for Node 5: 8
- › ES for Node 6: 9
- › ES for Node 7: 14
- › ES for Node 8: 17

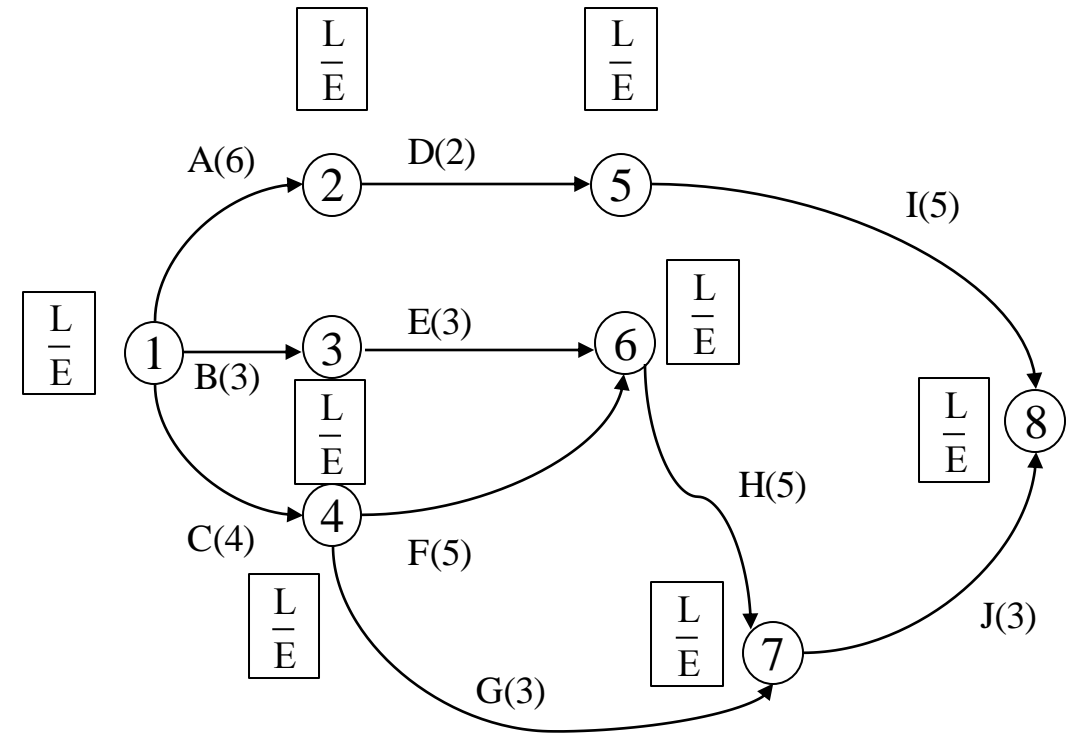


Figure 4: Project Network

Project Scheduling and Tracking

❑ PERT (Project Evaluation and Review Technique)

▪ Critical Path

- › ES for Node 1: 0
- › ES for Node 2: 6
- › ES for Node 3: 3
- › ES for Node 4: 4
- › ES for Node 5: 8
- › ES for Node 6: 9
- › ES for Node 7: 14
- › ES for Node 8: 17

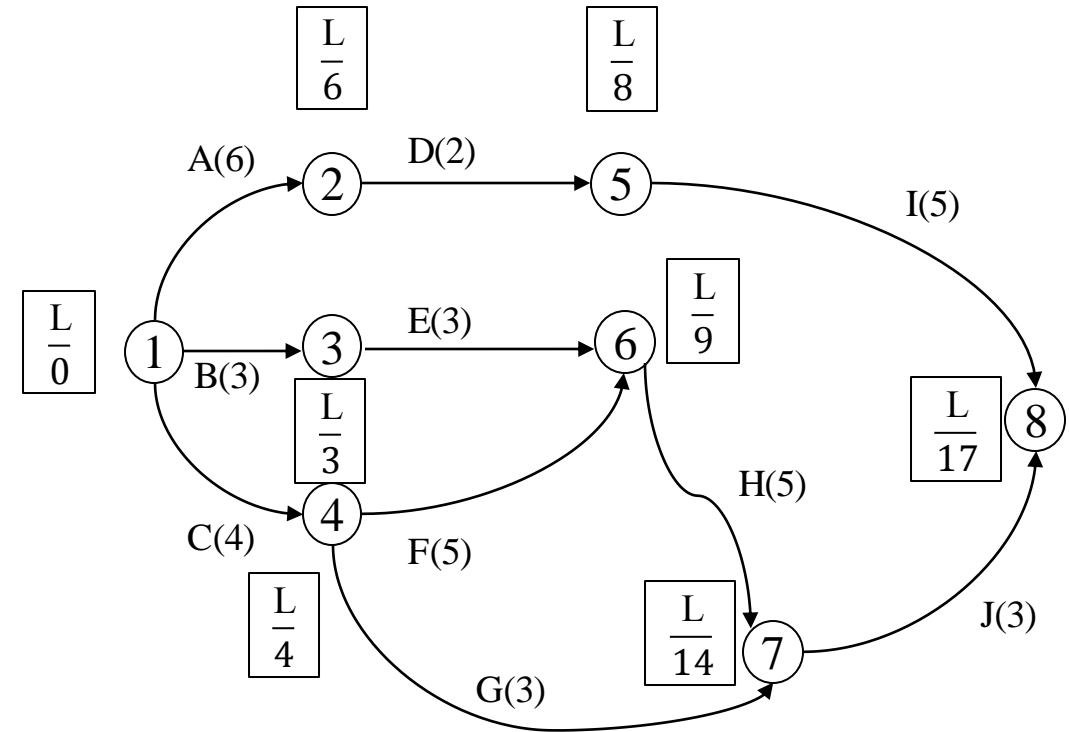


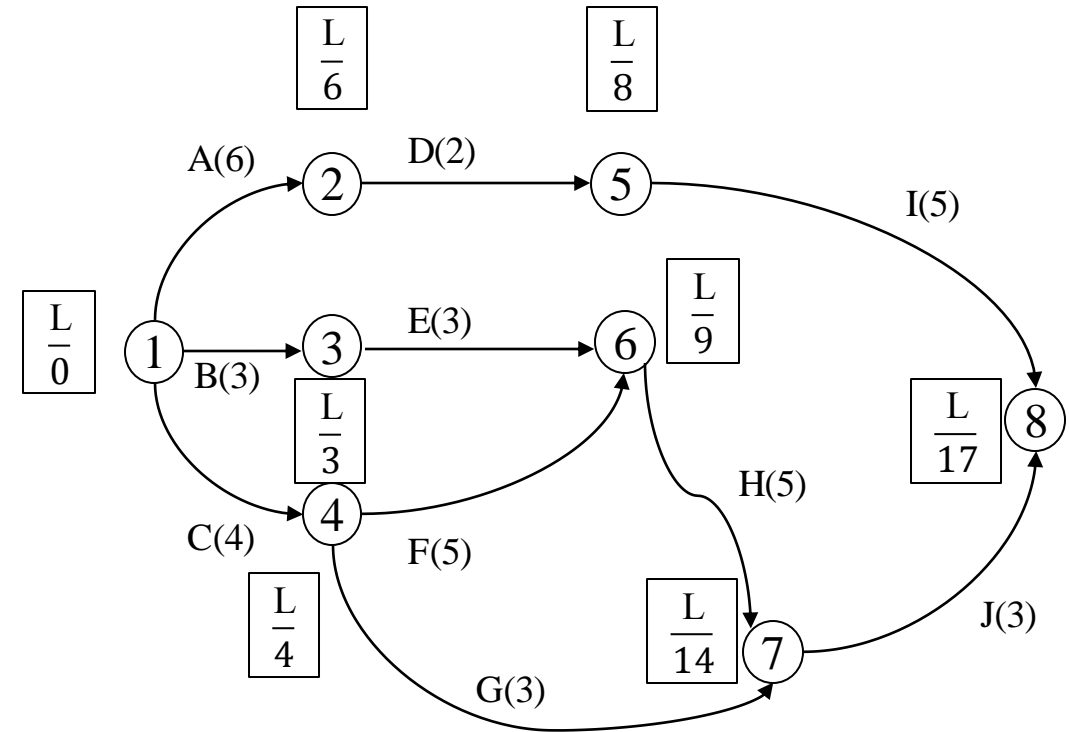
Figure 4: Project Network

Project Scheduling and Tracking

❑ PERT (Project Evaluation and Review Technique)

▪ Critical Path

- › LC for Node 8: 17
- › LC for Node 7: 14
- › LC for Node 6: 9
- › LC for Node 5: 12
- › LC for Node 4: 4
- › LC for Node 3: 6
- › LC for Node 2: 10
- › LC for Node 1: 0



Project Scheduling and Tracking

□ PERT (Project Evaluation and Review Technique)

■ Critical Path

- › LC for Node 8: 17
- › LC for Node 7: 14
- › LC for Node 6: 9
- › LC for Node 5: 12
- › LC for Node 4: 4
- › LC for Node 3: 6
- › LC for Node 2: 10
- › LC for Node 1: 0

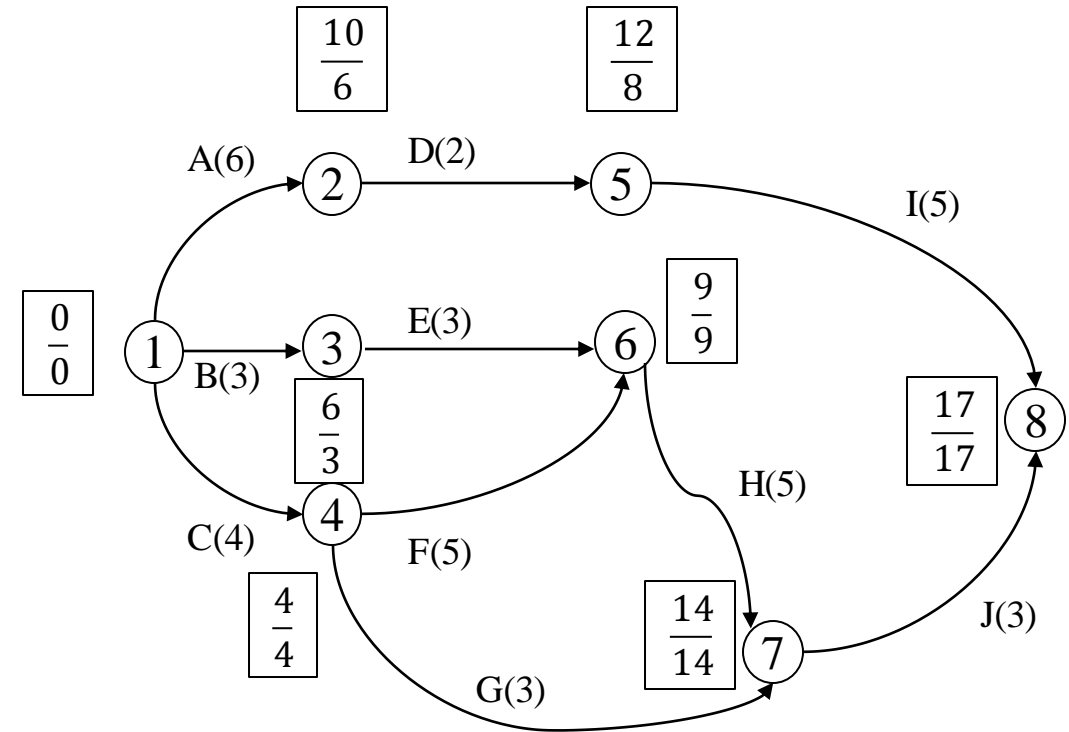


Figure 4: Project Network

Project Scheduling and Tracking

PERT (Project Evaluation and Review Technique)

■ Critical Path

- › $ES_i = LC_i$
- › $ES_j = LC_j$
- › $ES_j - ES_i = LC_j - LC_i = D_{ij}$

- › 1-4
- › 4-6
- › 6-7
- › 7-8

› Path

- › 1-4-6-7-8
- › C-F-H-J

› Distance (time)

- › $4+5+5+3=17$ months [expected project completion time]

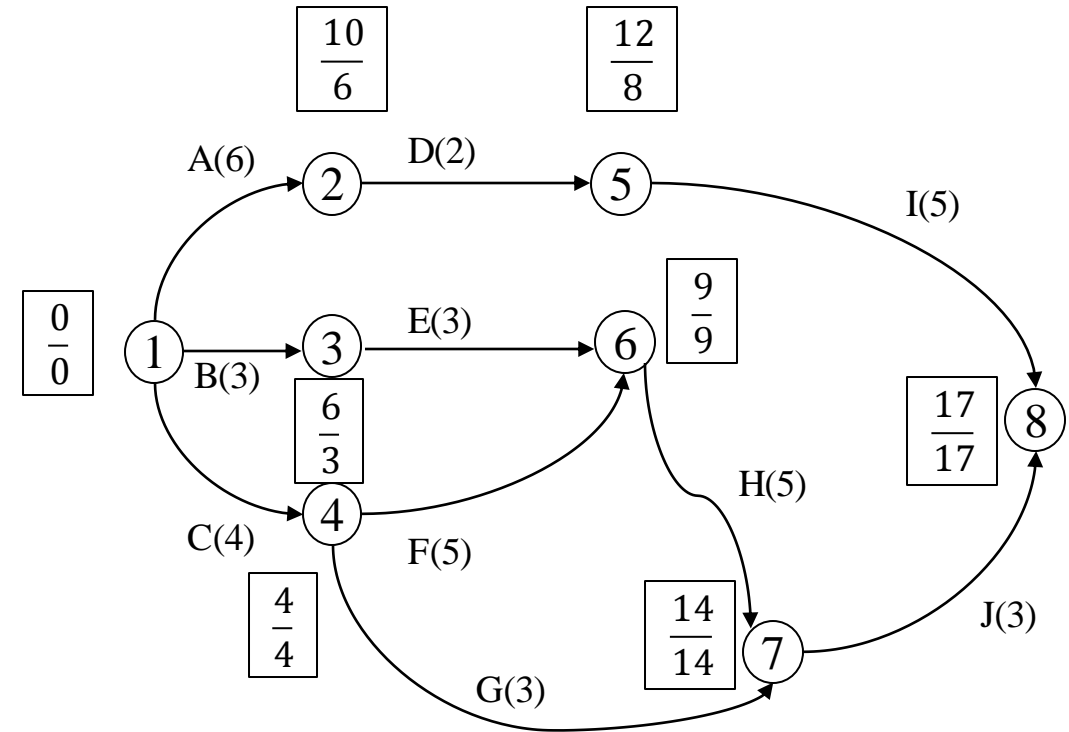


Figure 4: Project Network

Project Scheduling and Tracking

□ PERT (Project Evaluation and Review Technique)

▪ Critical Path

› C-F-H-J

→ Probability of completing the work on or before 19 months

Activity	Immediate Predecessor(s)	Duration (Months)				
		O	M	P	Mean	Variance
A	---	5	6	7	6	0.11
B	---	1	3	5	3	0.44
C	---	1	4	7	4	1.00
D	A	1	2	3	2	0.11
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H	E,F	4	4	10	5	1.00
I	D	2	5	8	5	1.00
J	H,G	2	2	8	3	1.00
Σ					17	4.78

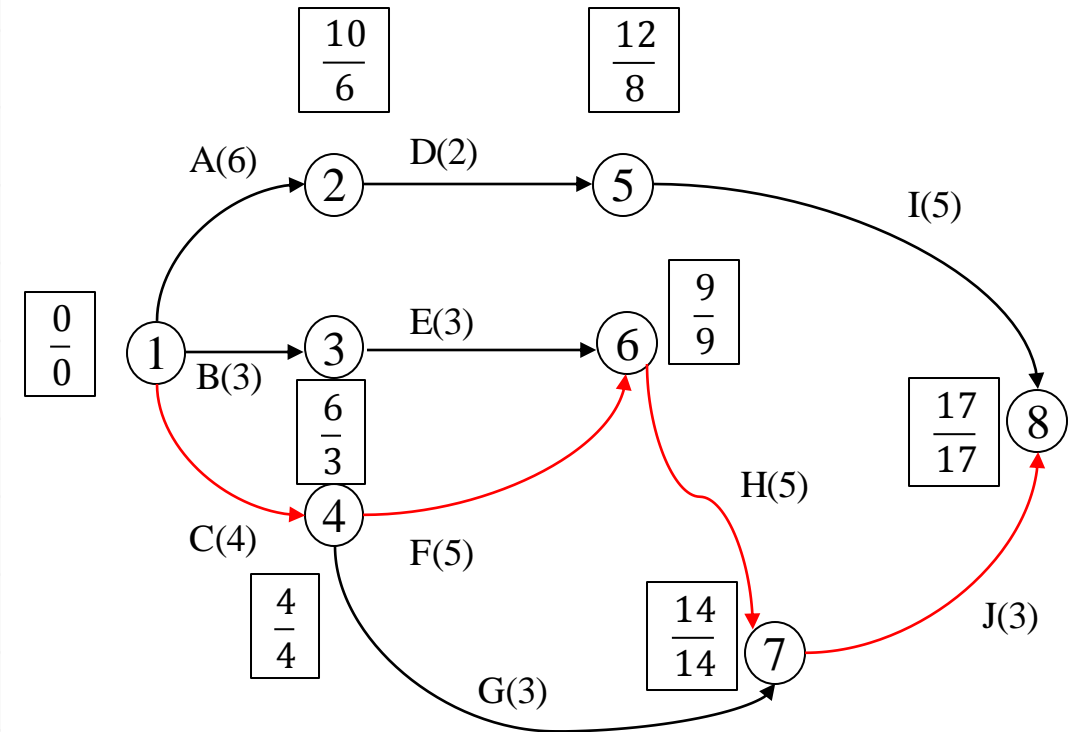


Figure 4: Project Network

Project Scheduling and Tracking

□ PERT (Project Evaluation and Review Technique)

- Probability of completing the work on or before 19 months
- $P(x \leq 19) = P\left(\frac{x-\mu}{\sigma} \leq \frac{19-17}{\sqrt{4.78}}\right) = P(z \leq 0.91) = 0.3186$ [Normal distribution]
- Probability of completing the work on or before 19 months is 31.86%

Activity	Duration (Months)	
	Mean	Variance
C	4	1.00
F	5	1.78
H	5	1.00
J	3	1.00
Σ	17	4.78

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621