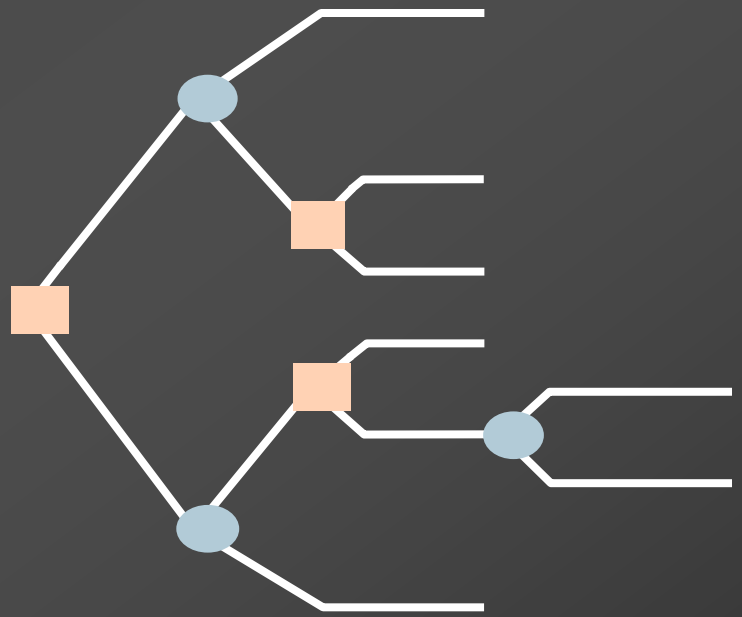
CHAPTER II – Decision making



1-Break-even analysis

- ***Evaluating services or products***

  – ***Volume sufficient to break even***

  – ***The portion of the total cost that varies directly***

  – ***The variable cost per unit***

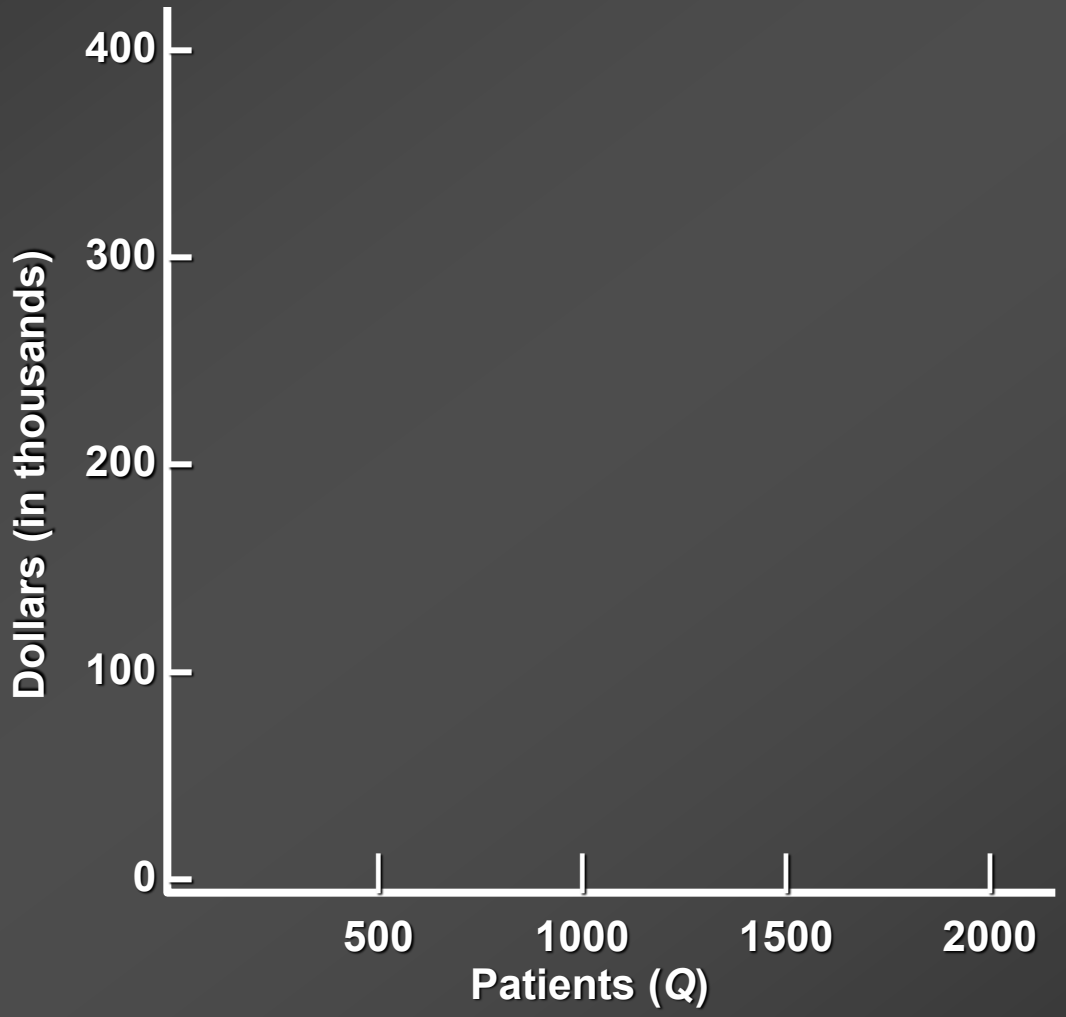
Example

FINDING THE BREAKEVEN QUANTITY

A hospital is considering a new procedure to be offered at $200 per patient. The fixed cost per year would be $100,000, with total variable costs of $100 per patient. What is the break-even quantity for this service? Use both algebraic and graphic approaches to get the answer.

Break-Even Analysis

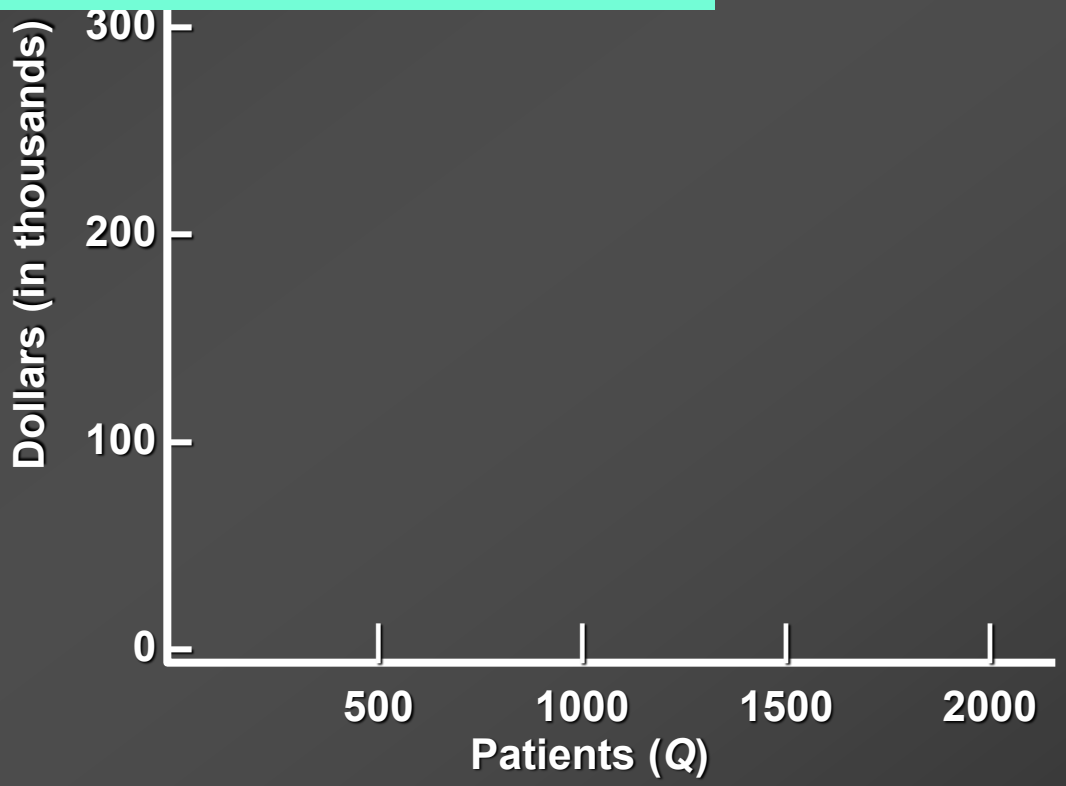
Break-Even Analysis



Example A.1

Break-Even Analysis

Quantity (patients) (Q)	Total Annual Cost ($) (100,000 + 100$Q$)	Total Annual Revenue ($) (200$Q$)
0	100,000	0
2000	300,000	400,000



Example A.1

Break-Even Analysis

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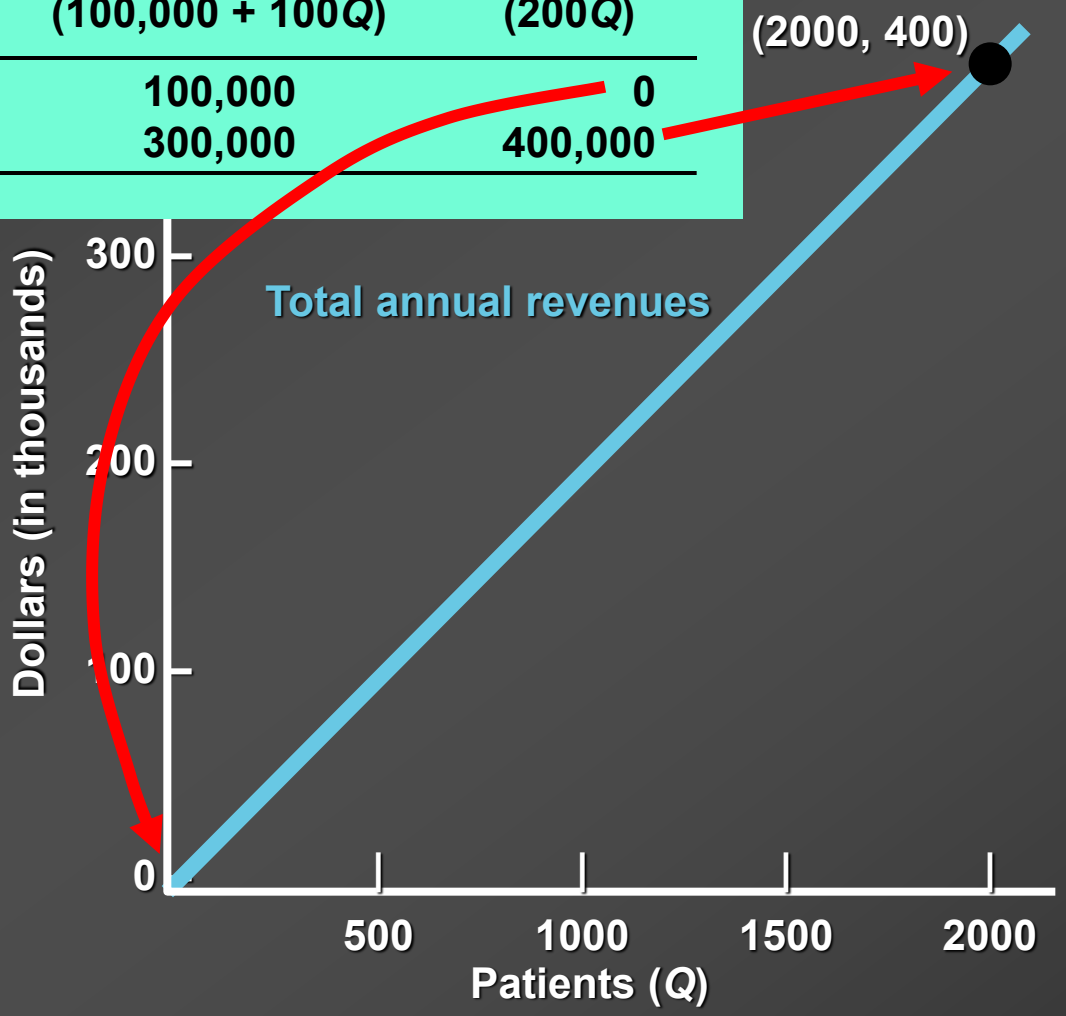

Example A.1

Break-Even Analysis

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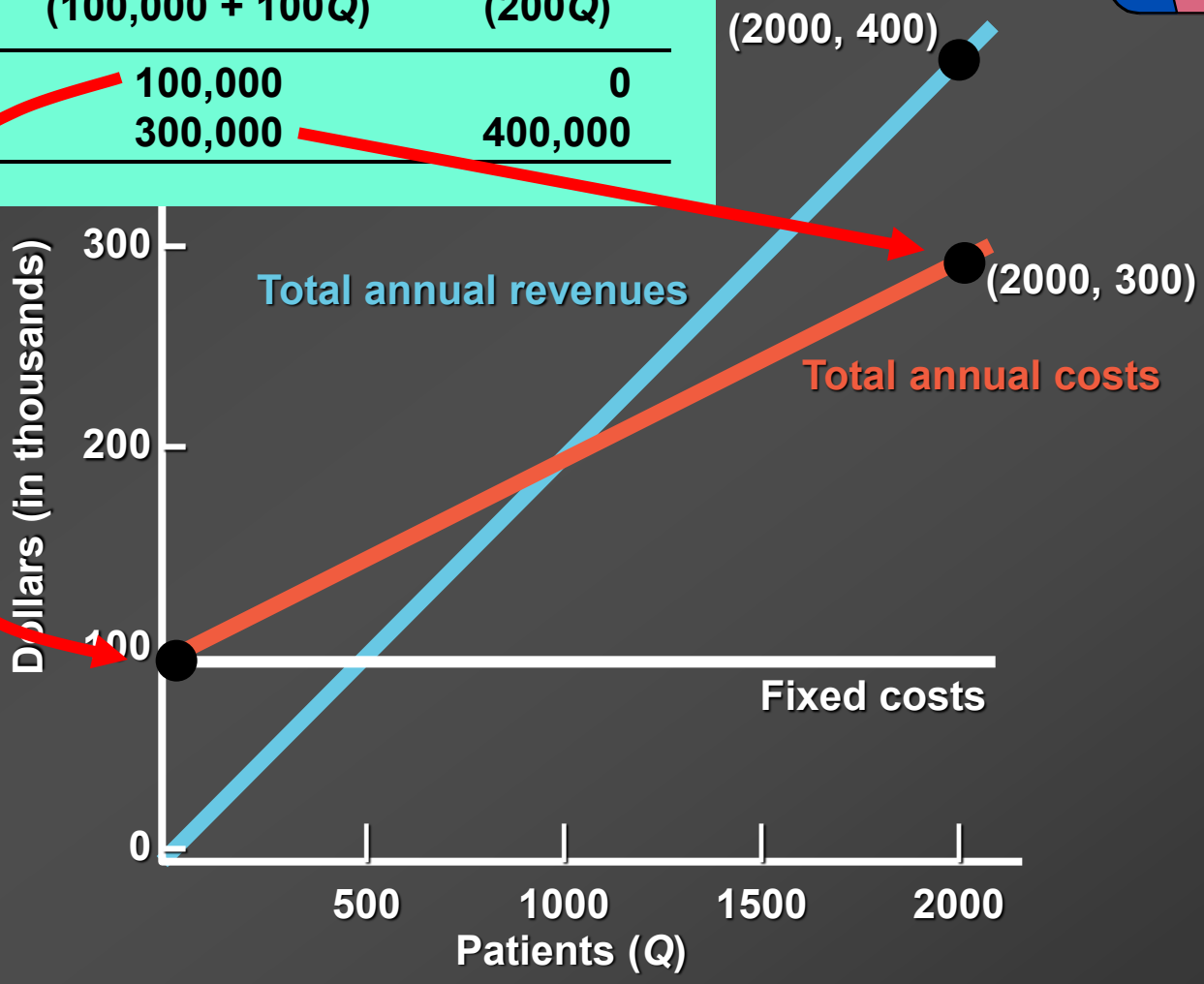
0	100,000	0
2000	300,000	400,000



Example A.1

Break-Even Analysis

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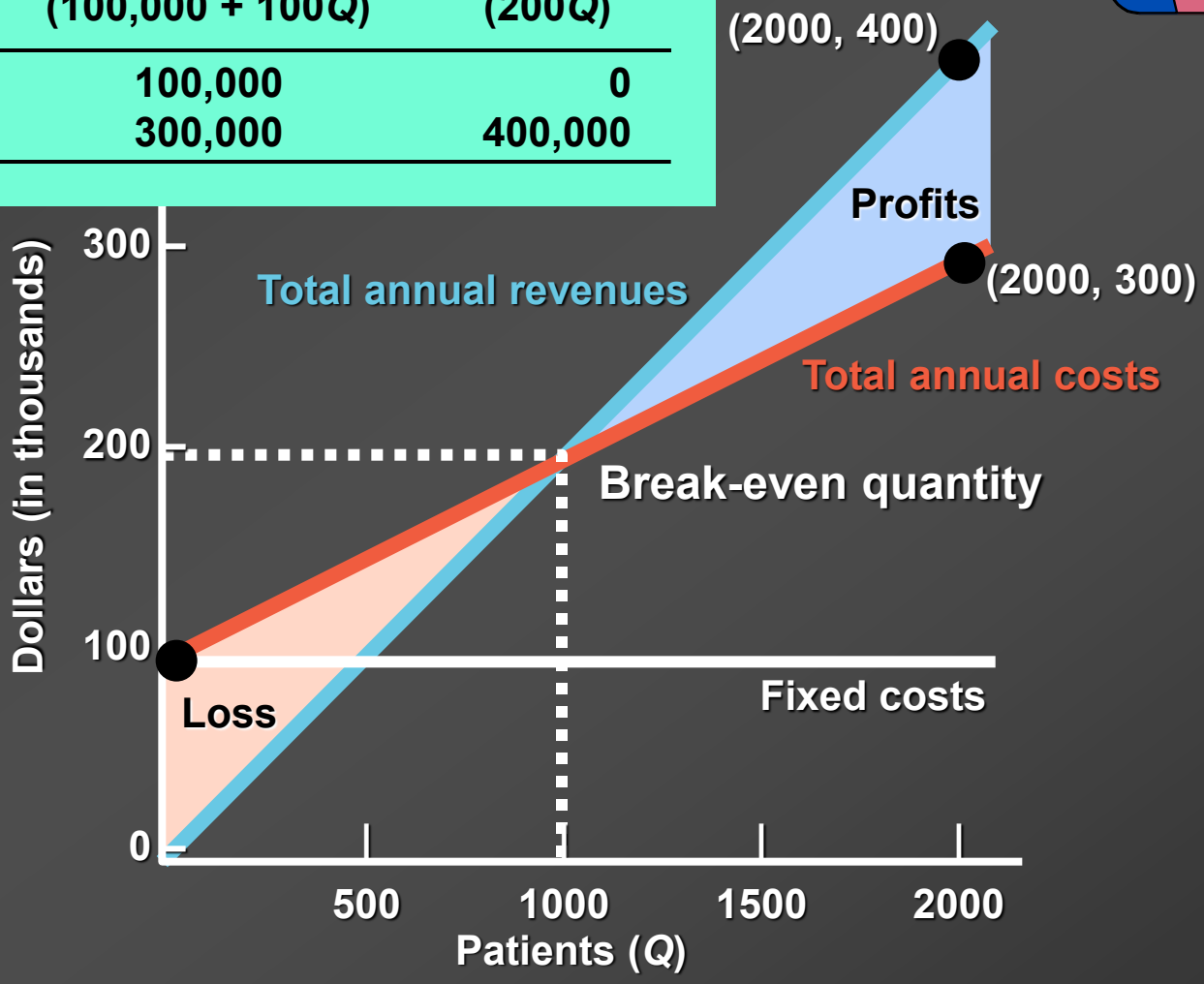


Example A.1

Break-Even Analysis

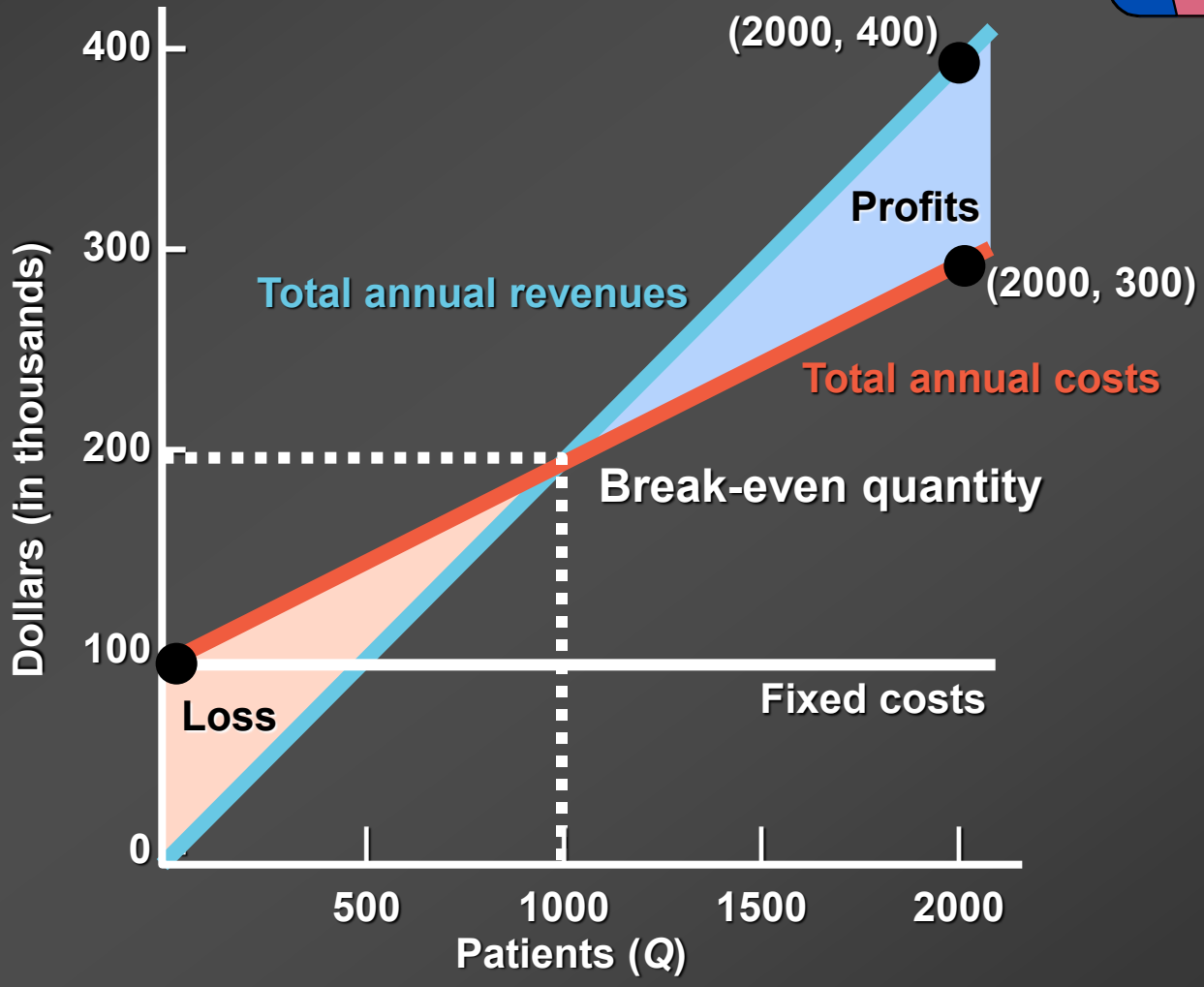
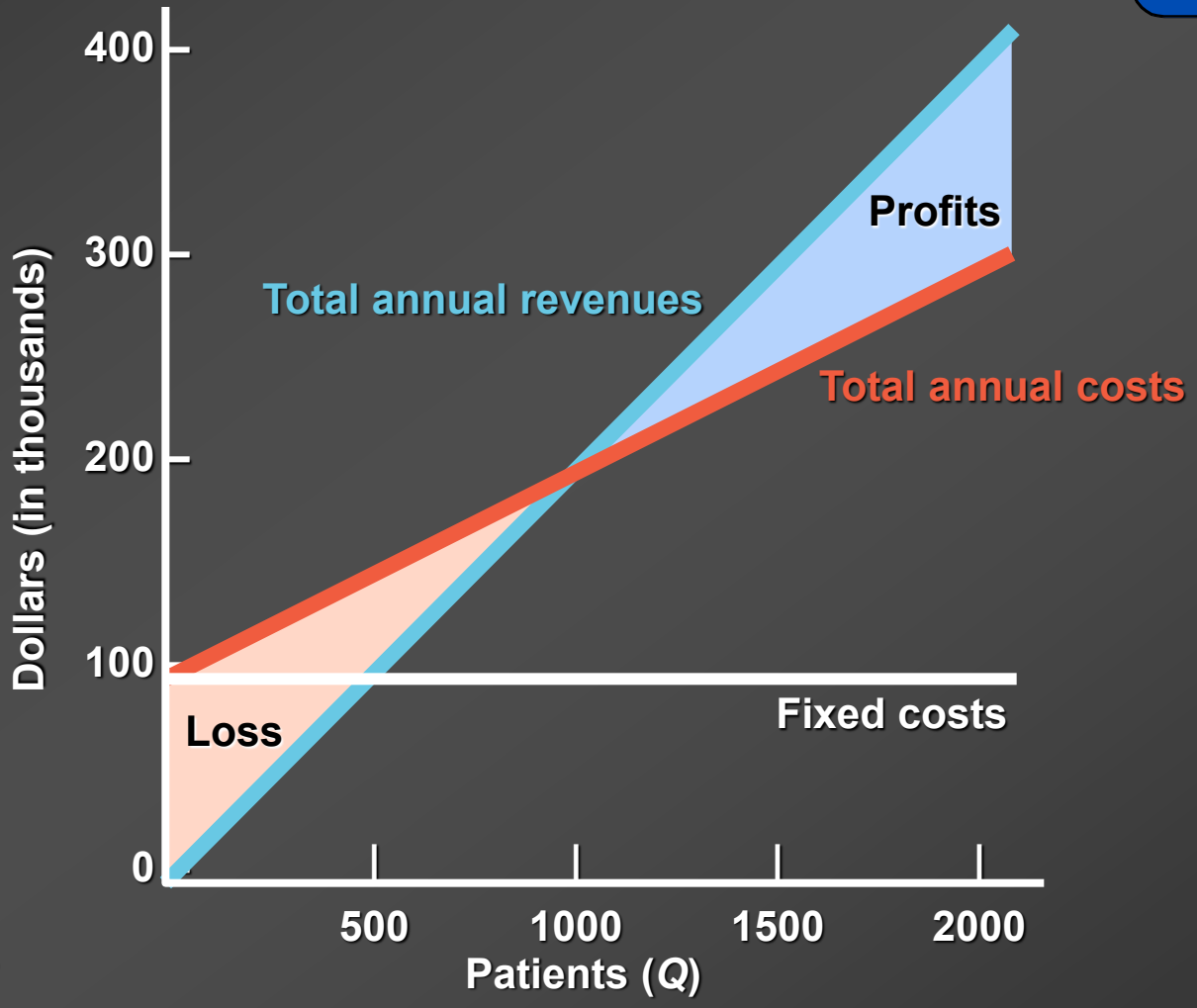


Figure A.1

Sensitivity analysis of sales forecasts

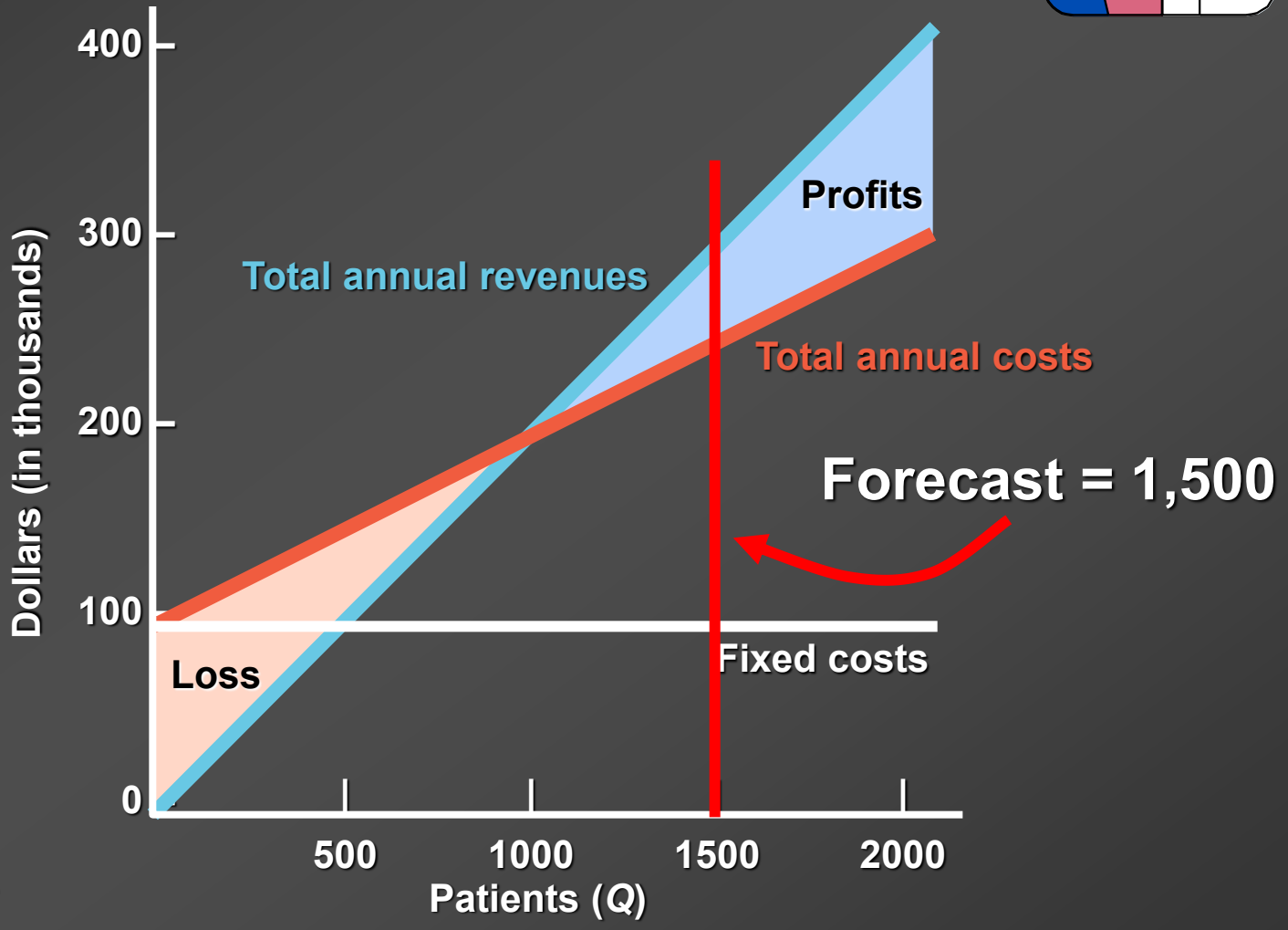
If the most pessimistic sales forecast for the proposed service in Figure A.I were 1,500 patients, what would be the procedure's total contribution to profit and overhead per year?

Sensitivity Analysis



Example A.2

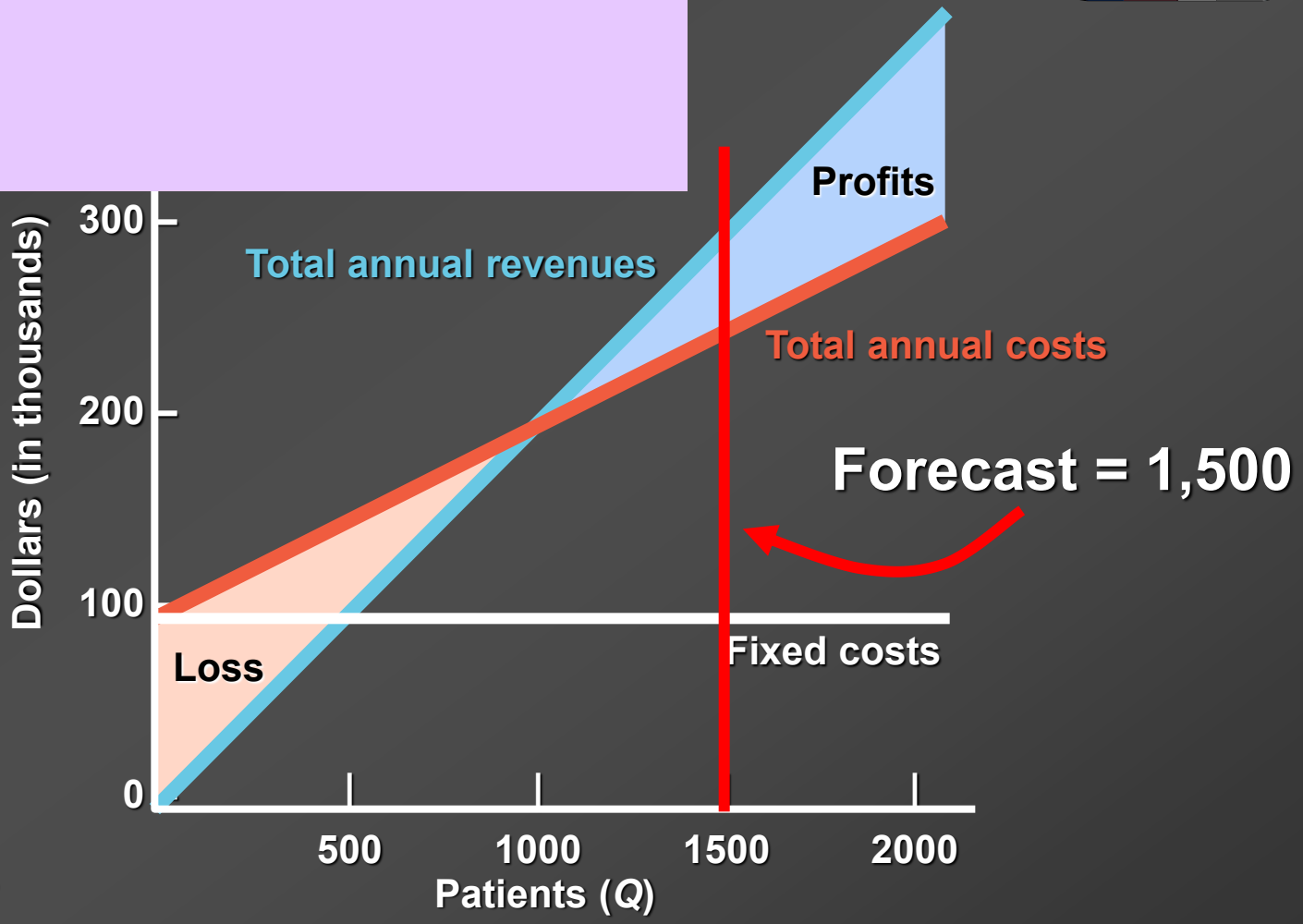
Sensitivity Analysis



Example A.2

Sensitivity Analysis

$$pQ - (F + cQ)$$



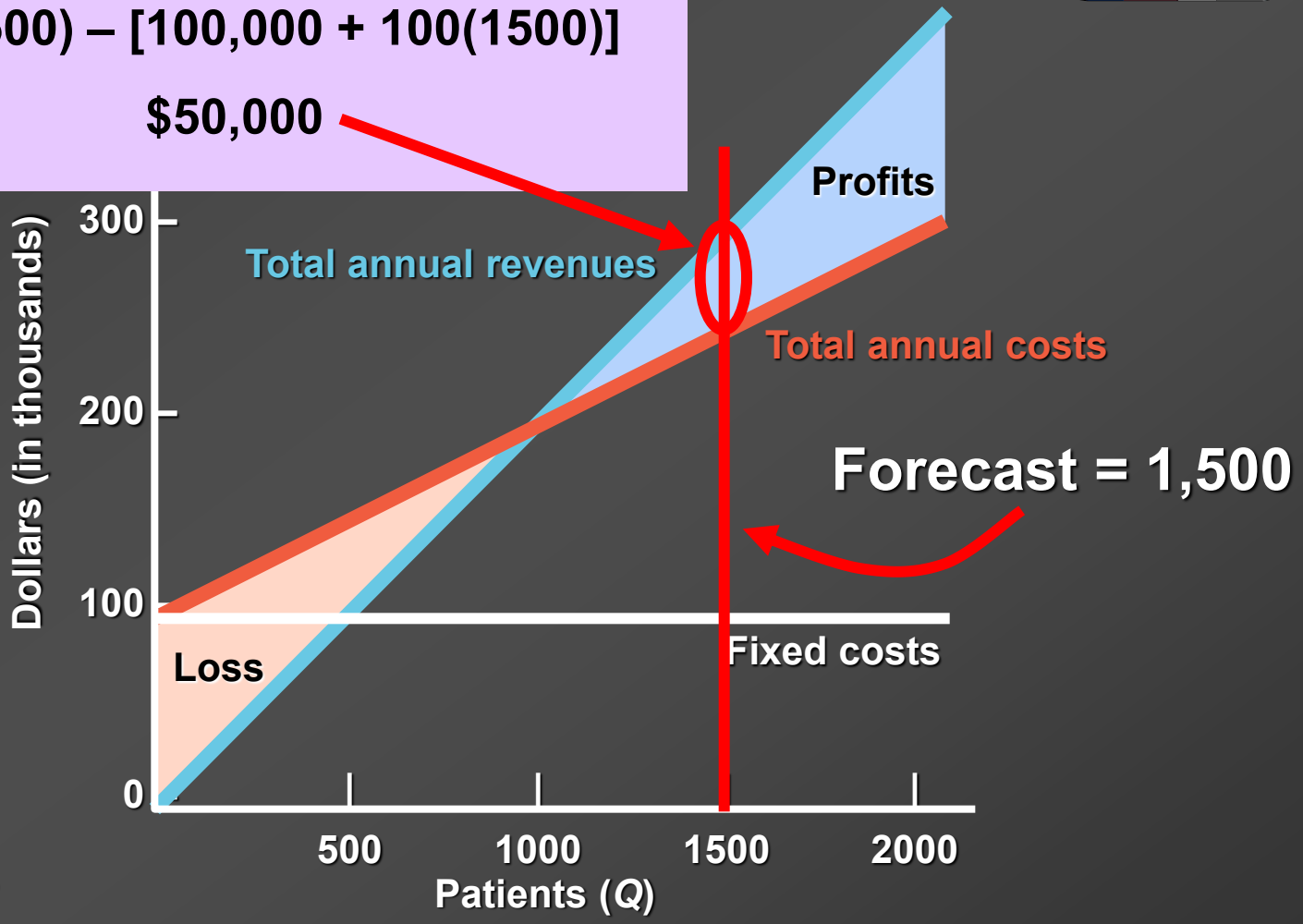
Example A.2

Sensitivity Analysis

$$pQ - (F + cQ)$$

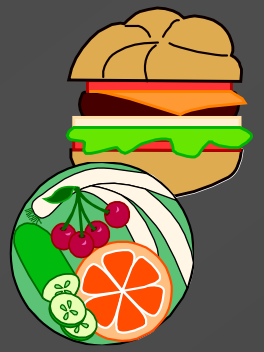
$$200(1500) - [100{,}000 + 100(1500)]$$

$$\$50{,}000$$



Example A.2

Make-or-Buy Decisions



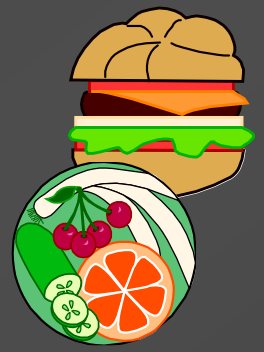
Evaluating processes

The manager of a fast-food restaurant featuring hamburgers is adding salads to the menu.

There are two options, and the price to the customer will be the same for each. The make option is to install a salad bar stocked with vegetables, fruits, and toppings and let the customer assemble the salad. The salad bar would have to be leased and a part-time employee hired. The manager esti mates the fixed costs at $12,000 and variable costs totaling $1.50 per salad. The buy option is to have preassembled salads available for sale. They would be purchased from a local supplier at $2.00 per salad. Offering preassembled salads would require installation and operation of addi tional refrigeration, with an annual fixed cost of $2,400. The manager expects to sell 25,000 sal ads per year.

What is the break-even quantity?

Make-or-Buy Decisions



Type
- ○ Product/Service
- ◉ Two Processes

Solver - Break-Even Analysis

Enter data in yellow- shaded areas.

	Process 1	Process 2
Fixed costs (F)	$12,000	$2,400
Variable costs (c)	$1.50	$2.00
Expected demand	25,000	
Break-even quantity	19,200.0	

Decision: Process 1

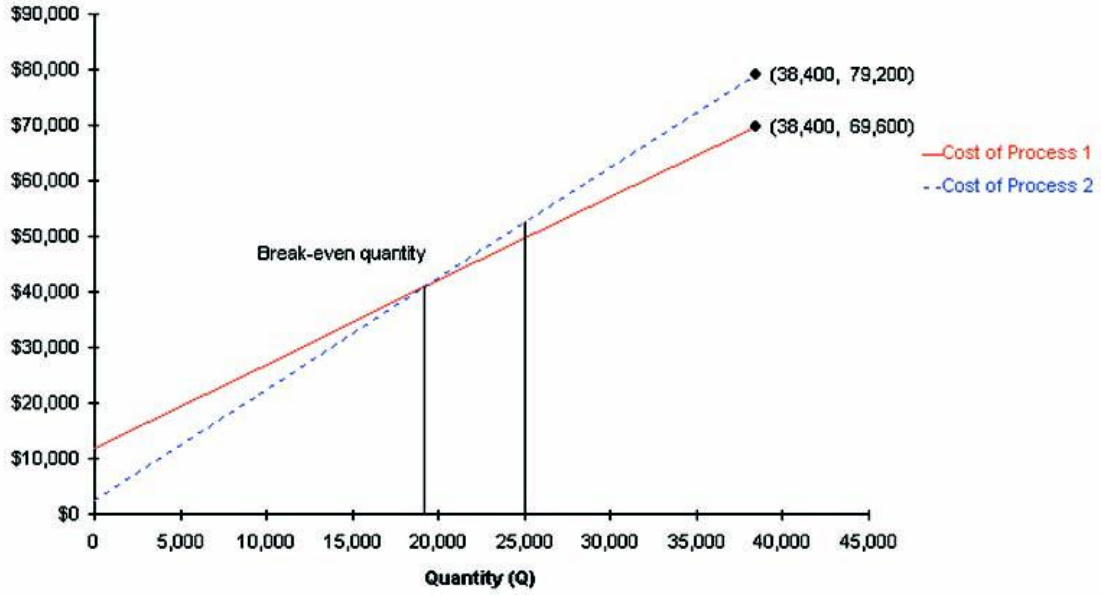
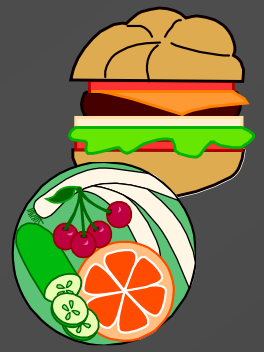


Figure A.2

Make-or-Buy Decisions



Type
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	Process 1	Process 2
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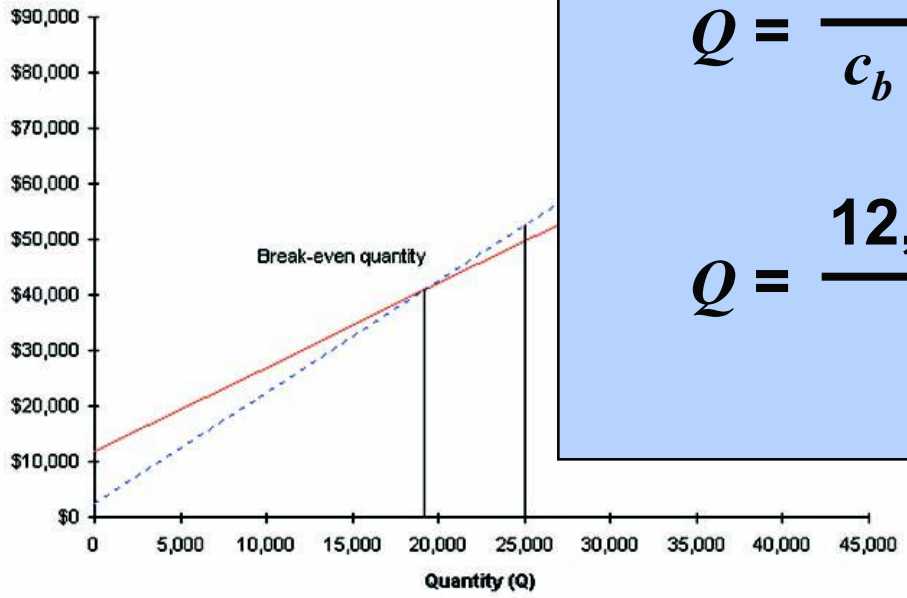
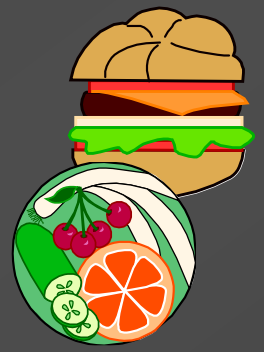


$$Q = \frac{F_m - F_b}{c_b - c_m}$$

$$Q = \frac{12{,}000 - 2{,}400}{2.0 - 1.5}$$

Example A.3

Make-or-Buy Decisions



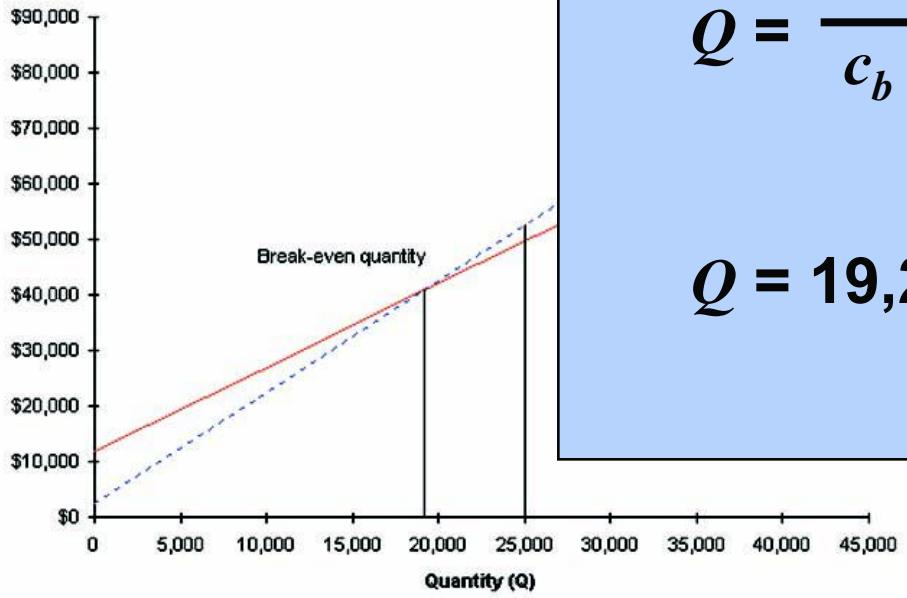
Type
- ○ Product/Service
- ◉ Two Processes

Solver - Break-Even Analysis

Enter data in yellow- shaded areas.

	Process 1	Process 2
Fixed costs (F)	$12,000	$2,400
Variable costs (c)	$1.50	$2.00
Expected demand	25,000	
Break-even quantity	19,200.0	

Decision: Process 1

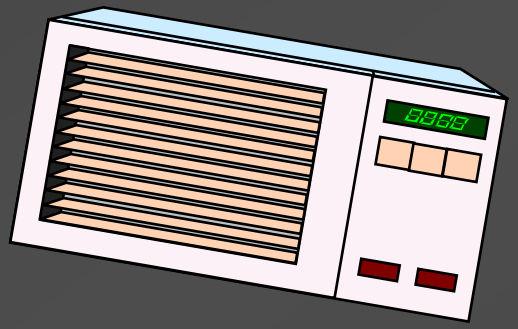


$$Q = \frac{F_m - F_b}{c_b - c_m}$$

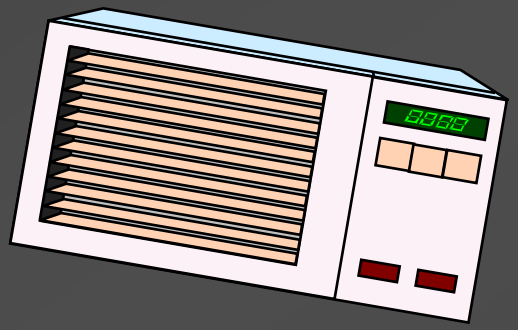
Q = 19,200 salads

Example A.3

Preference Matrix



Preference Matrix

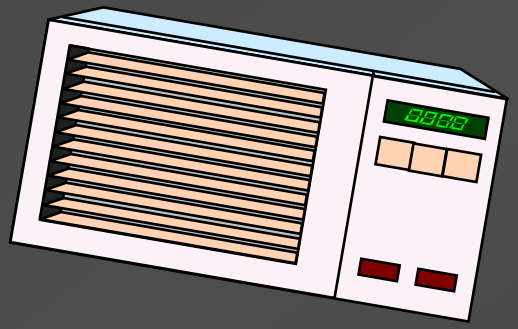


***Threshold score* = 800**

Performance Criterion	Weight (*A*)	Score (*B*)	Weighted Score (*A* x *B*)
Market potential			
Unit profit margin			
Operations compatibility			
Competitive advantage			
Investment requirement			
Project risk			

Example A.4

Preference Matrix

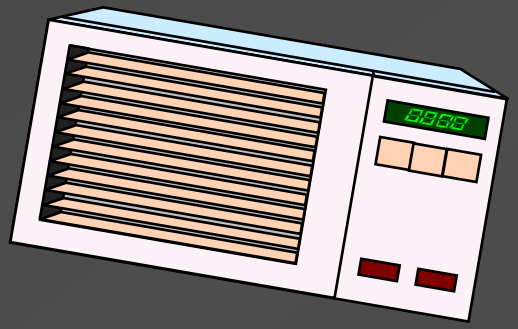


***Threshold score* = 800**

Performance Criterion	Weight (*A*)	Score (*B*)	Weighted Score (*A* x *B*)
Market potential	30		
Unit profit margin	20		
Operations compatibility	20		
Competitive advantage	15		
Investment requirement	10		
Project risk	5		

Example A.4

Preference Matrix

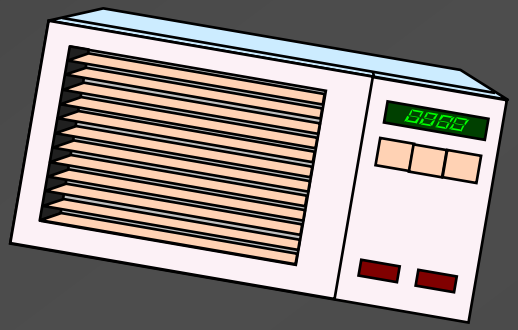


Threshold score = 800

Performance Criterion	Weight (*A*)	Score (*B*)	Weighted Score (*A* x *B*)
Market potential	30	8	
Unit profit margin	20	10	
Operations compatibility	20	6	
Competitive advantage	15	10	
Investment requirement	10	2	
Project risk	5	4	

Example A.4

Preference Matrix

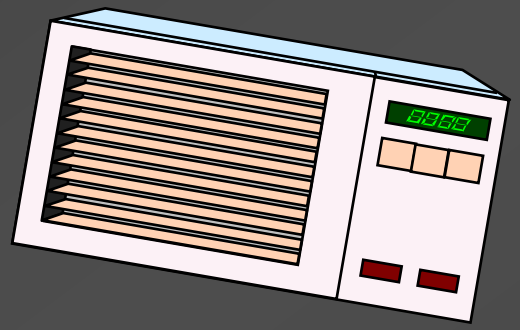


***Threshold score* = 800**

Performance Criterion	Weight (*A*)	Score (*B*)	Weighted Score (*A* x *B*)
Market potential	30	8	240
Unit profit margin	20	10	200
Operations compatibility	20	6	120
Competitive advantage	15	10	150
Investment requirement	10	2	20
Project risk	5	4	20

Example A.4

Preference Matrix

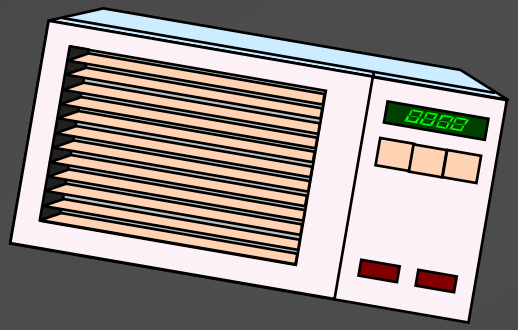


Threshold score = 800

Performance Criterion	Weight (*A*)	Score (*B*)	Weighted Score (*A* x *B*)
Market potential	30	8	240
Unit profit margin	20	10	200
Operations compatibility	20	6	120
Competitive advantage	15	10	150
Investment requirement	10	2	20
Project risk	5	4	20
		Weighted score =	750

Example A.4

Preference Matrix



Threshold score = 800

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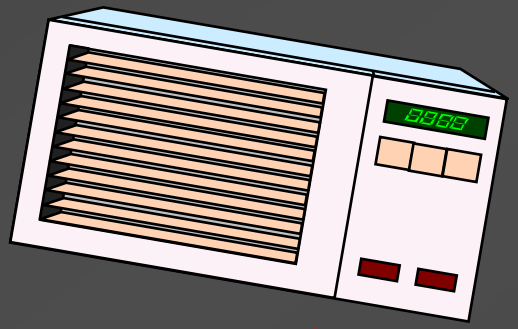
Competitive advantage	15	10	150
Investment requirement	10	2	20
Project risk	5	4	20

< 800

Weighted score = 750

Example A.4

Preference Matrix



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Unit profit margin	20	10	200
Operations compatibility	20	6	120
Competitive advantage	15	10	150
Investment requirement	10	2	20
Project risk	5	4	20
		Weighted score =	750

Not At This Time

Example A.4

Together

Together

Supplier Selection

Your company is considering new suppliers in three different countries to provide critical raw materials. Each supplier has its strengths and weaknesses in terms of cost, reliability, and geopolitical stability.

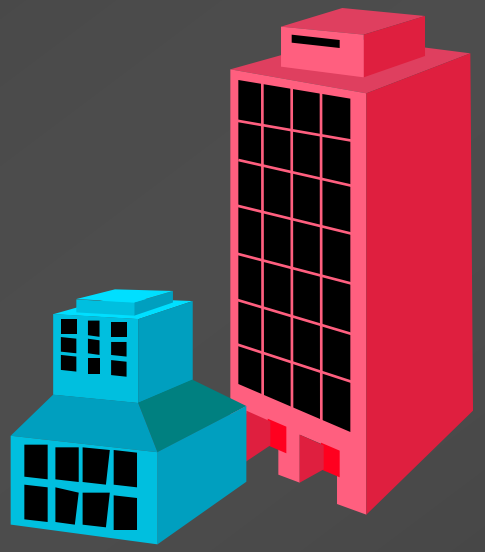
Questions:

- ***What decision-making framework will you use to evaluate these suppliers?***
- ***How will you assess the risks associated with each supplier?***
- ***How will you ensure a balanced and diversified supply chain?***

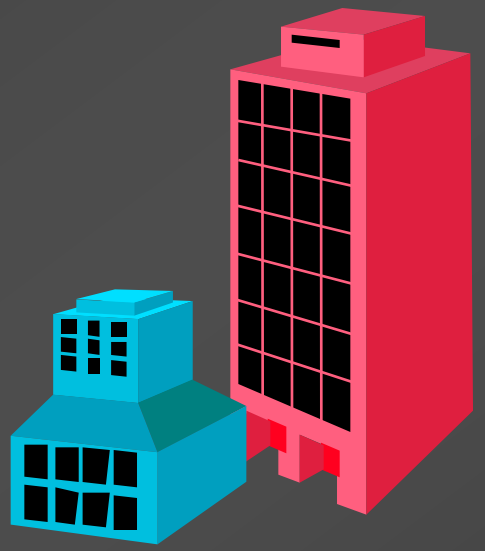
3- decision theory

- ***List the feasible alternatives***
- ***List the events***
- ***Calculate the payoff***
- ***Estimate the likelihood of each events***
- ***Select a decision rule***

Under Certainty



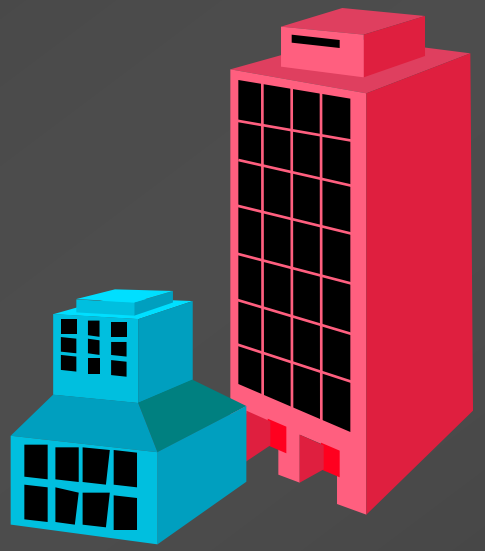
Under Certainty



Alternative	Possible Future Demand	
	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Example A.5

Under Certainty

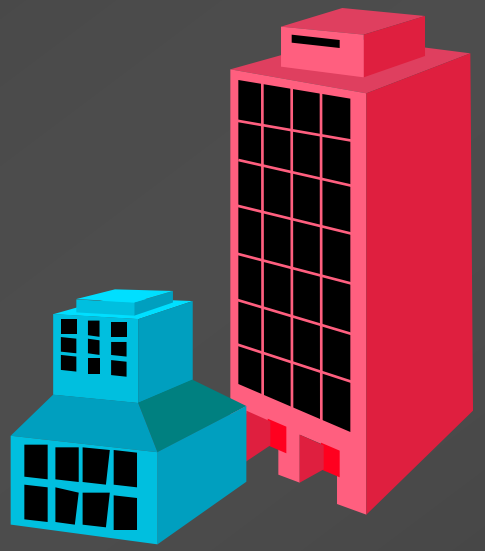


Alternative	Possible Future Demand	
	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

If future demand will be low –

Example A.5

Under Certainty

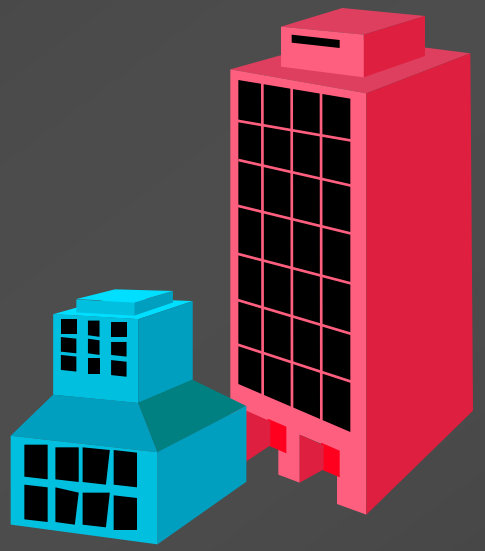


Alternative	Possible Future Demand: Low	Possible Future Demand: High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

If future demand will be low – Choose the small facility.

Example A.5

Under Certainty



Alternative	Possible Future Demand: Low	Possible Future Demand: High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

If future demand will be low – Choose the small facility.

Example A.5

Under Uncertainty

Alternative	Possible Future Demand	
	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Example A.6

Under Uncertainty

Alternative	Possible Future Demand: Low	Possible Future Demand: High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin –

Example A.6

Under Uncertainty

Alternative	Possible Future Demand: Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin –

Best of the worst

Example A.6

Under Uncertainty

Alternative	Possible Future Demand: Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small

Best of the worst

Example A.6

Under Uncertainty

Alternative	Possible Future Demand	
	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax –

Example A.6

Under Uncertainty

Alternative	Possible Future Demand: Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax –

Best of the best

Example A.6

Under Uncertainty

Alternative	Possible Future Demand: Low	Possible Future Demand: High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax – Large

Best of the best

Example A.6

Under Uncertainty

Alternative	Possible Future Demand	
	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax – Large
Laplace –

Example A.6

Under Uncertainty

Alternative	Possible Future Demand: Low	Possible Future Demand: High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax – Large
Laplace –

Small facility 0.5(200) + 0.5(270) = 235

Best weighted payoff

Example A.6

Under Uncertainty

Alternative	Possible Future Demand: Low	Possible Future Demand: High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax – Large
Laplace –

Small facility 0.5(200) + 0.5(270) = 235
Large facility 0.5(160) + 0.5(800) = 480

Best weighted payoff

Example A.6

Under Uncertainty

Alternative	Possible Future Demand	
	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax – Large
Laplace – Large

Small facility 0.5(200) + 0.5(270) = 235
Large facility 0.5(160) + 0.5(800) = 480

Best weighted payoff

Example A.6

Under Uncertainty

Alternative	Possible Future Demand	
	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax – Large
Laplace – Large
Minimax Regret –

Example A.6

Under Uncertainty

Alternative	Possible Future Demand: Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax – Large
Laplace – Large
Minimax Regret –

	Regret: Low Demand	High Demand
Small facility	200 – 200 = 0	800 – 270 = 530

Best worst regret

Example A.6

Under Uncertainty

Alternative	Possible Future Demand: Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax – Large
Laplace – Large
Minimax Regret –

	Regret: Low Demand	High Demand
Small facility	200 – 200 = 0	800 – 270 = 530
Large facility	200 – 160 = 40	800 – 800 = 0

Best worst regret

Example A.6

Under Uncertainty

Alternative	Possible Future Demand: Low	Possible Future Demand: High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax – Large
Laplace – Large
Minimax Regret – Large

	Regret: Low Demand	Regret: High Demand
Small facility	200 – 200 = 0	800 – 270 = 530
Large facility	200 – 160 = 40	800 – 800 = 0

Best worst regret

Example A.6

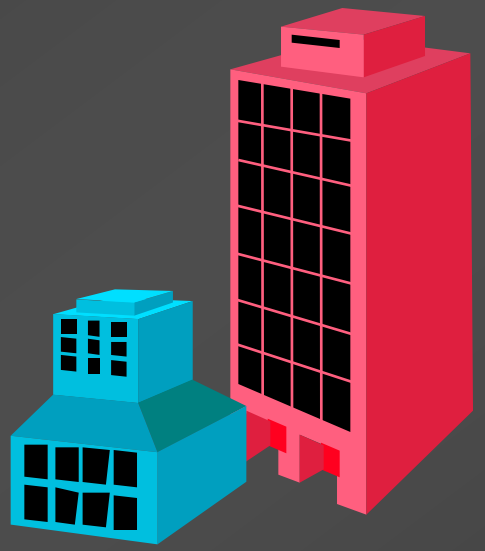
Under Uncertainty

Alternative	Possible Future Demand	
	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Maximin – Small
Maximax – Large
Laplace – Large
Minimax Regret – Large

Example A.6

Under Risk



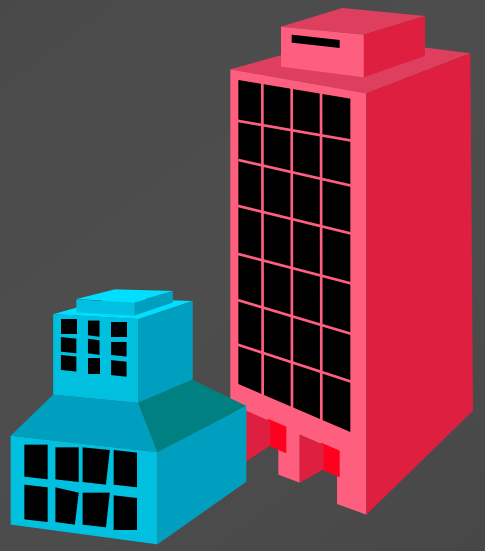
Alternative	Possible Future Demand	
	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

$P_{small} = 0.4$

$P_{large} = 0.6$

Example A.7

Under Risk



Alternative	Possible Future Demand: Low	Possible Future Demand: High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

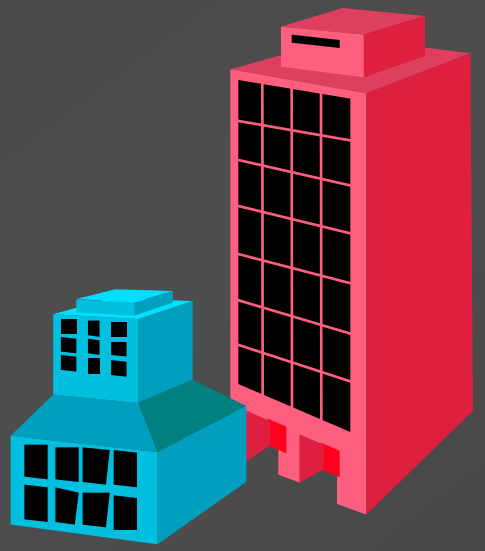
$P_{small} = 0.4$

$P_{large} = 0.6$

Alternative	Expected Value
Small facility	0.4(200) + 0.6(270) = 242

Example A.7

Under Risk



Alternative	Possible Future Demand	
	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

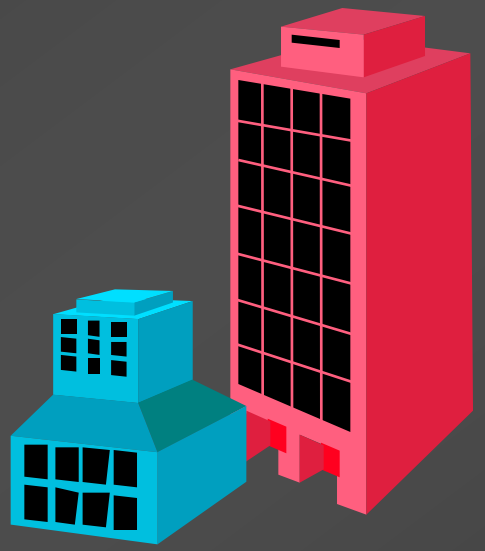
$P_{small} = 0.4$

$P_{large} = 0.6$

Alternative	Expected Value
Small facility	0.4(200) + 0.6(270) = 242
Large facility	0.4(160) + 0.6(800) = 544

Example A.7

Under Risk



Alternative	Possible Future Demand	
	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

$P_{small} = 0.4$

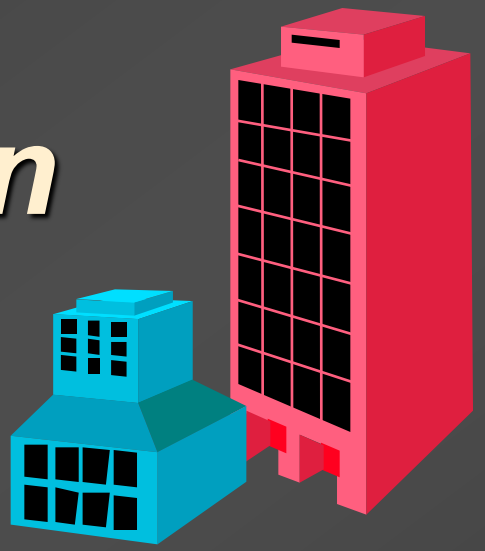
$P_{large} = 0.6$

Alternative	Expected Value
Small facility	0.4(200) + 0.6(270) = 242
Large facility	0.4(160) + 0.6(800) = 544

Highest Expected Value

Example A.7

Perfect Information



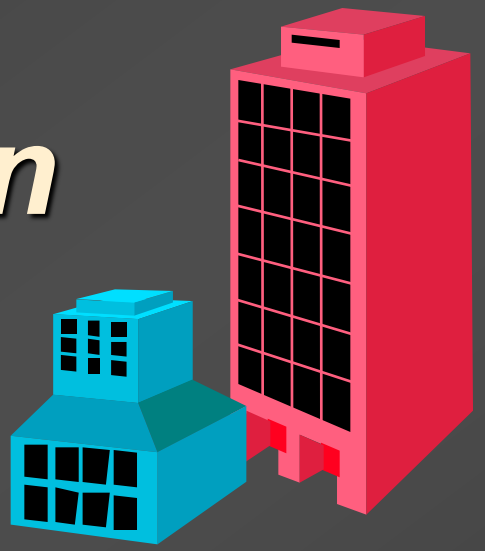
Alternative	Possible Future Demand: Low	Possible Future Demand: High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

$P_{small} = 0.4$

$P_{large} = 0.6$

Example A.8

Perfect Information



Alternative	Possible Future Demand: Low	Possible Future Demand: High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

Event	Best Payoff
Low demand	200
High demand	800

$P_{small} = 0.4$

$P_{large} = 0.6$

Example A.8

Decision Trees

Decision Trees

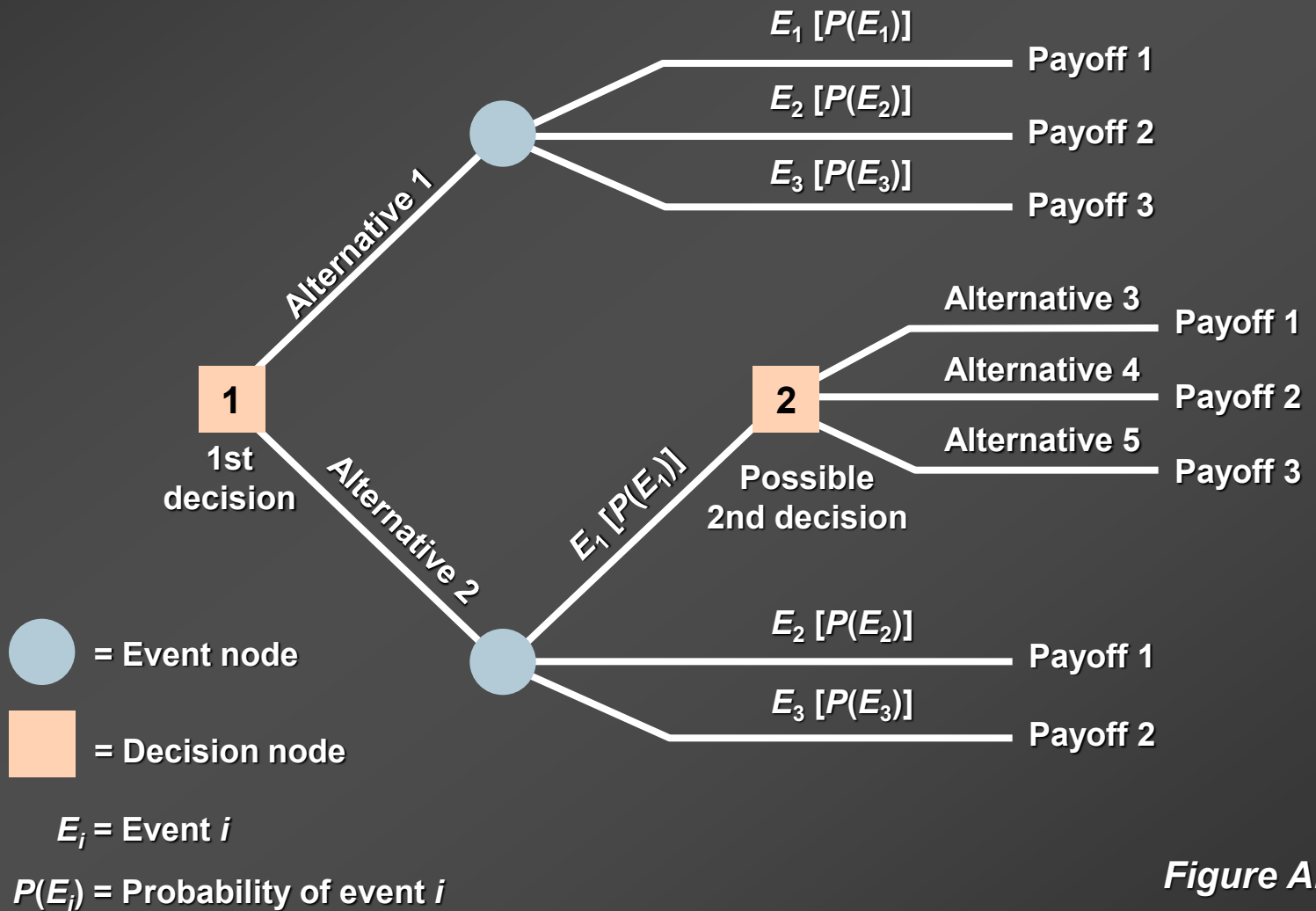
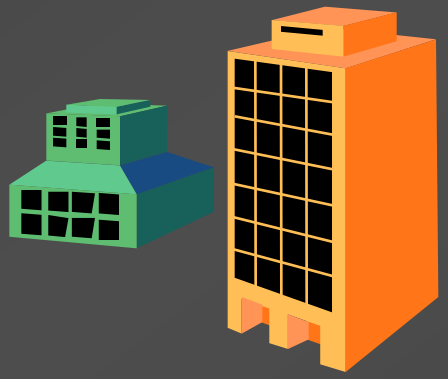
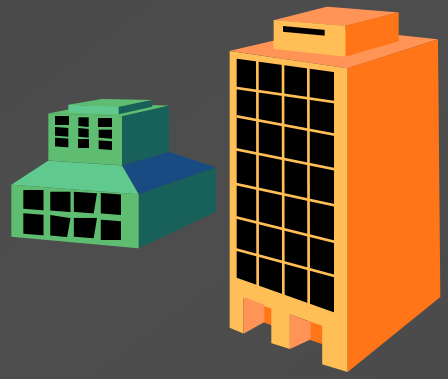


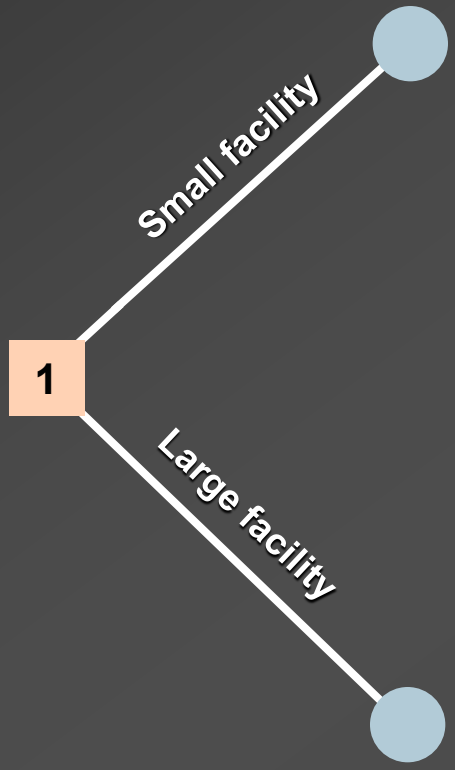
Figure A.5

Decision Trees



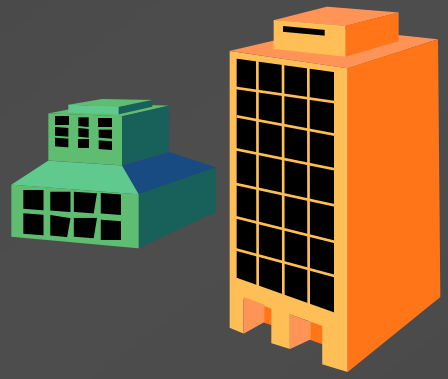
Decision Trees

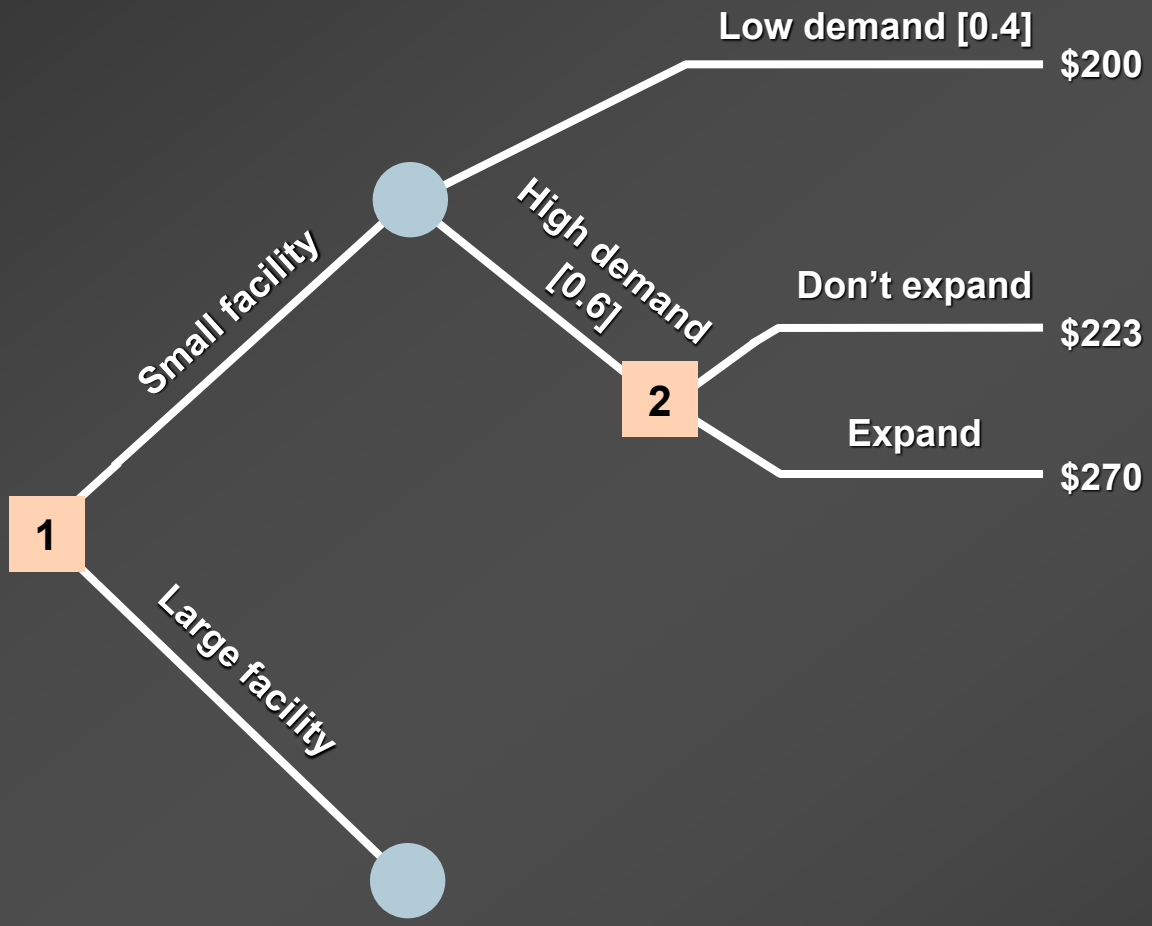




Example A.9

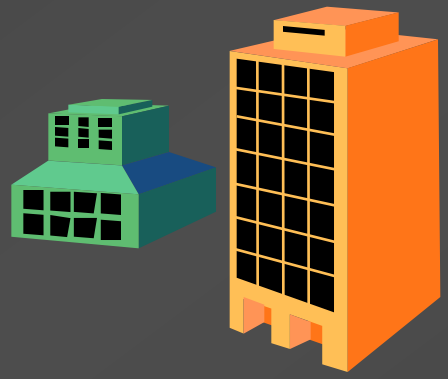
Decision Trees

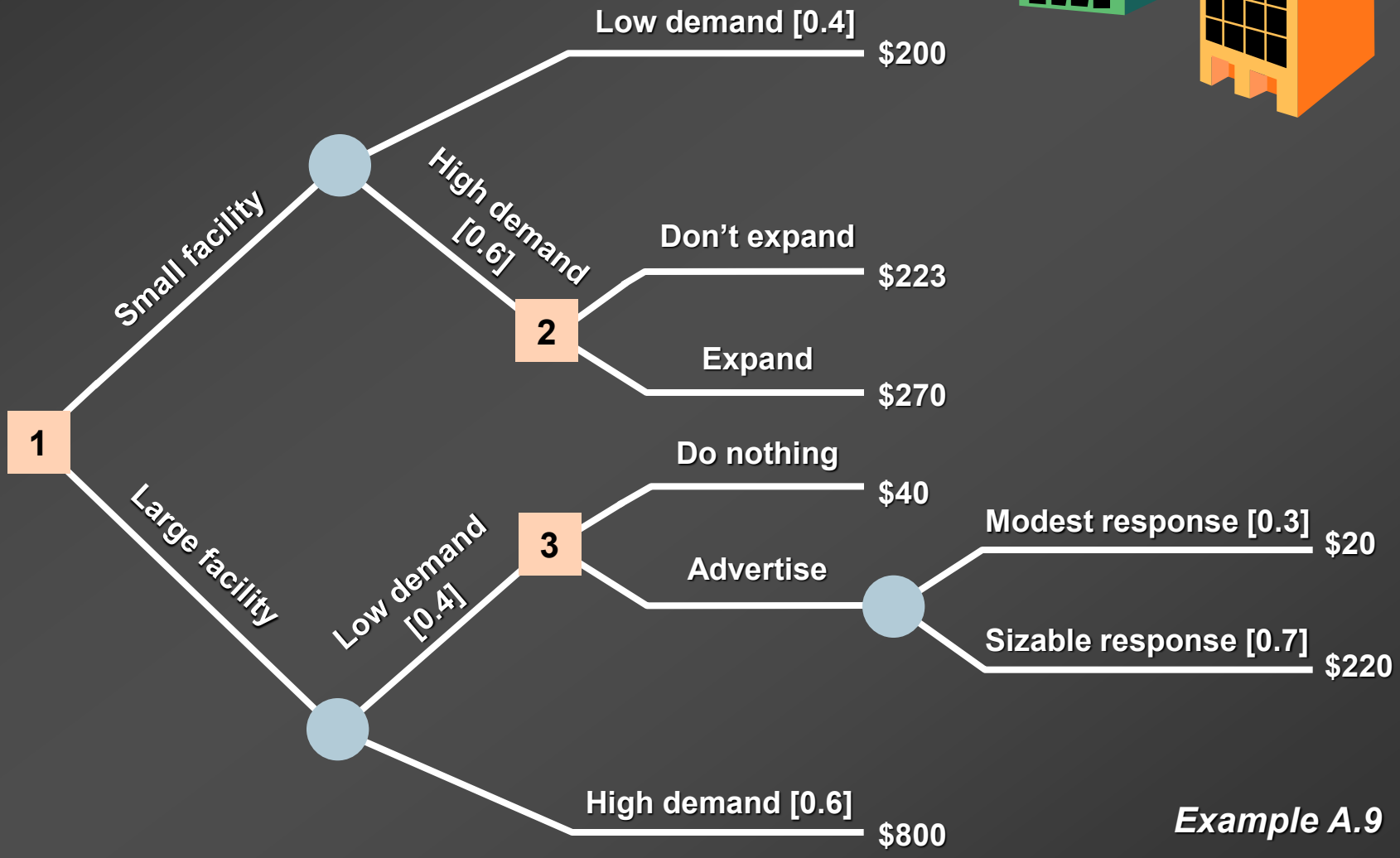




Example A.9

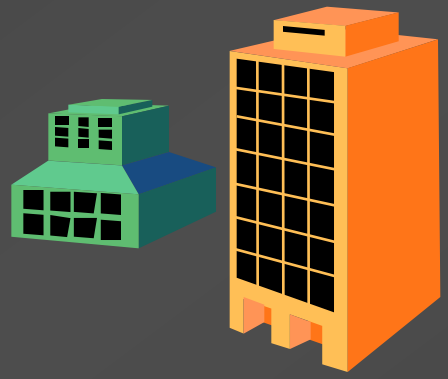
Decision Trees

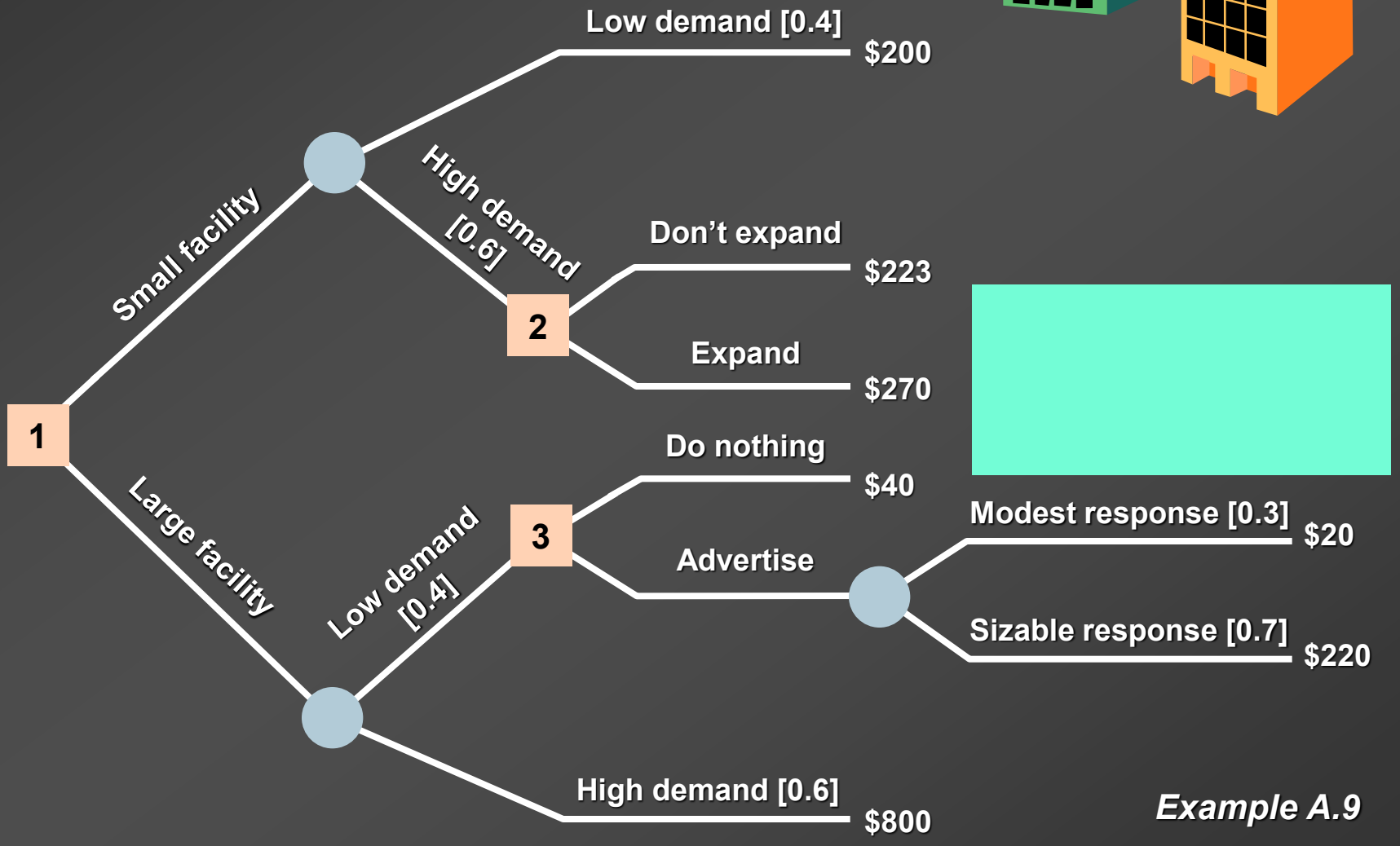




Example A.9

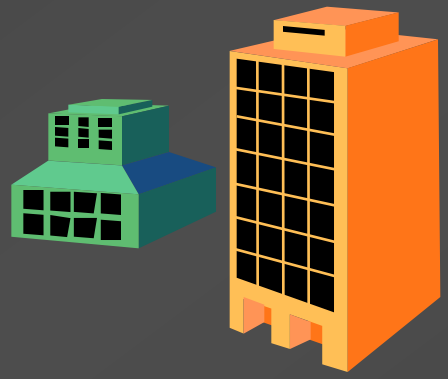
Decision Trees





Example A.9

Decision Trees



Low demand [0.4]

$200

High demand [0.6]

Small facility

Don't expand

$223

2

Expand

$270

1

Do nothing

$40

Large facility

Low demand [0.4]

3

Advertise

Modest response [0.3]

$20

Sizable response [0.7]

$220

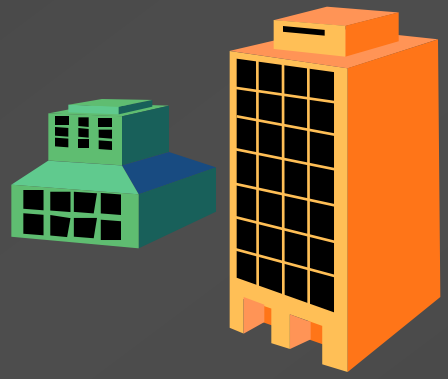
0.3(20) + 0.7(220)

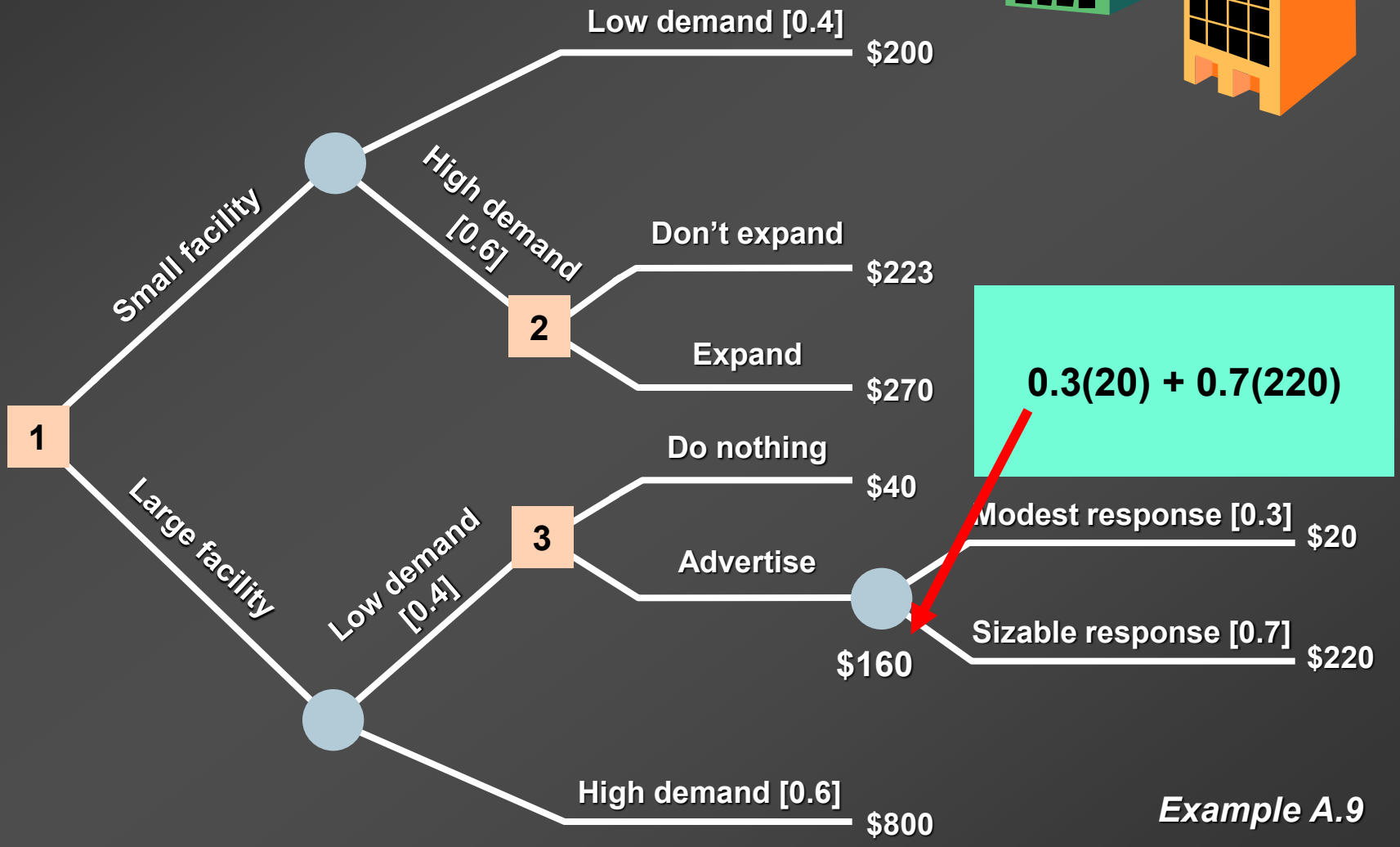
High demand [0.6]

$800

Example A.9

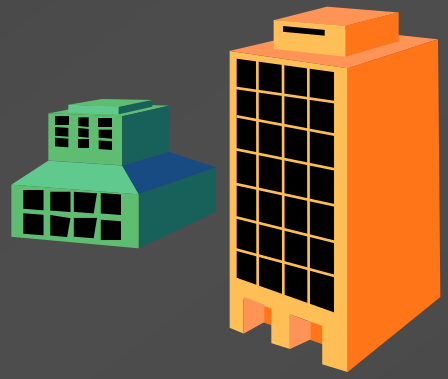
Decision Trees

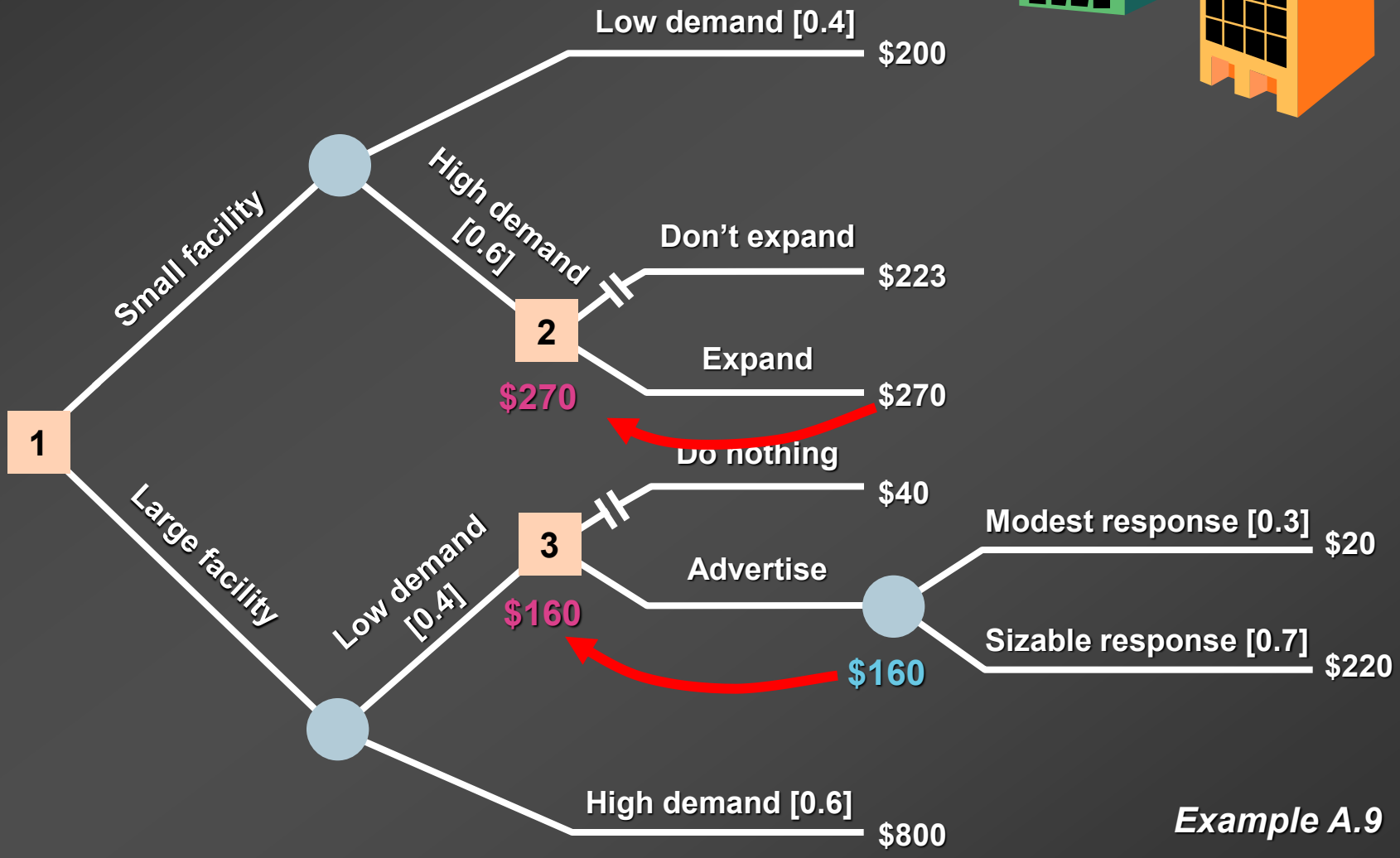




Example A.9

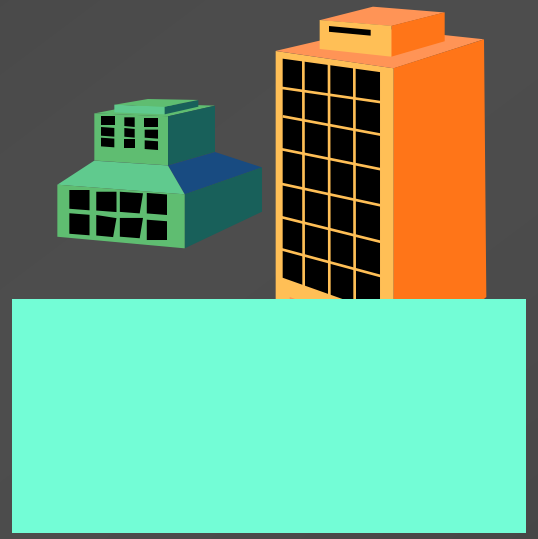
Decision Trees





Example A.9

Decision Trees



Low demand [0.4]

$200

Small facility

High demand [0.6]

Don't expand

$223

2

Expand

$270

$270

1

Do nothing

$40

Large facility

Low demand [0.4]

3

Modest response [0.3]

$20

Advertise

response [0.7]

$220

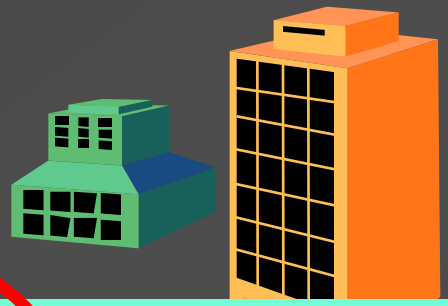
$160

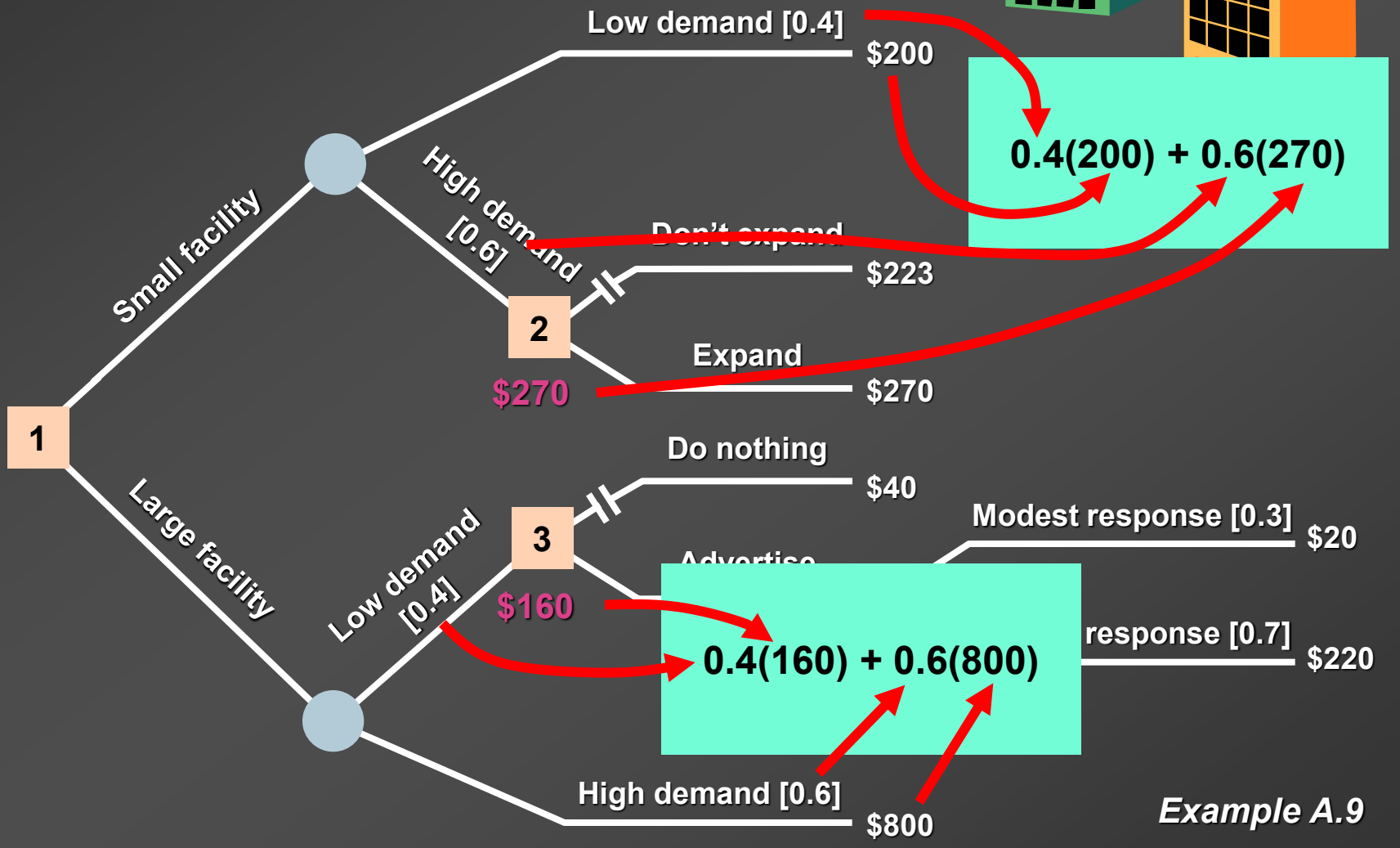
High demand [0.6]

$800

Example A.9

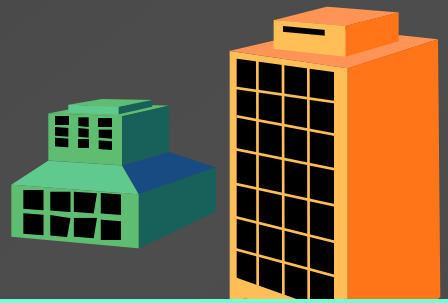
Decision Trees





Example A.9

Decision Trees



Low demand [0.4]

$200

0.4(200) + 0.6(270)

Small facility

$242

High demand [0.6]

Don't expand

$223

2

Expand

$270

$270

1

Do nothing

$40

Large facility

Low demand [0.4]

3

Modest response [0.3]

$20

Advertise

response [0.7]

$220

$160

0.4(160) + 0.6(800)

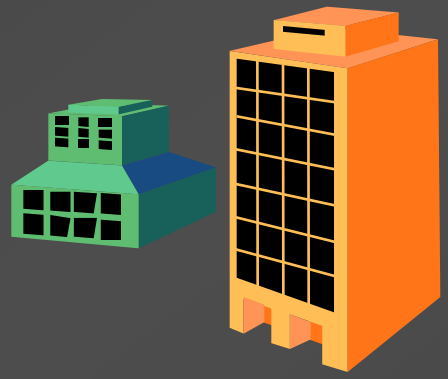
$544

High demand [0.6]

$800

Example A.9

Decision Trees



Low demand [0.4]

$200

Small facility

$242

High demand [0.6]

Don't expand

$223

2

Expand

$270

$270

1

Do nothing

$40

$544

Large facility

Low demand [0.4]

3

Modest response [0.3]

$20

Advertise

$160

Sizable response [0.7]

$220

$160

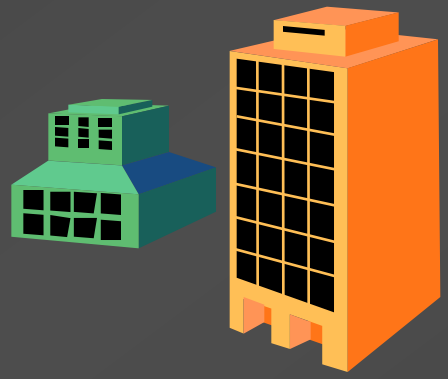
$544

High demand [0.6]

$800

Example A.9

Decision Trees



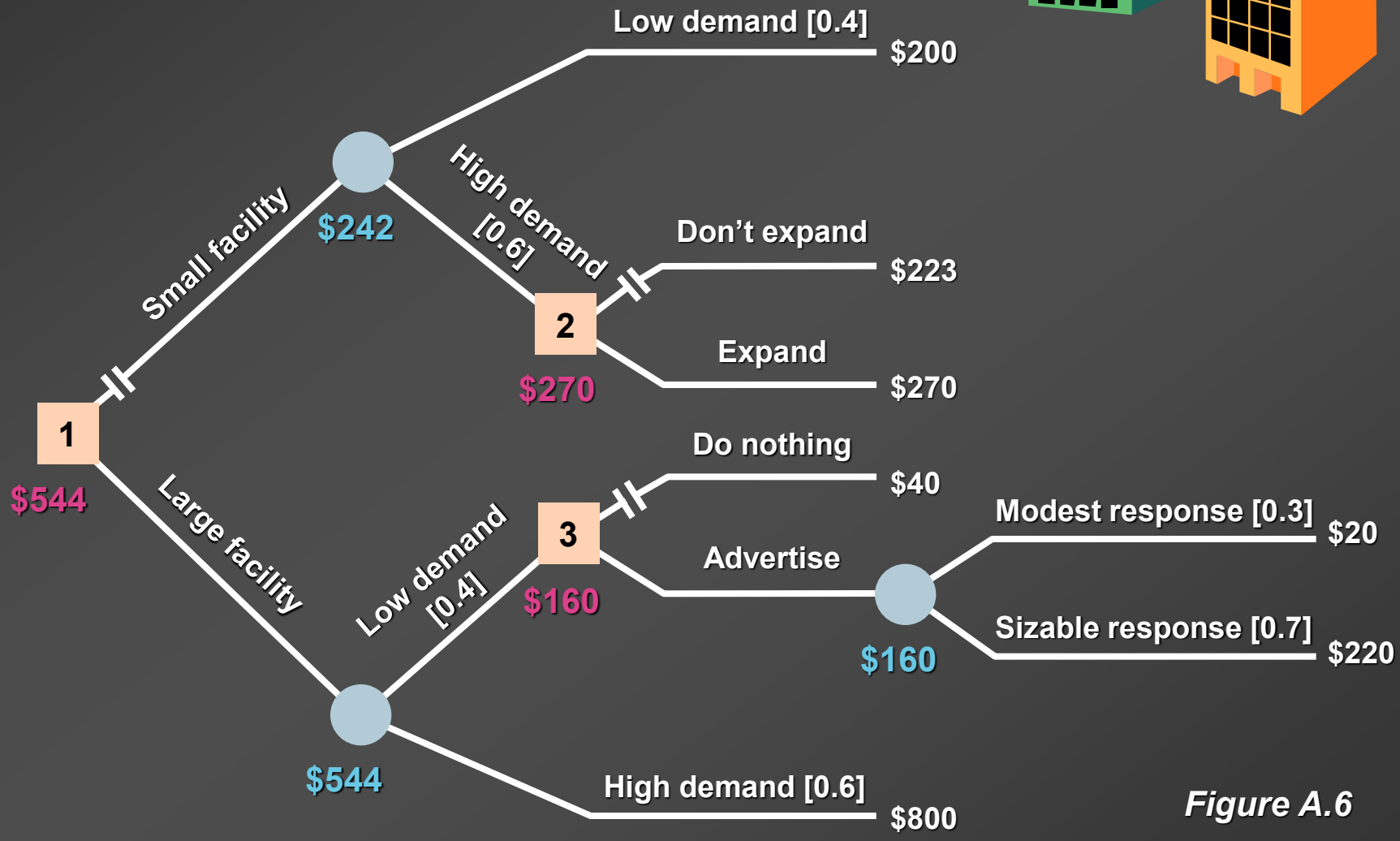


Figure A.6

NETWORK DESIGN DECISIONS

- ***Introducing method***
  - ***Fixed and variable cost***
  - ***Identified forecasts***
  - ***One product***
  - ***Total cost is fixed cost +unit variable cost x Quantity***
  - ***Example and identification of equivalence levels***
  - ***Best choice is ….***

Fixed and variable cost

Site	Fixed cost	Variable cost
A	250 000 $	11 $ per unit
B	100 000 $	30 $ per unit
C	150 000 $	20 $ per unit
D	200 000 $	35 $ per unit

Site	Fixed cost	Variable cost …	Total cost
A	250 000 $	11x10 000 u	360 000 $
B	100 000 $	30x 10 000 u	400 000 $
C	150 000 $	20 x 10 000 u	350 000 $
D	200 000 $	35 x 10 000 u	550 000 $

Let’s come back to break even

100 000 $ + 30 $ x Q = 150 000 $ + 20 $ x Q Q= 5000 u
150 000 $ +20$ x Q = 250 000 $ + 11 $ x Q Q = 11 111 u
100 000 $ + 30 $ x Q = 250 000 $ + 11 $ x Q Q = 7 895 u

NETWORK DESIGN DECISIONS

- ***Transport cost***
  - ***Impact***
  - ***Finished goods flows***
  - ***Raw materials***
  - ***Multi choice to be solved through transport model***
- ***Weighing method***
  - ***Relevant factors***
  - ***Weighing***
- ***Gravity center method***
  - ***Geographical coordinates***

Gravity center method

Coordonates of x,y

Average of x = Sum of xi / n destinations

Average of y = sum of yi / n destinations

Average of x,y will be optimum location

BUT
we have to take into account quantities carried

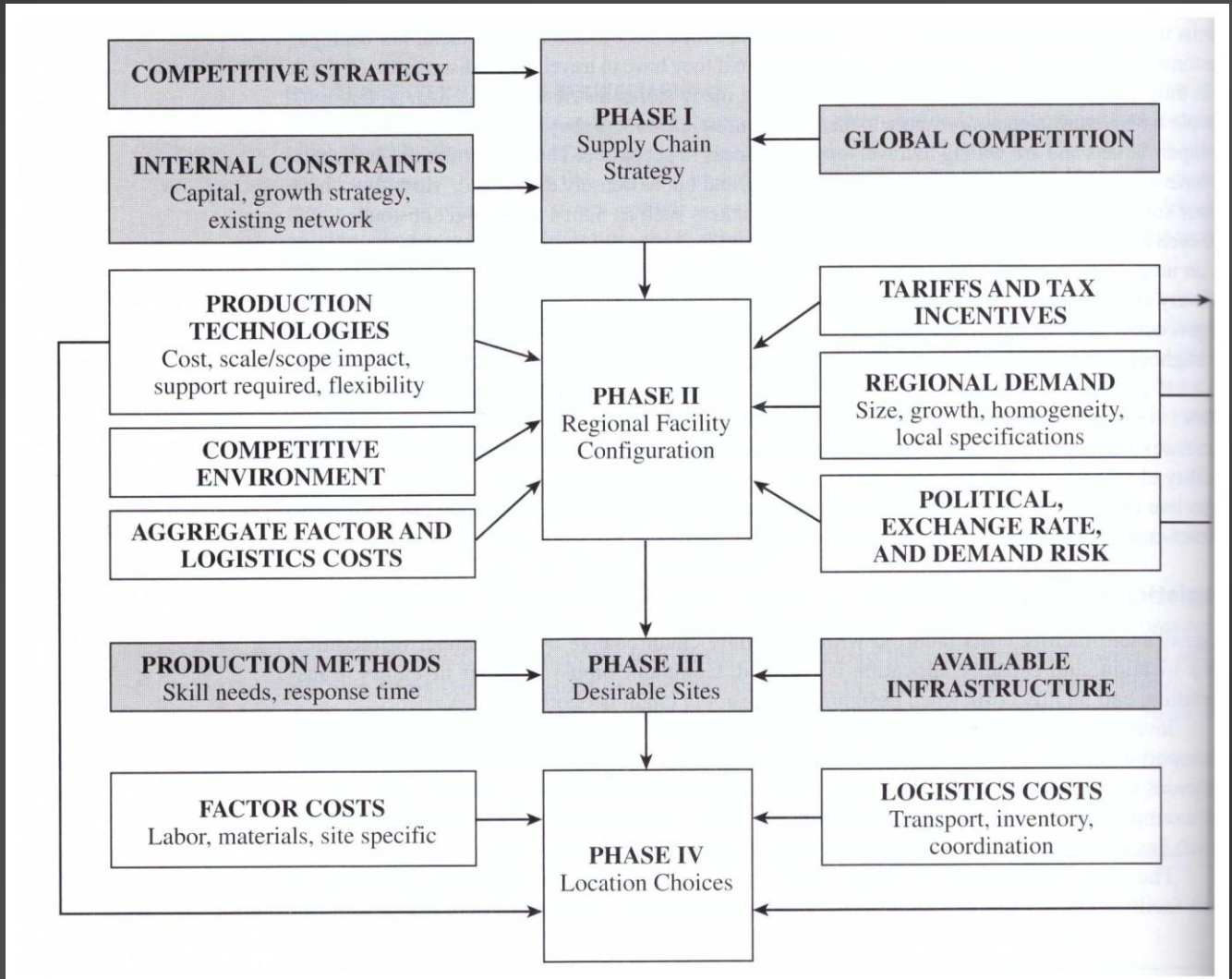
- ***Average of x becomes***

  sum of xi.Qi / sum Qi

- ***Average of y becomes***

  sum of yi.Qi/sum Qi

NETWORK DESIGN DECISIONS



Together

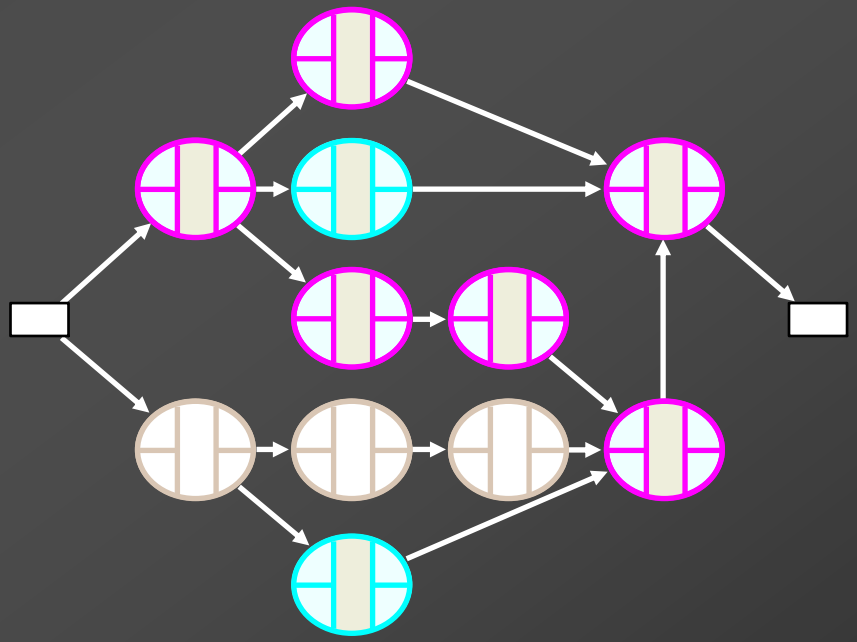
Route Optimization

Your company needs to transport goods from a manufacturing plant in Vietnam to distribution centers in Europe. Due to rising fuel prices and environmental regulations, optimizing transportation routes is crucial.

Questions:

- ***Which criteria will you prioritize in your route optimization (cost, time, environmental impact)?***
- ***What alternative transportation methods could you consider (e.g., sea, air, rail)?***
- ***How will you balance the trade-offs between cost, speed, and sustainability?***

Planning and Managing Projects



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Activity Relationships

Activity Relationship

AOA	AON

Activity on Arc ***Activity on Network***

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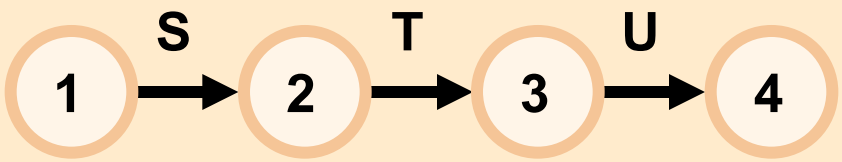
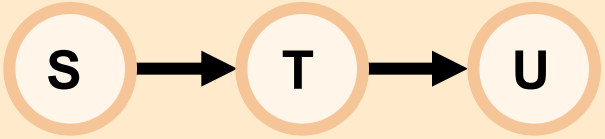
Activity Relationships

Activity Relationship

S precedes T, which precedes U.

AOA	AON
	

Activity on Arc ***Activity on Network***

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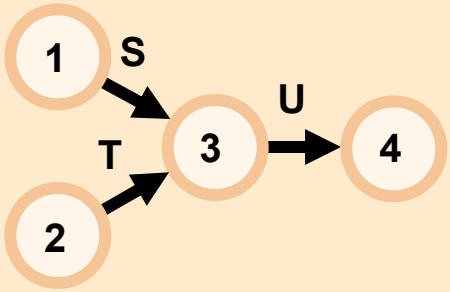
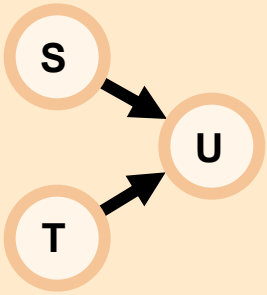
Activity Relationships

Activity Relationship

S and T must be completed before U can be started.

AOA	AON
	

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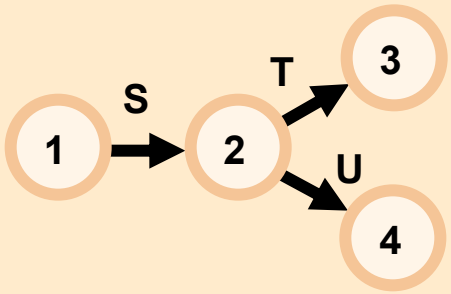
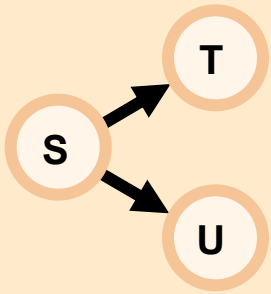
Activity Relationships

Activity Relationship

T and U cannot begin until S has been completed.

AOA	AON
	

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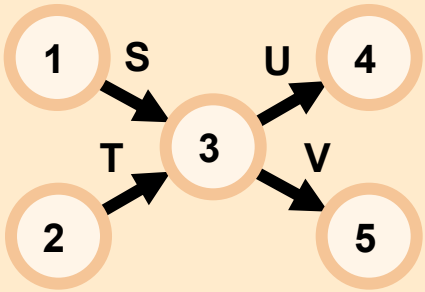
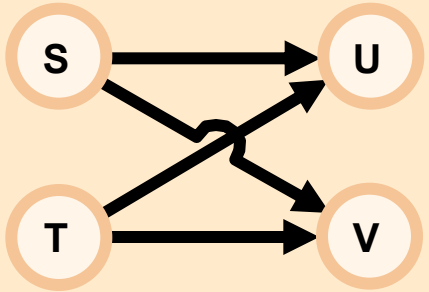
Activity Relationships

Activity Relationship

U and V cannot begin until both S and T have been completed.

AOA	AON
	

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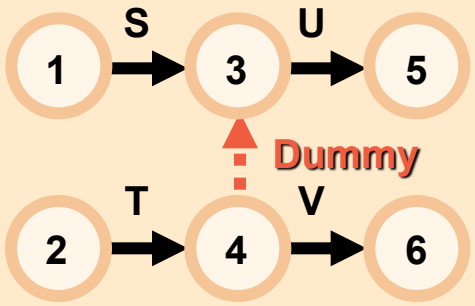
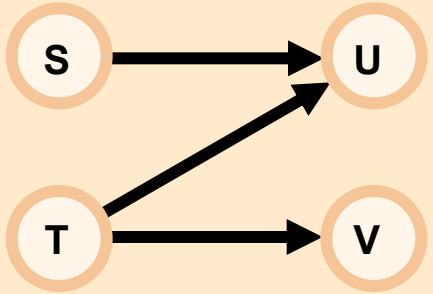
Activity Relationships

Activity Relationship

U cannot begin until both S and T have been completed;
V cannot begin until T has been completed.

AOA	AON
	

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Activity Relationships

Activity Relationship

T and U cannot begin until S has been completed; V cannot begin until both T and U have been completed.

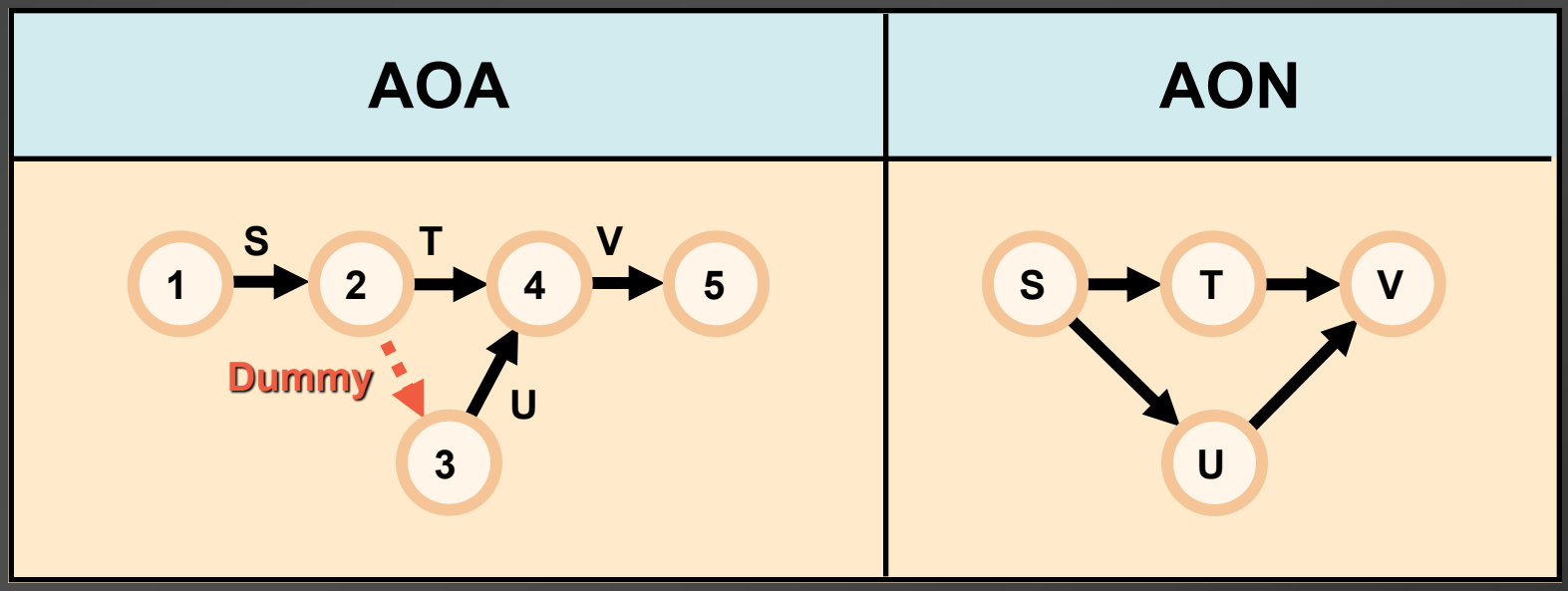

Figure 8.3

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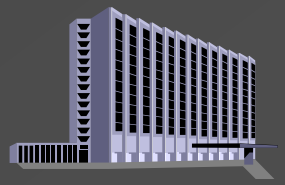

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Activity	Description	Immediate Predecessor(s)	Responsibility
A	Select administrative and medical staff.		
B	Select site and do site survey.		
C	Select equipment.		
D	Prepare final construction plans and layout.		
E	Bring utilities to the site.		
F	Interview applicants and fill positions in nursing, support staff, maintenance, and security.		
G	Purchase and take delivery of equipment.		
H	Construct the hospital.		
I	Develop an information system.		
J	Install the equipment.		
K	Train nurses and support staff.		

Example 8.1

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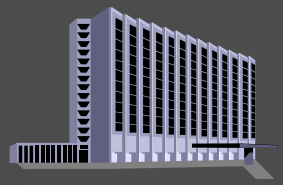

Activity	Description	Immediate Predecessor(s)	Responsibility
A	Select administrative and medical staff.	—	Johnson
B	Select site and do site survey.	—	Taylor
C	Select equipment.	A	Adams
D	Prepare final construction plans and layout.	B	Taylor
E	Bring utilities to the site.	B	Burton
F	Interview applicants and fill positions in nursing, support staff, maintenance, and security.	A	Johnson
G	Purchase and take delivery of equipment.	C	Adams
H	Construct the hospital.	D	Taylor
I	Develop an information system.	A	Simmons
J	Install the equipment.	E,G,H	Adams
K	Train nurses and support staff.	F,I,J	Johnson

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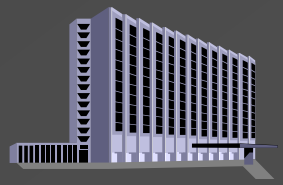

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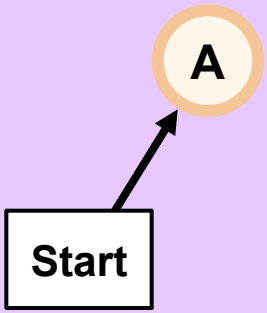

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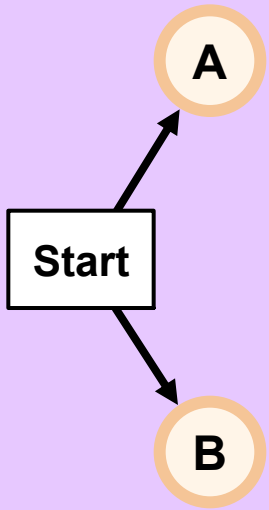

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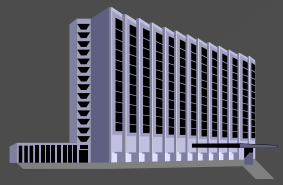

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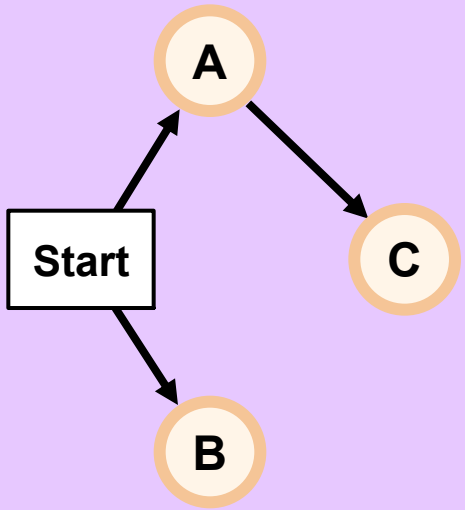

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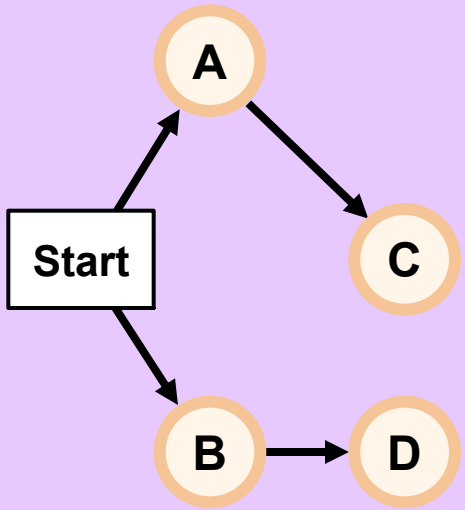

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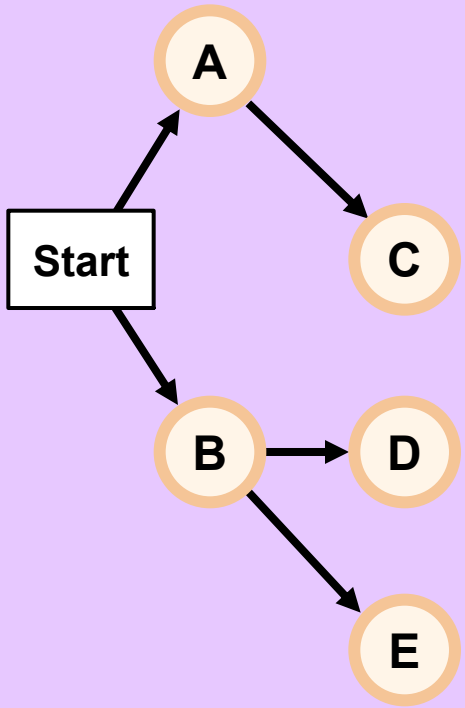

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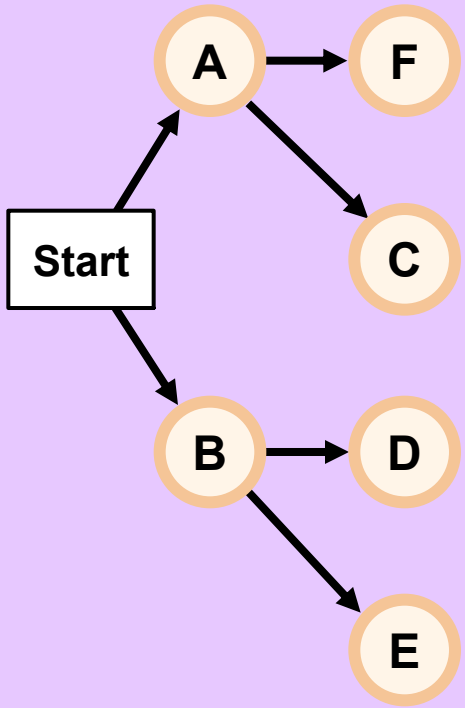

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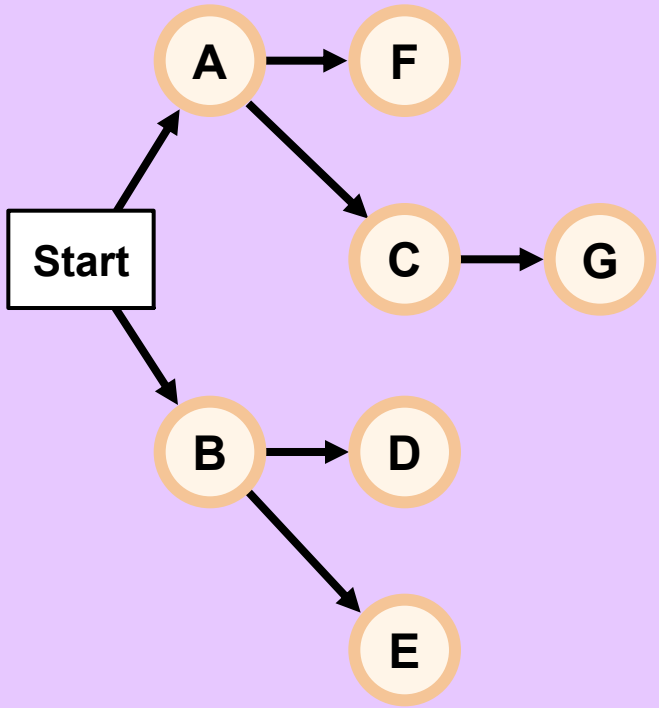

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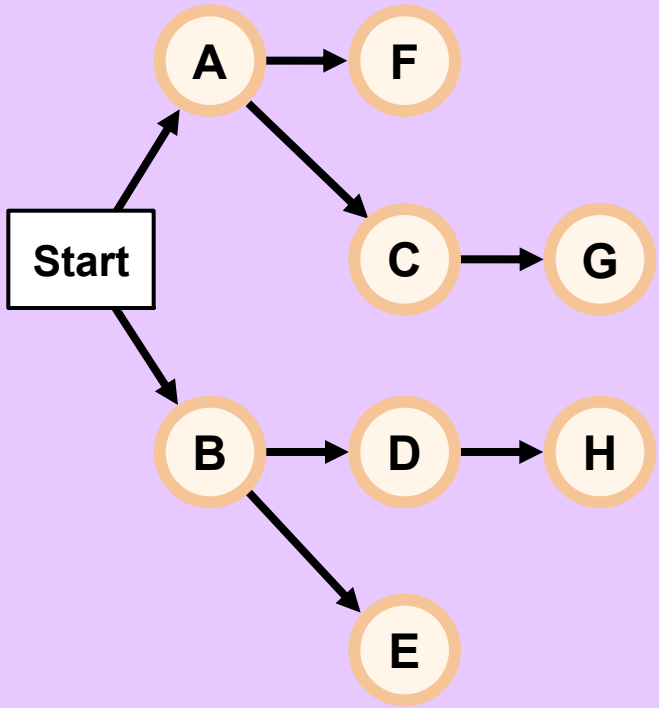

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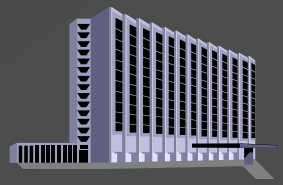

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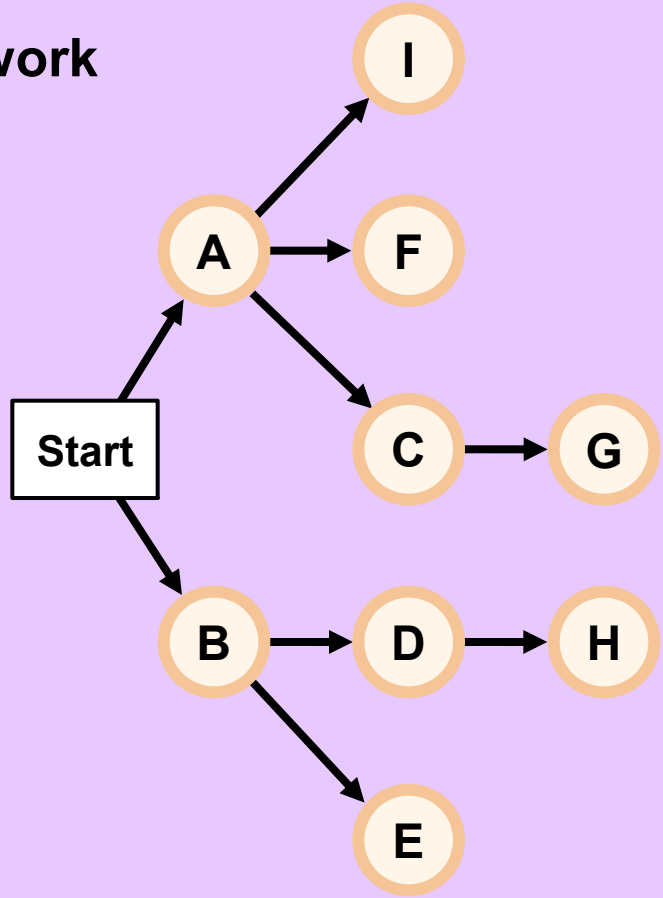

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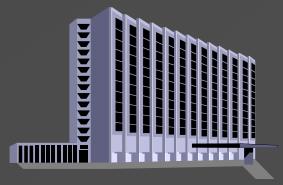

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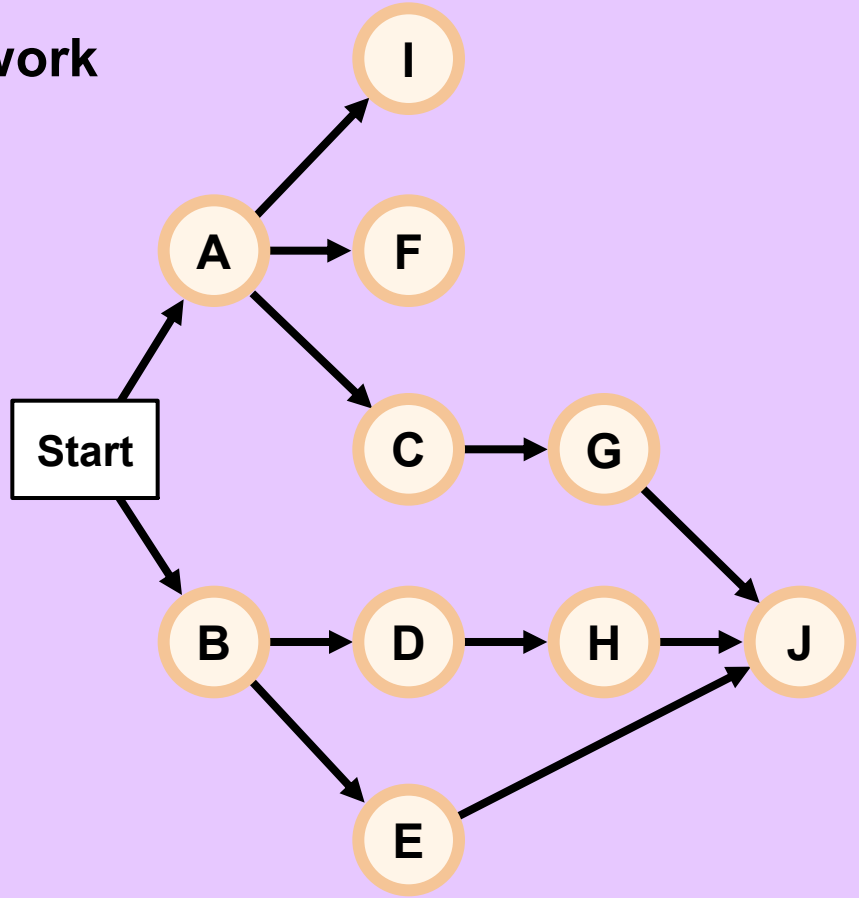

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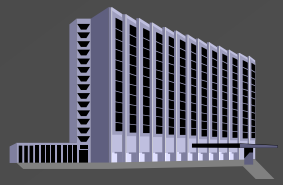

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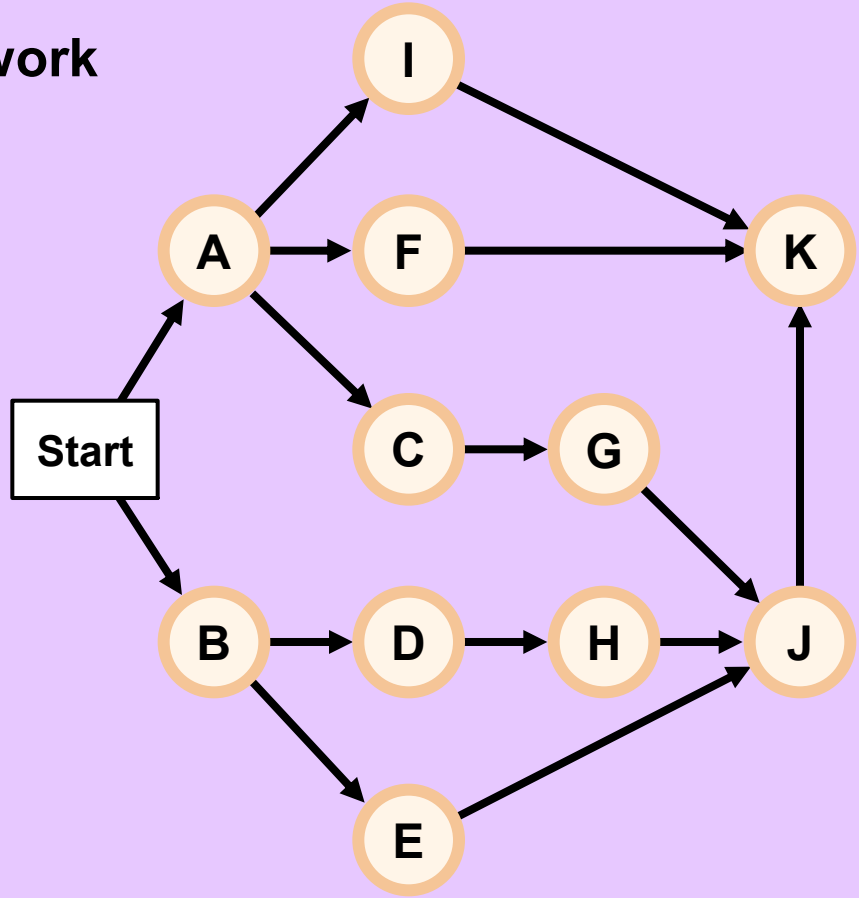

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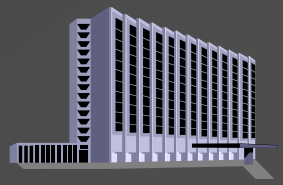

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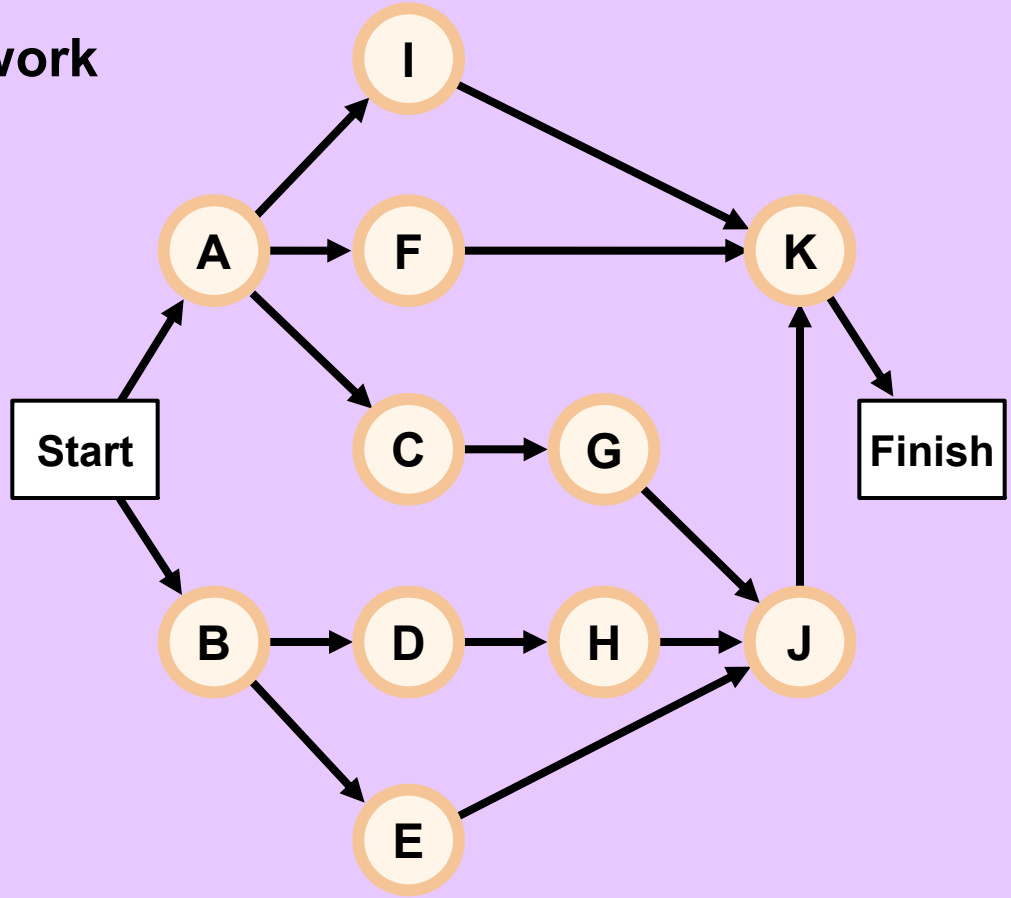

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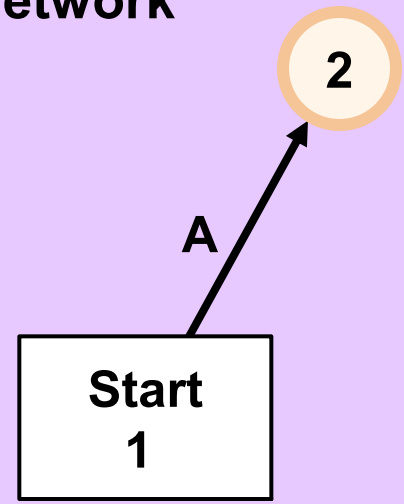

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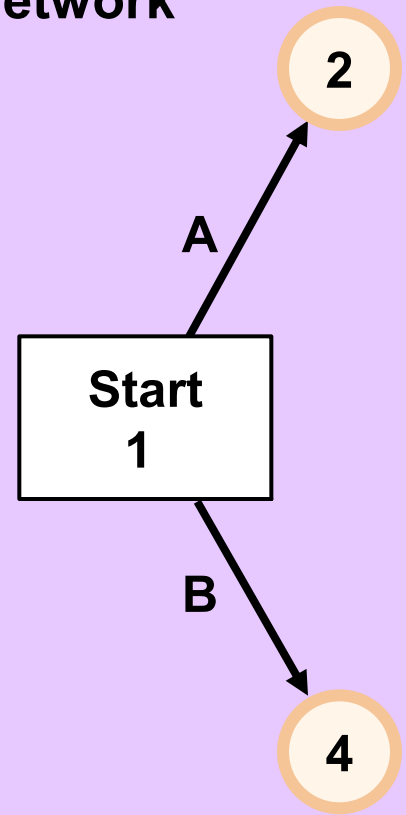

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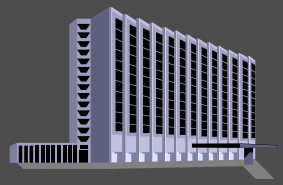

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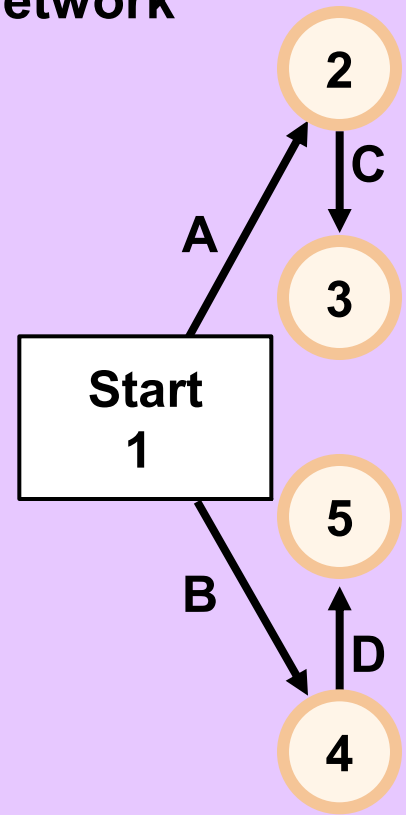

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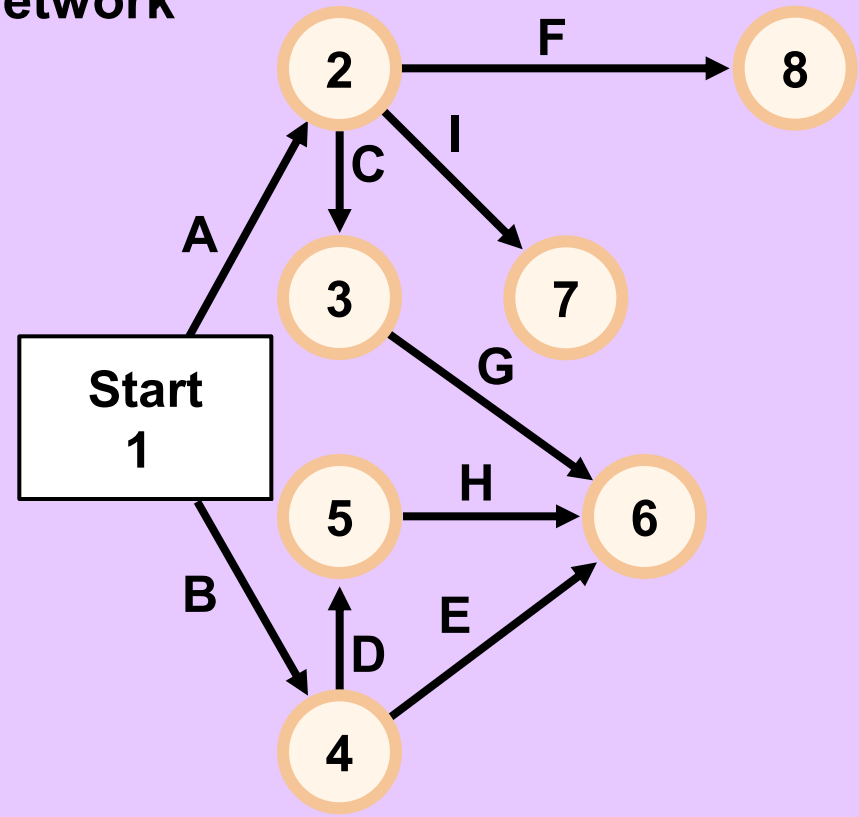

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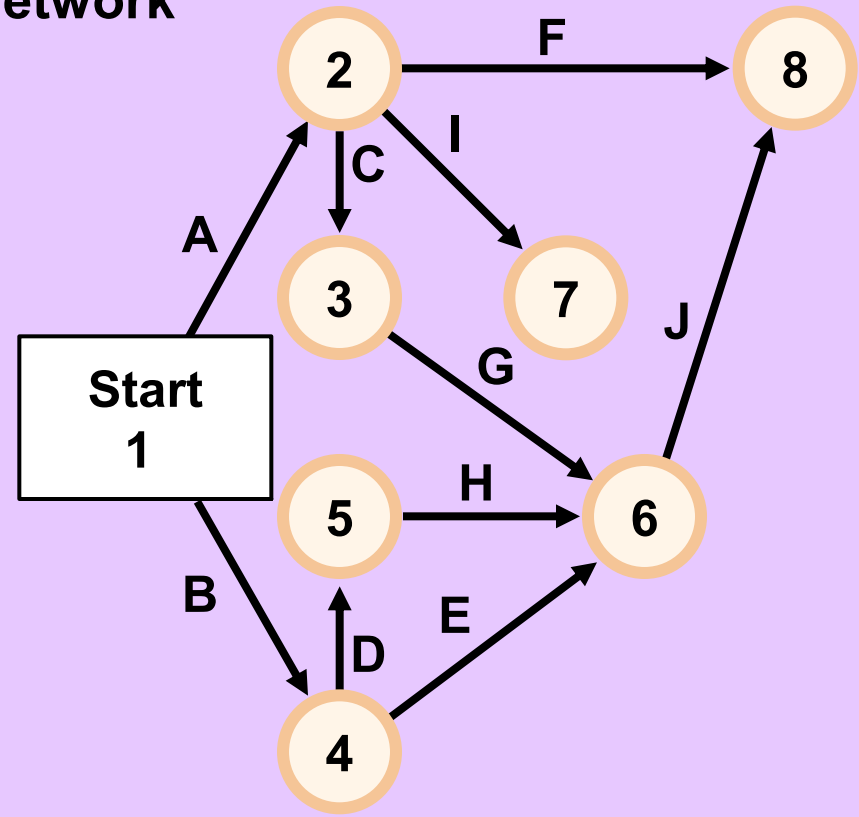

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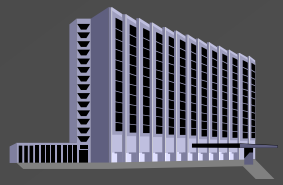

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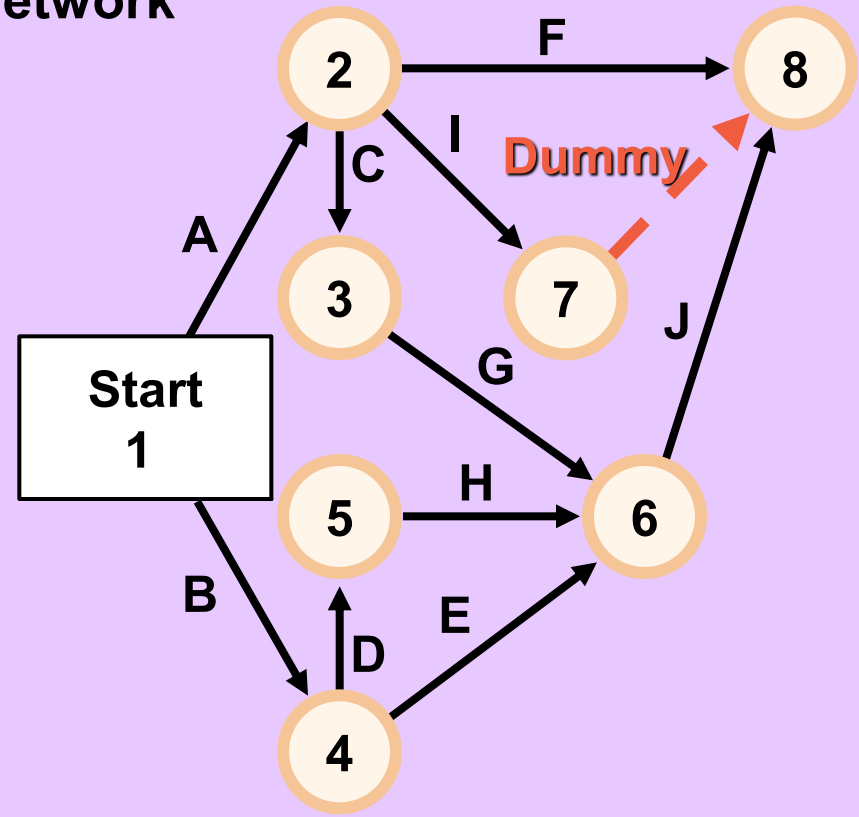

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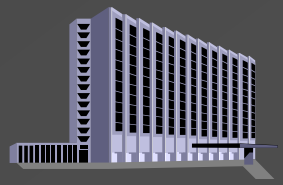

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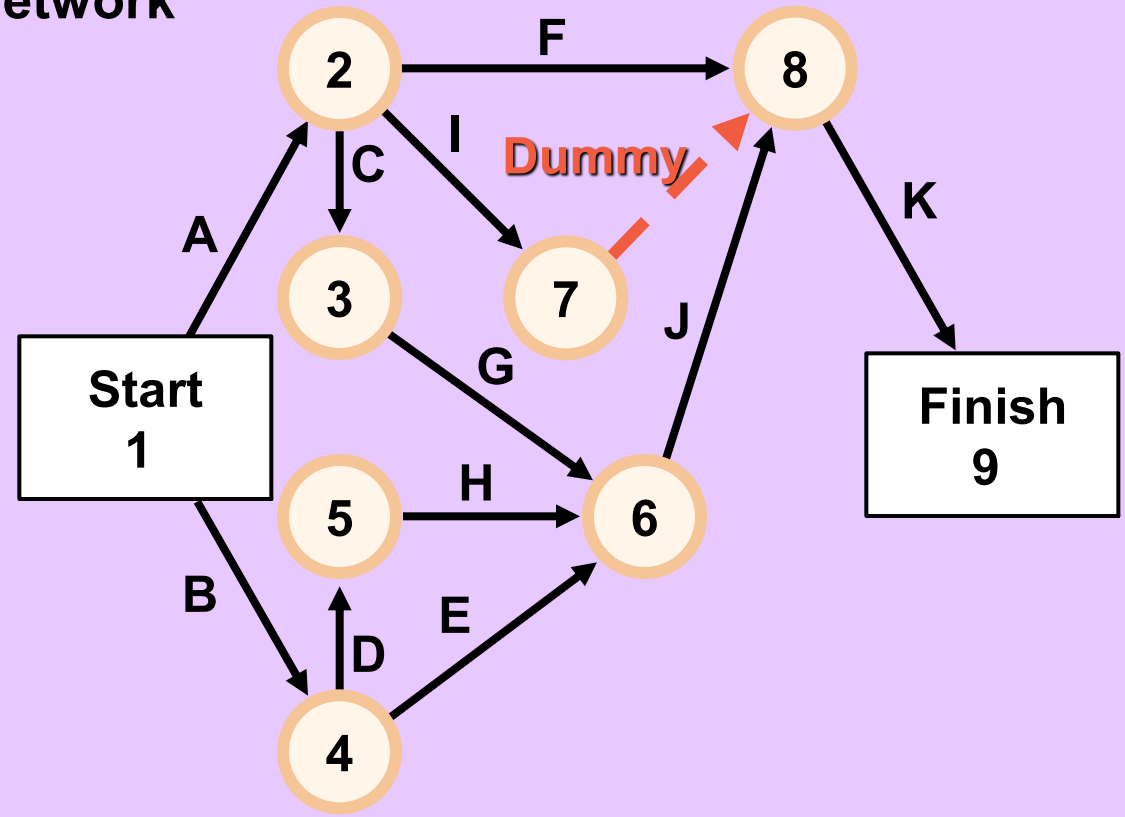

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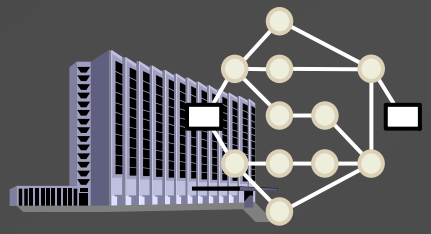

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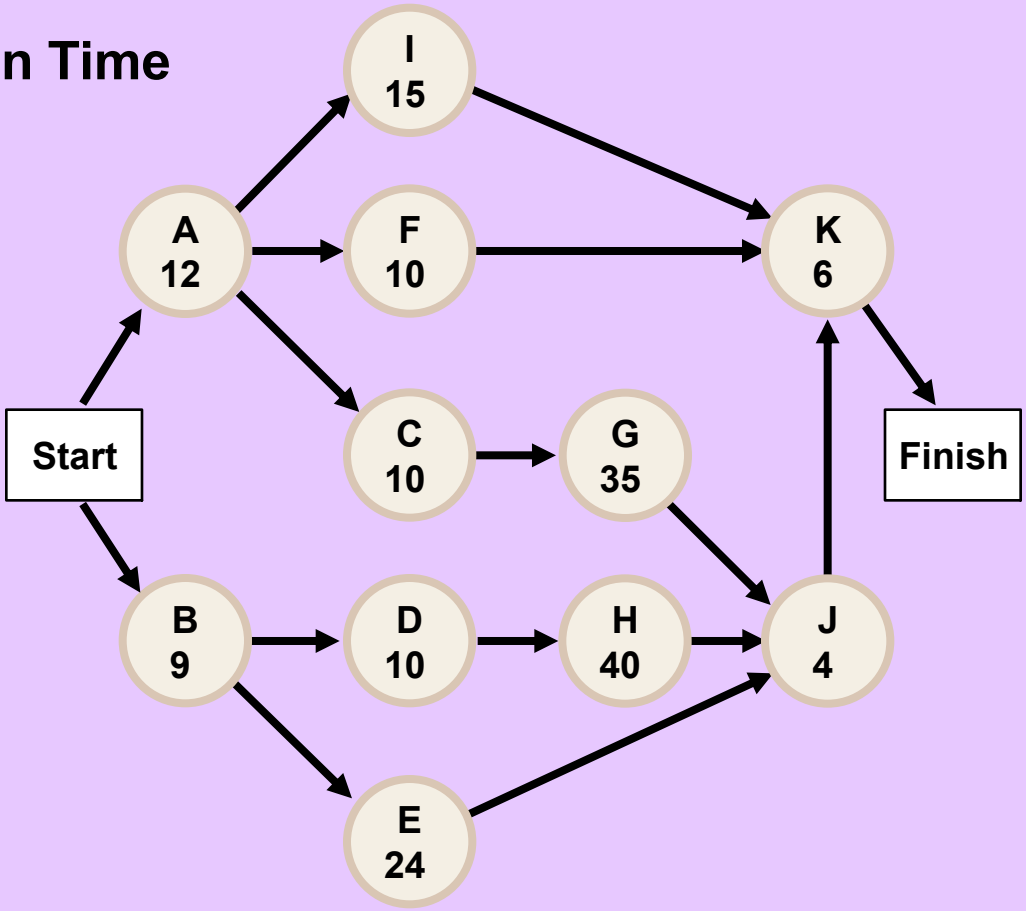

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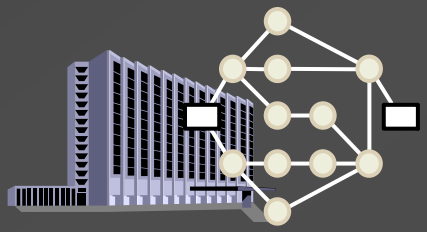

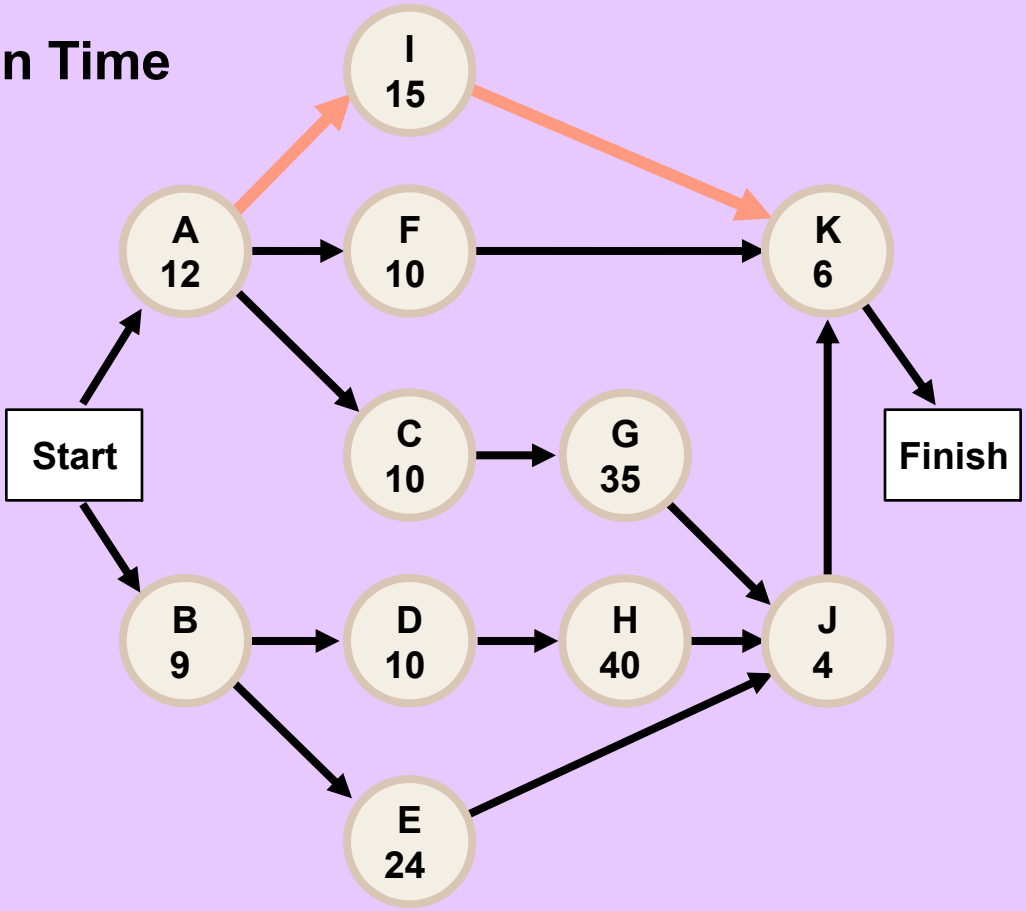

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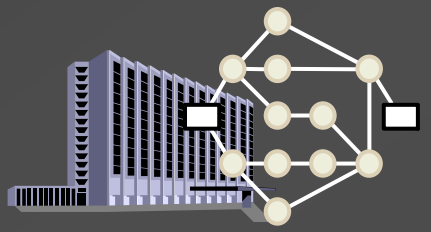

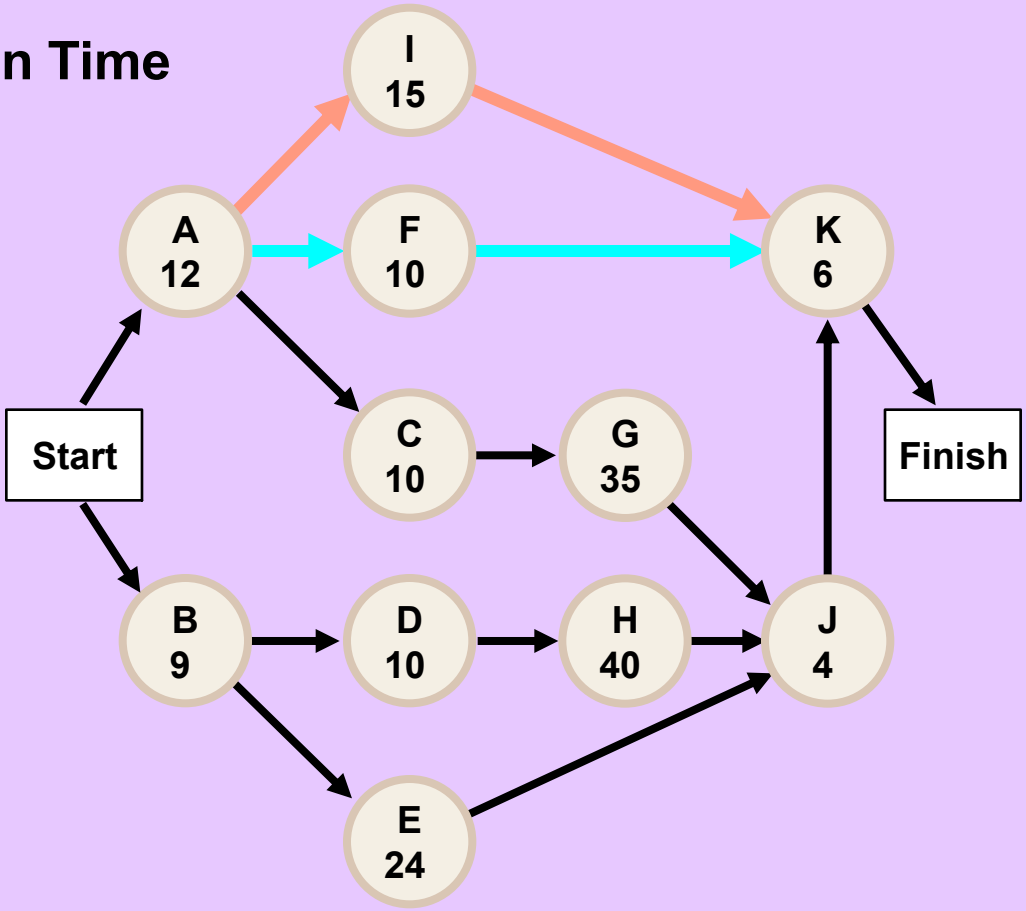

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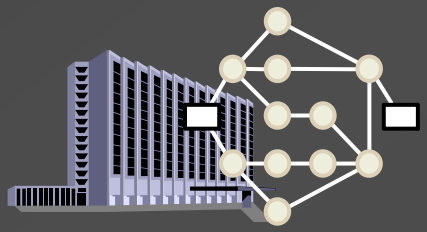

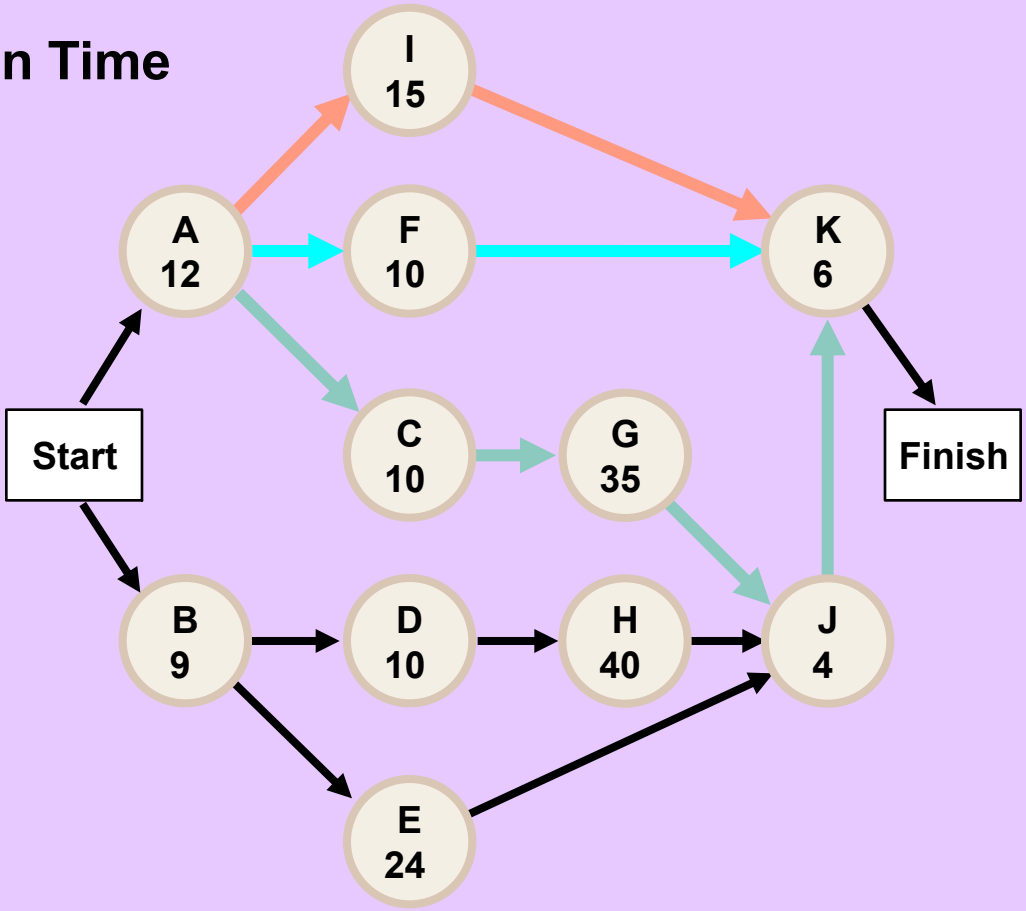

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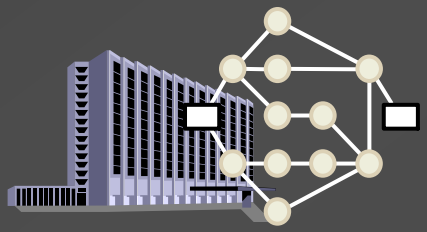

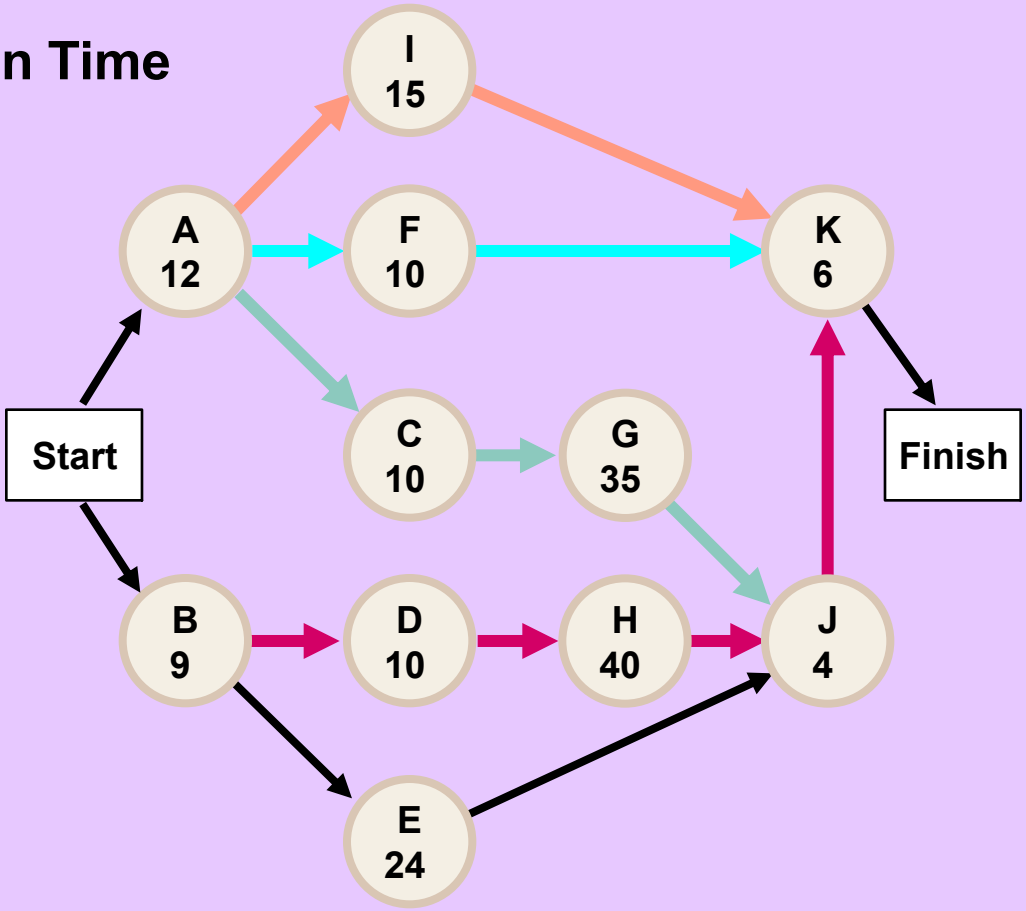

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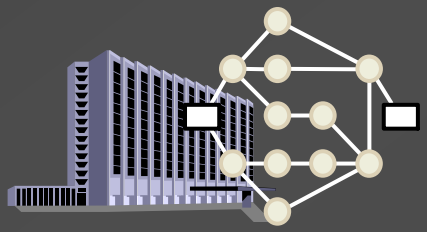

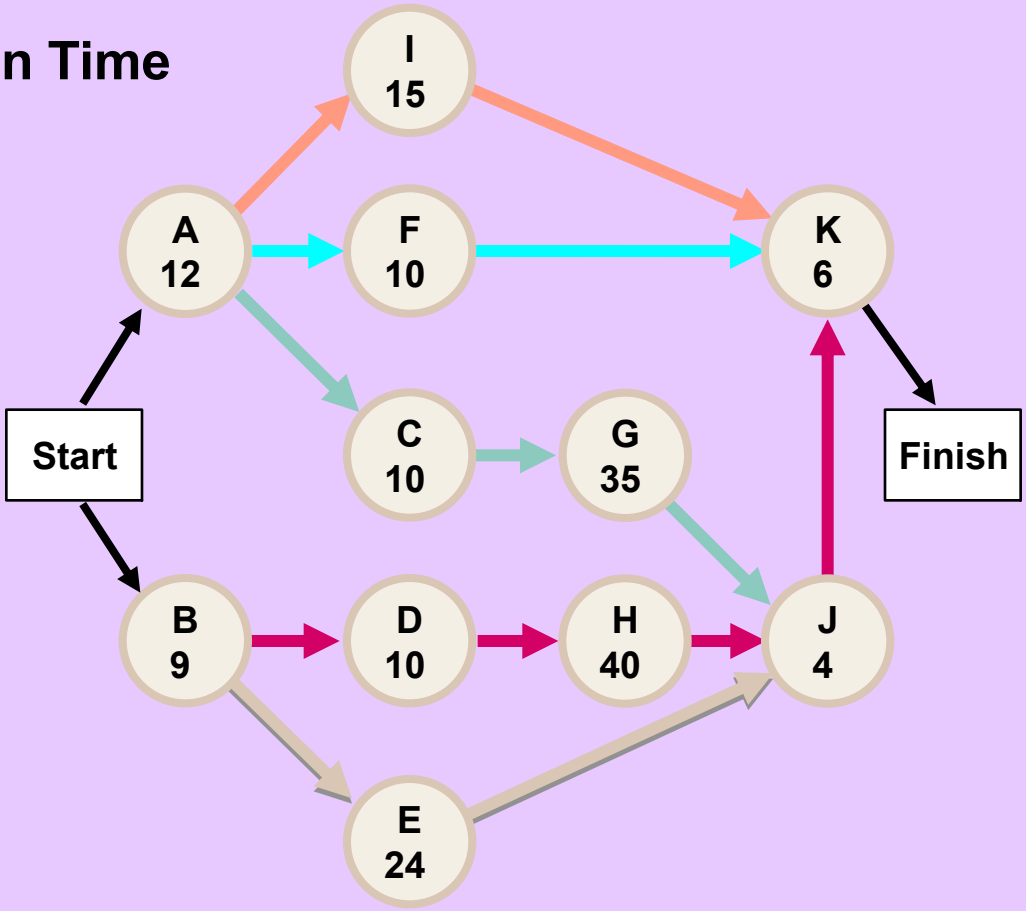

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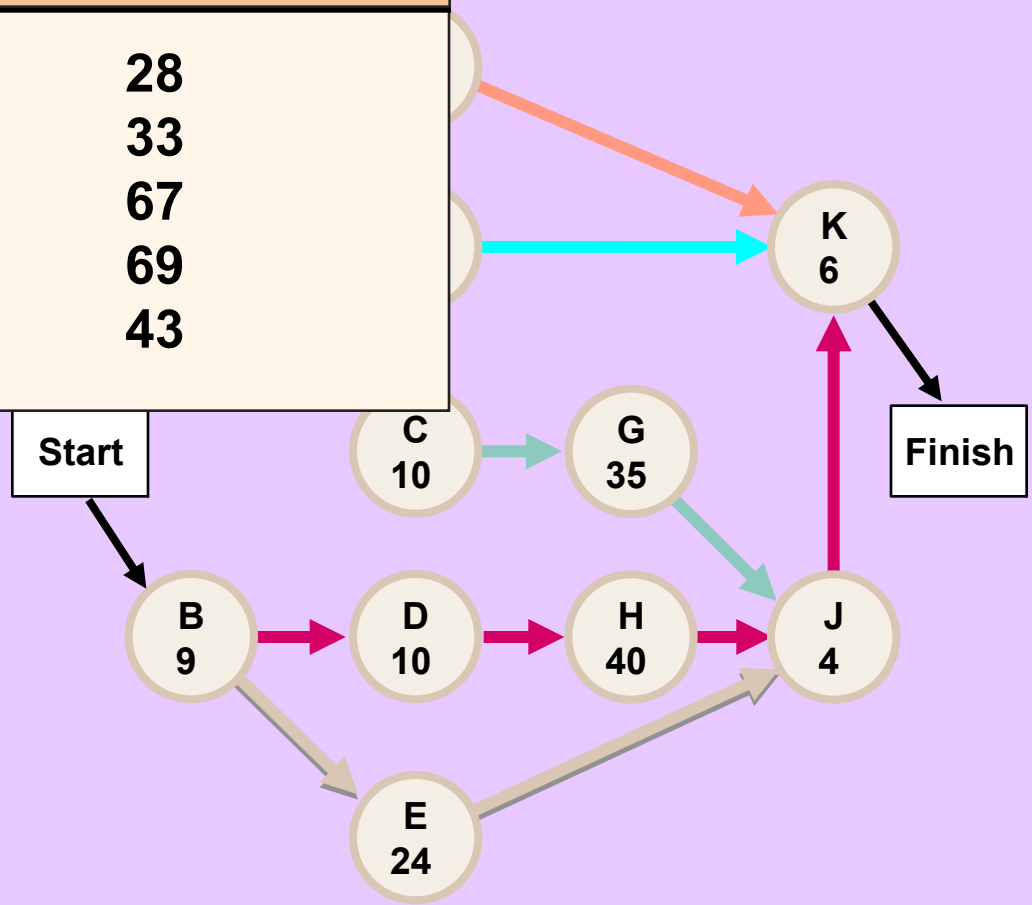
Path	Expected Time (wks)
A-F-K	28
A-I-K	33
A-C-G-J-K	67
B-D-H-J-K	69
B-E-J-K	43



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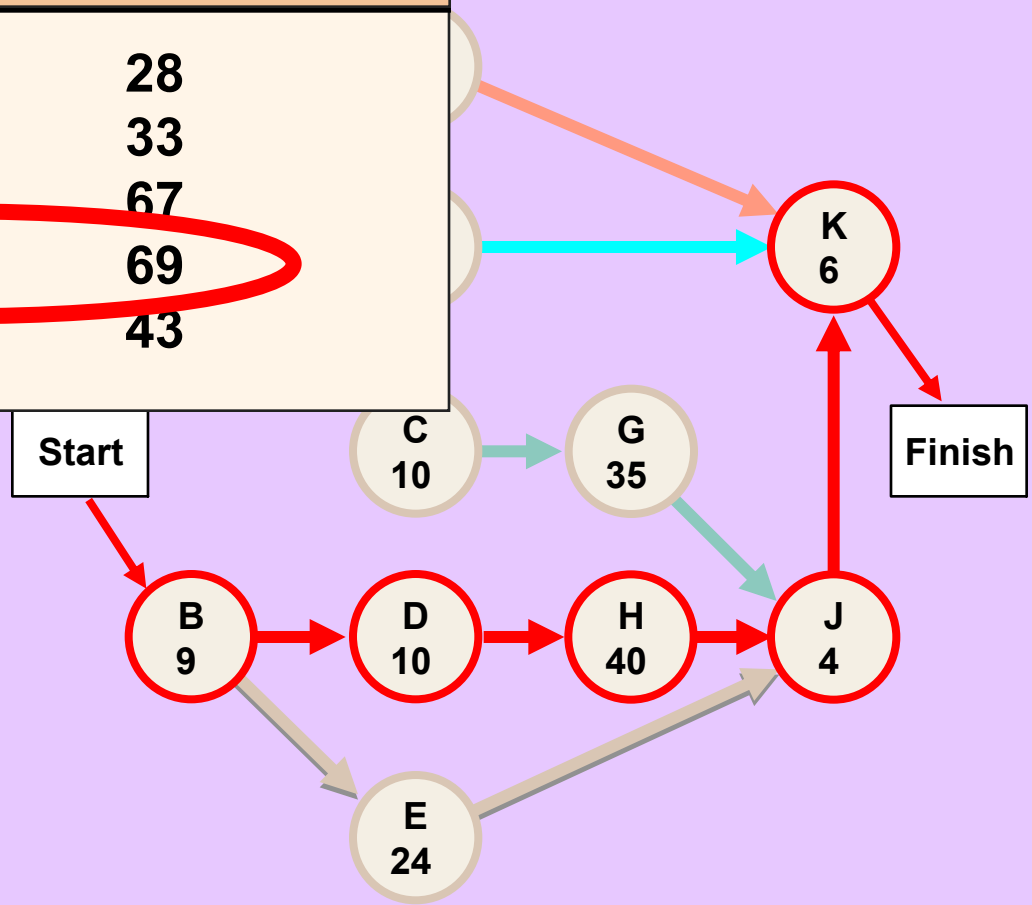

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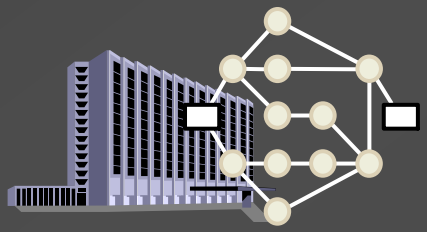

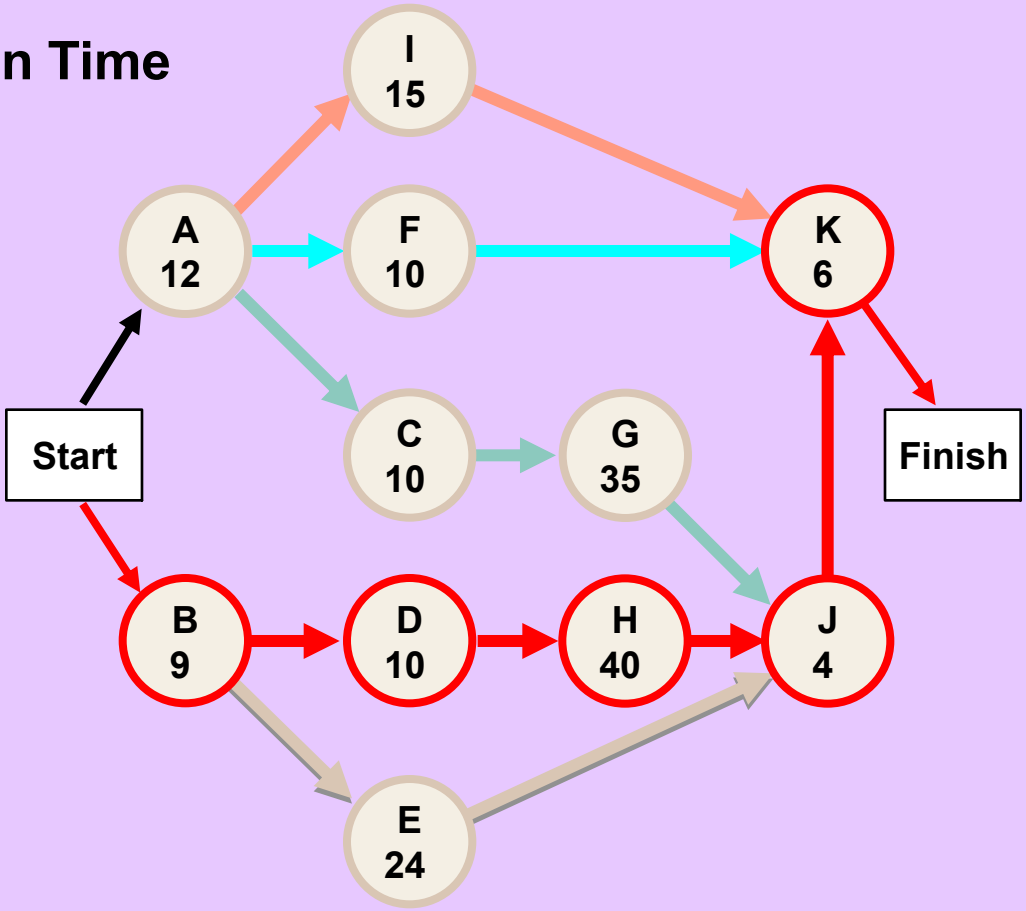

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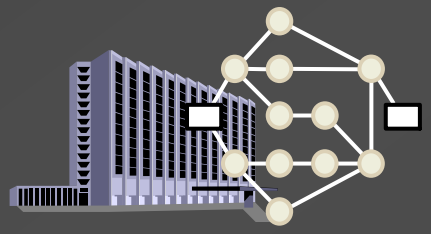

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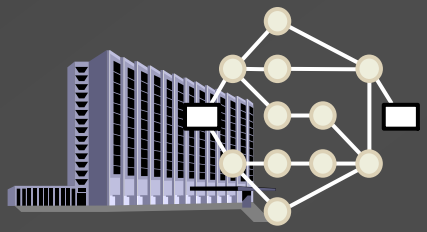

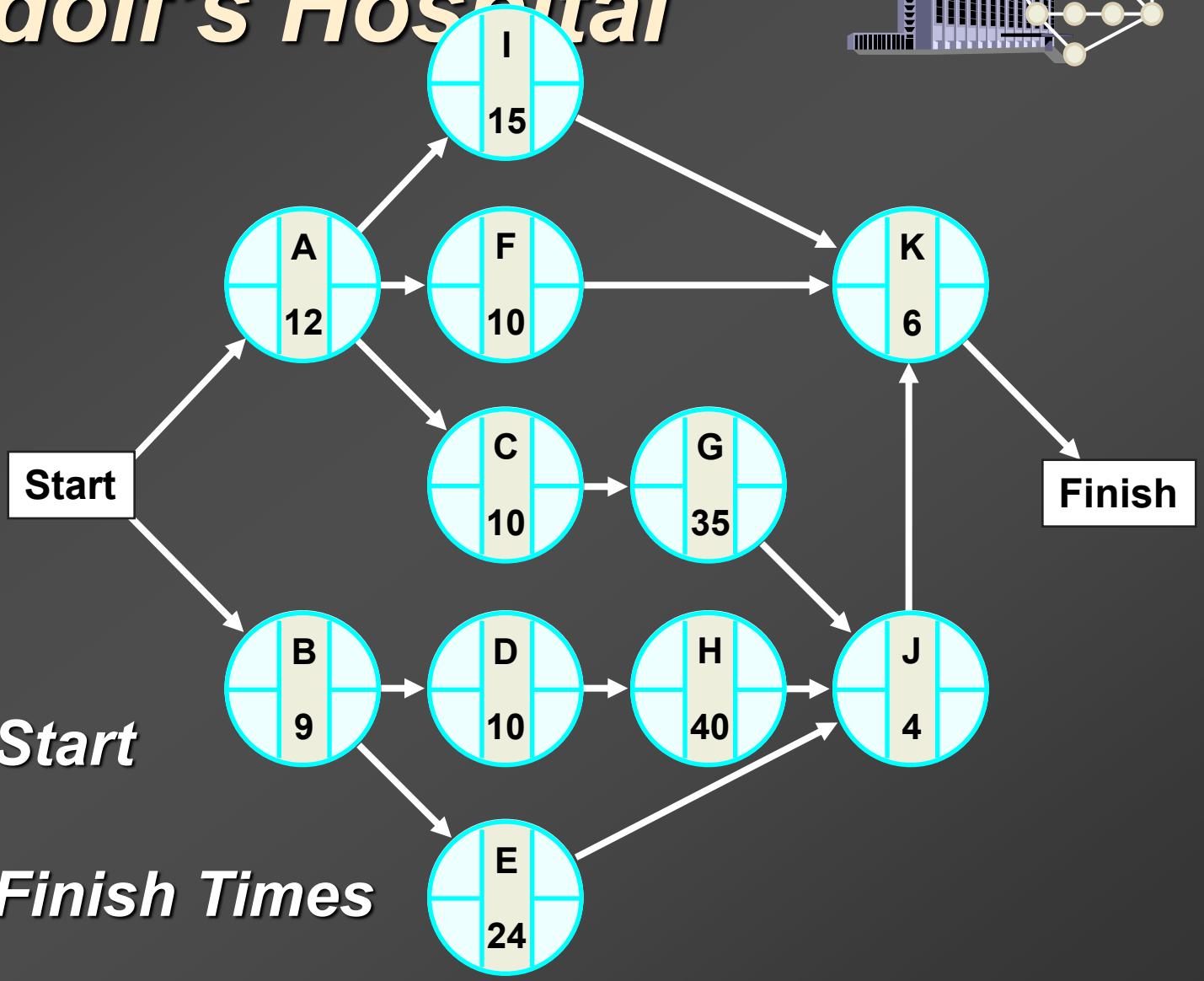

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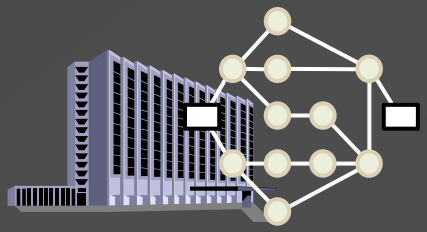

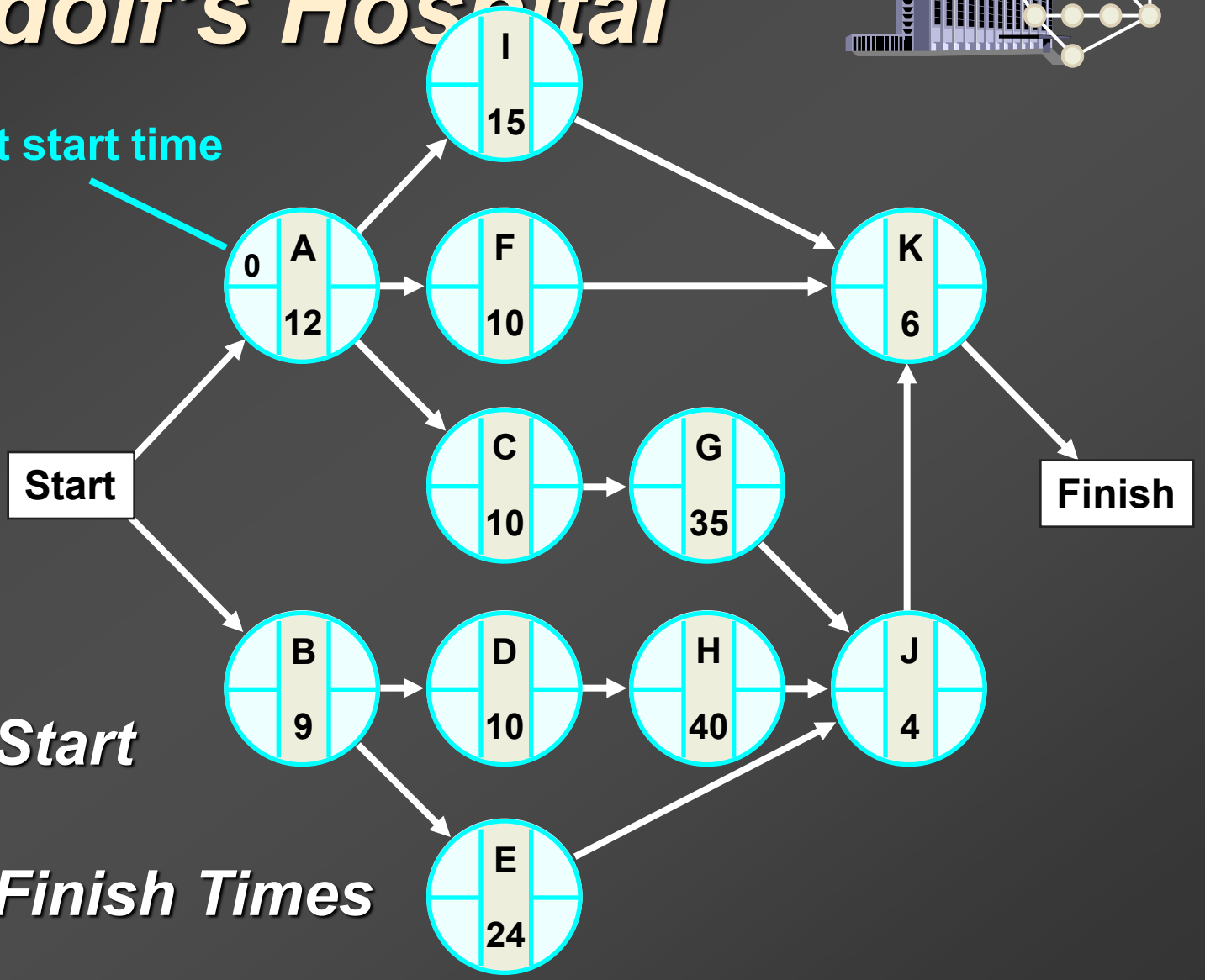

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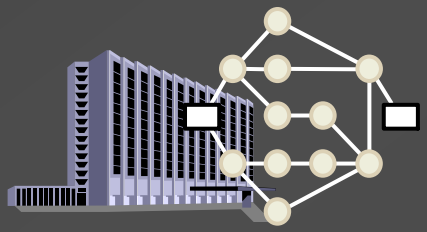

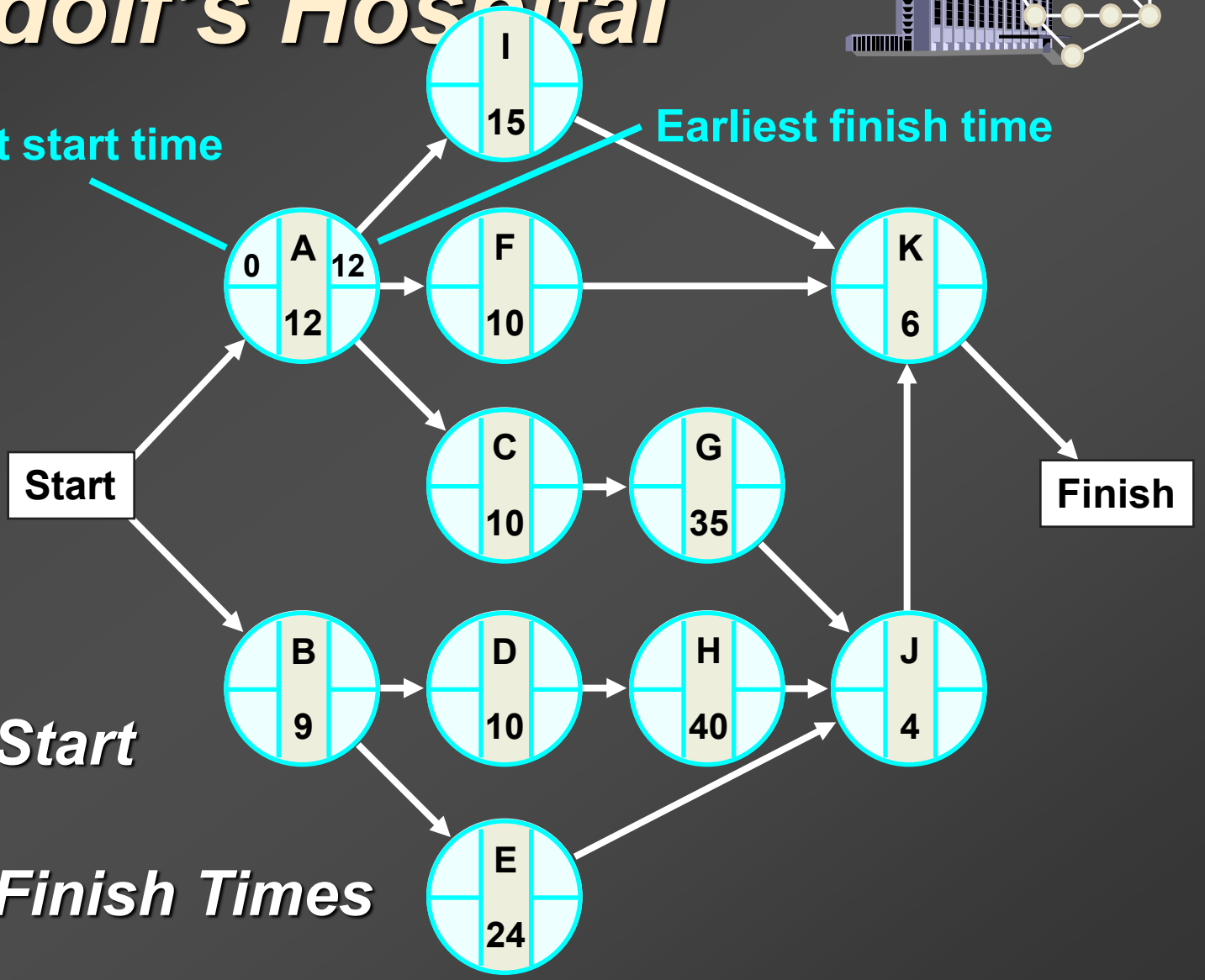

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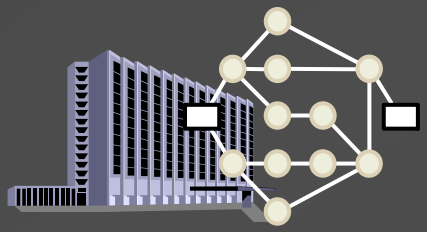

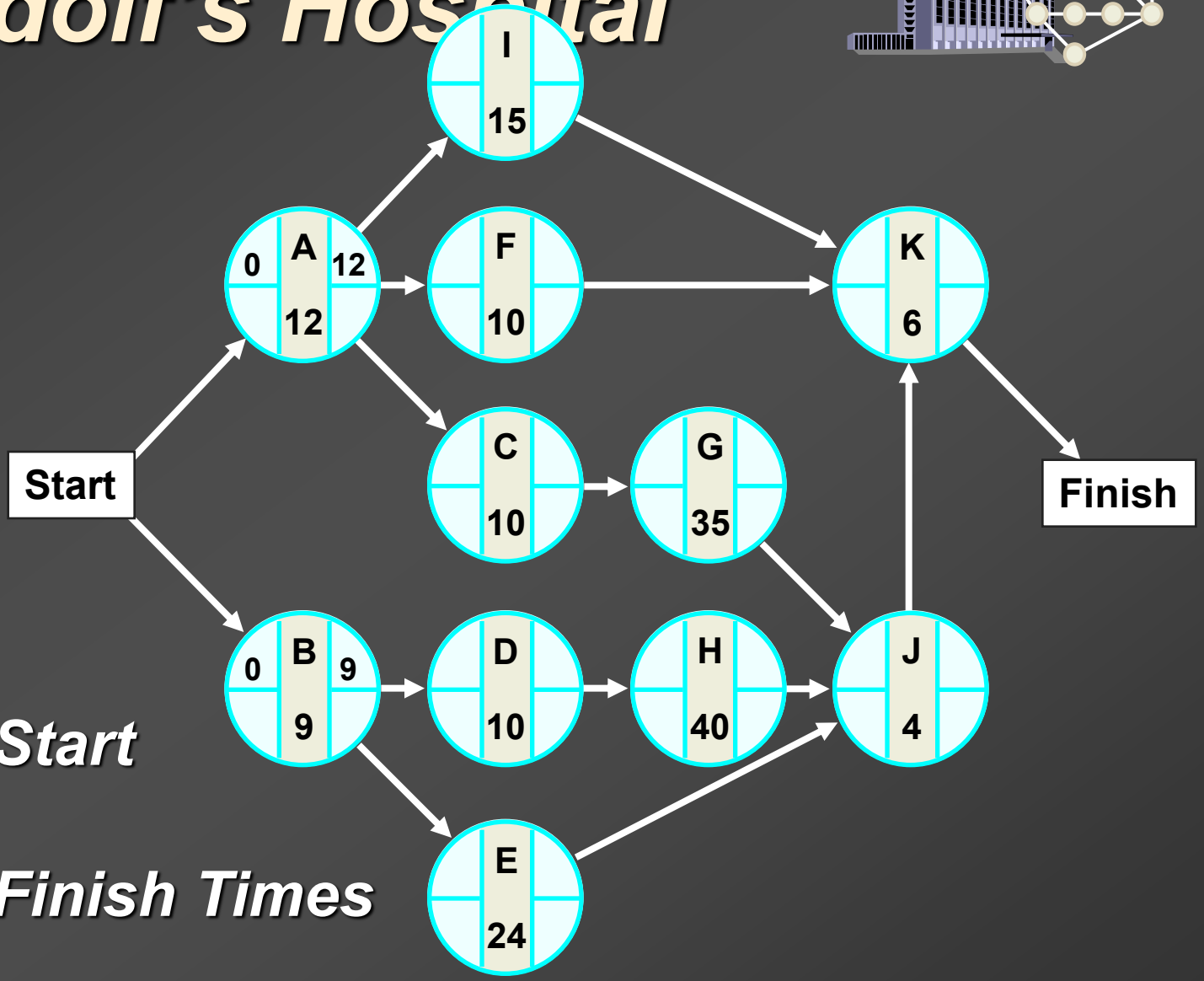

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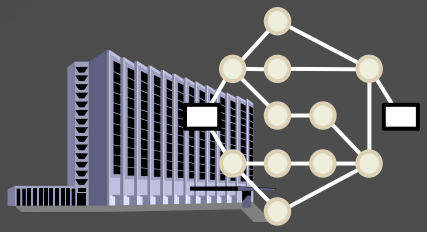

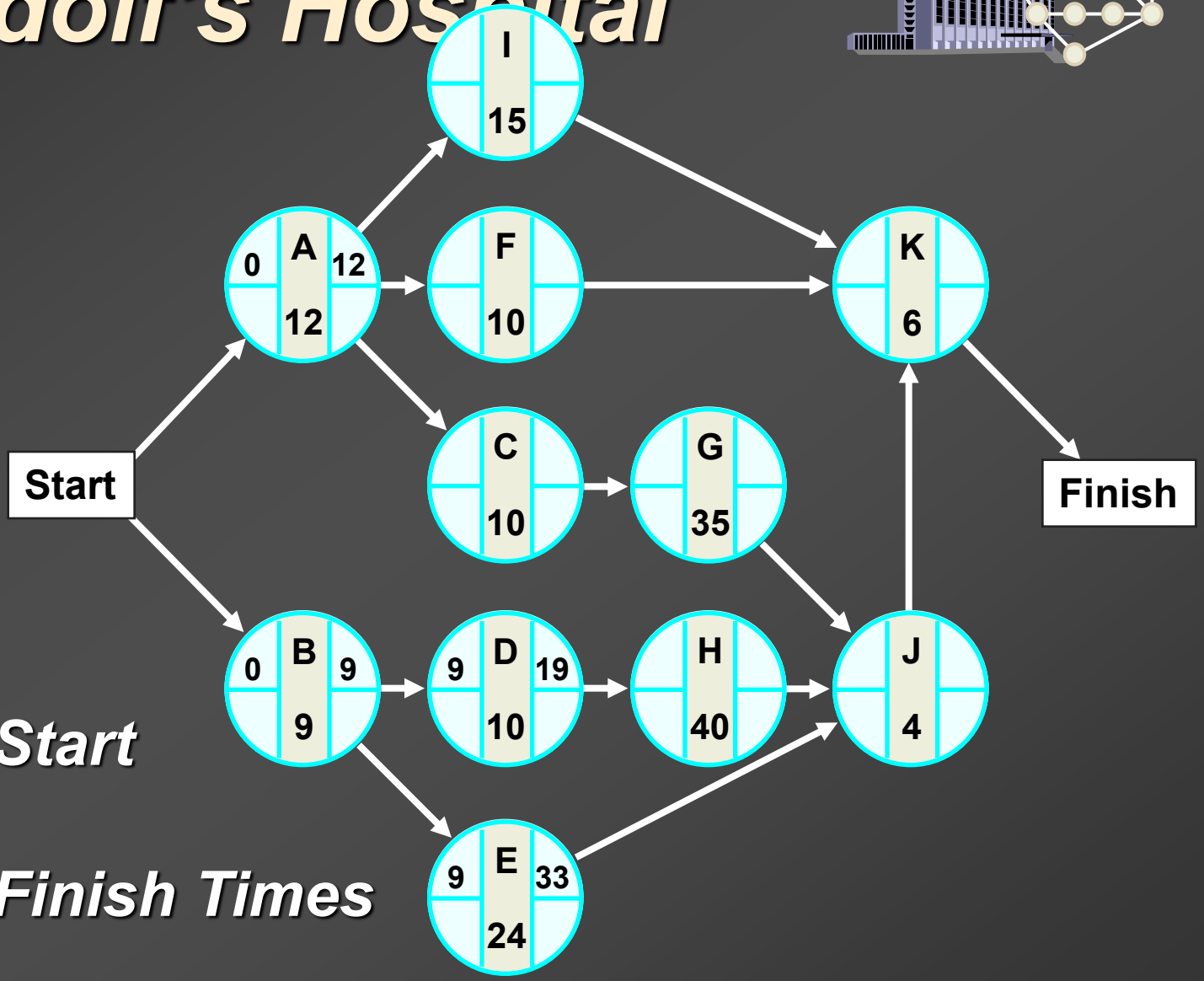

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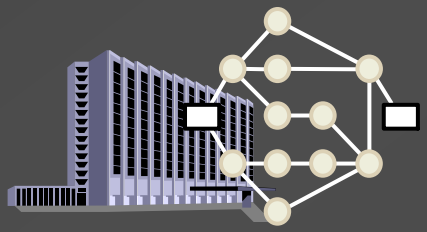

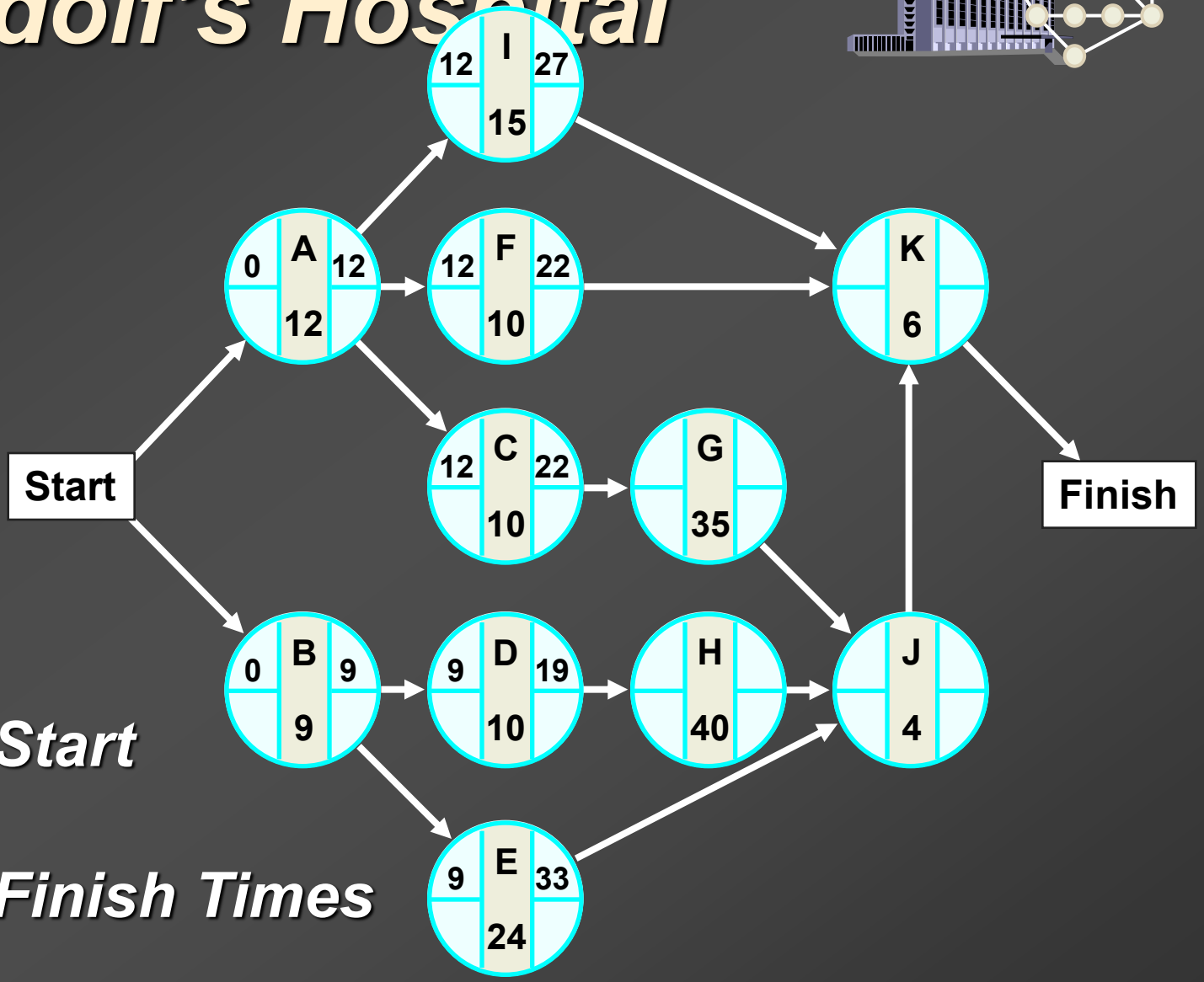

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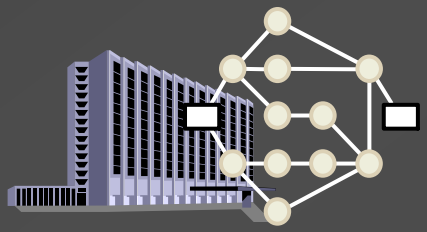

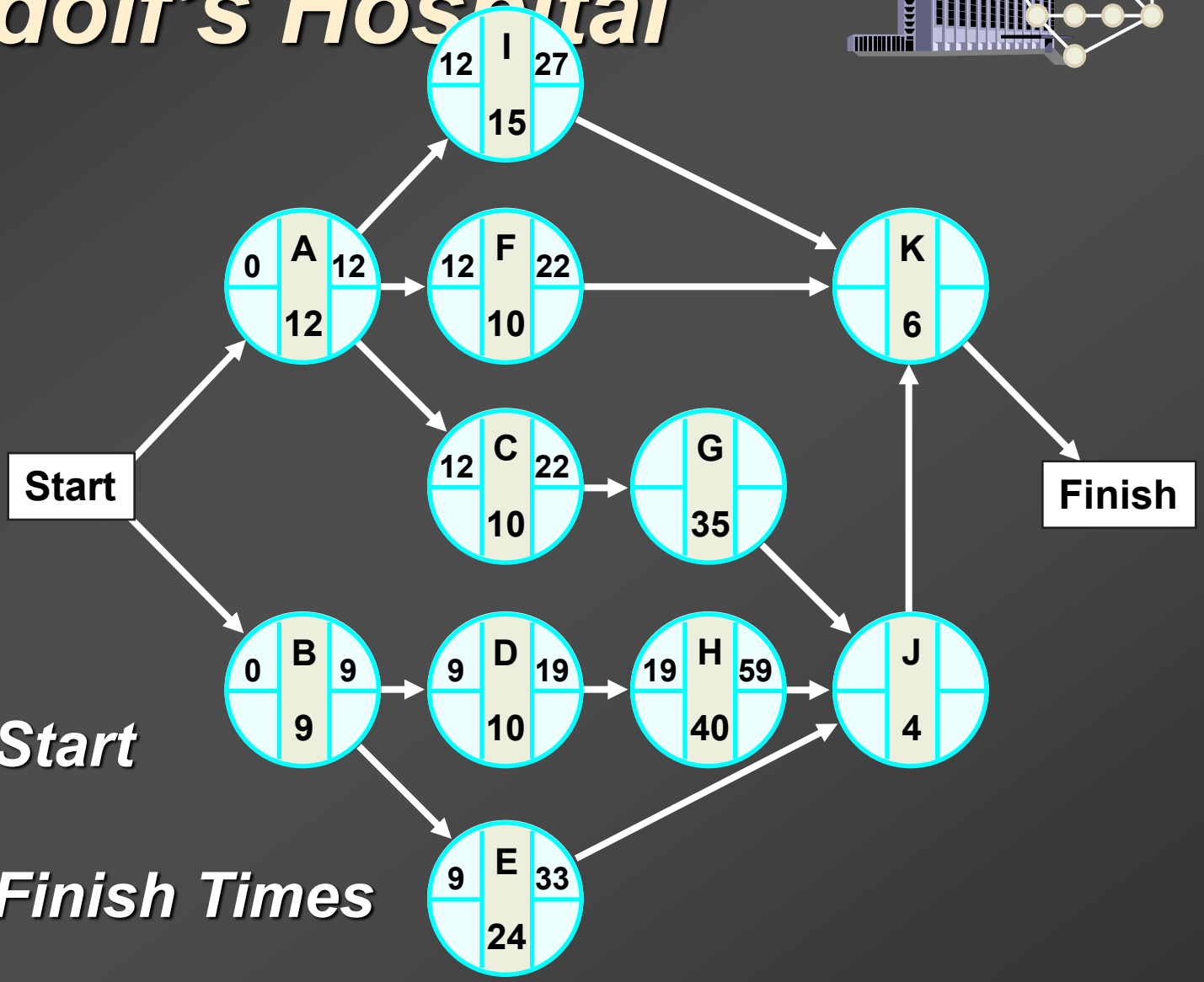

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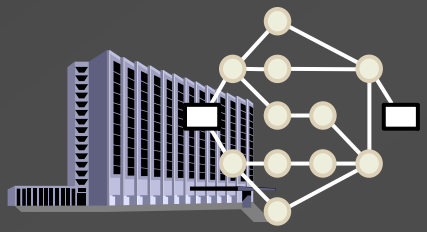

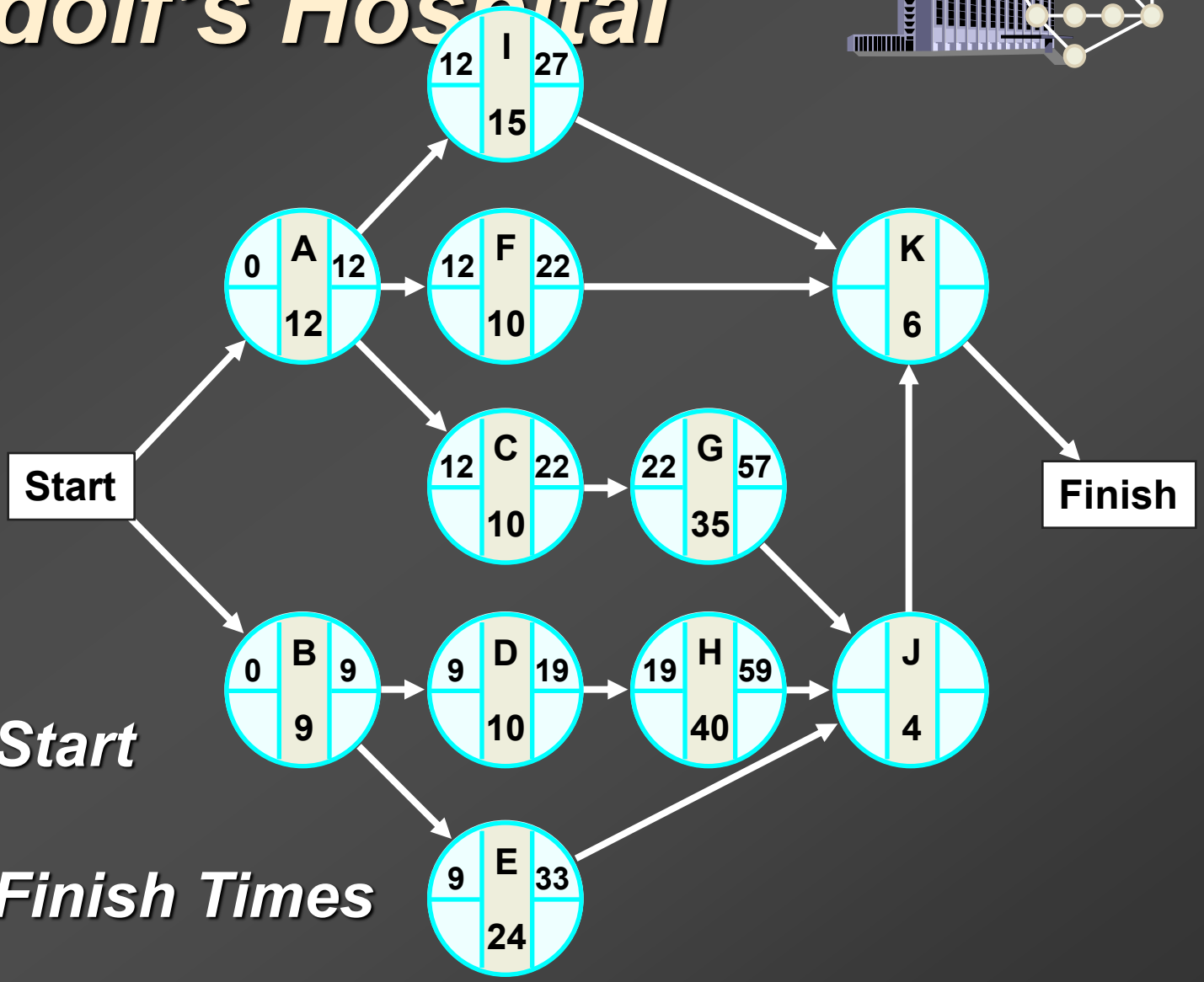

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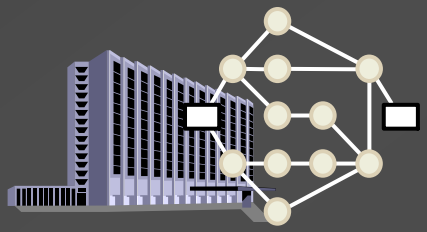

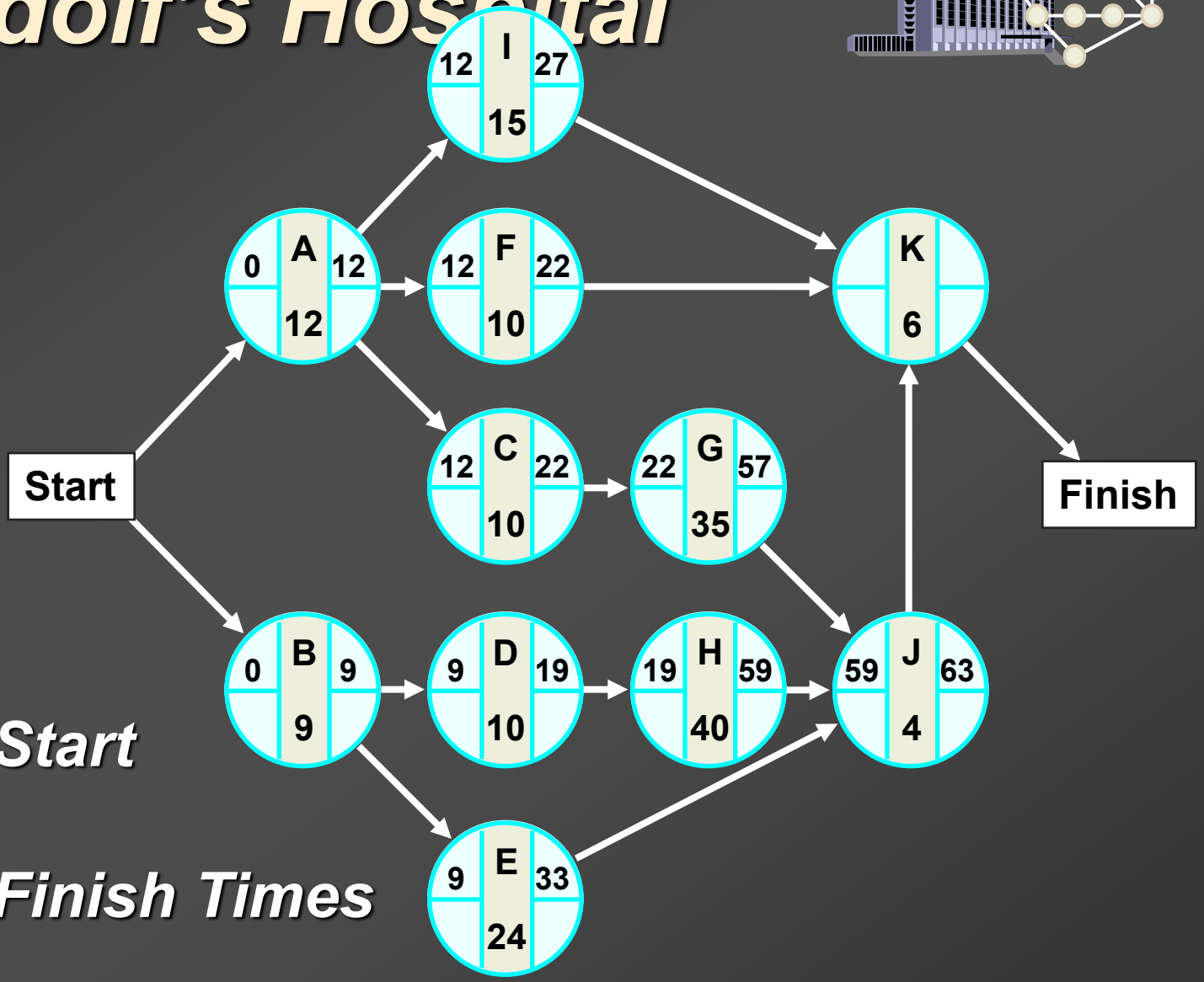

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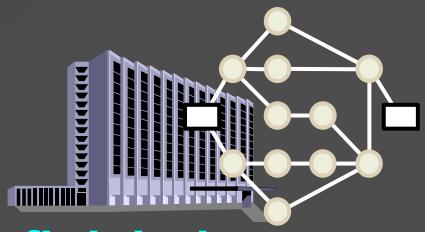

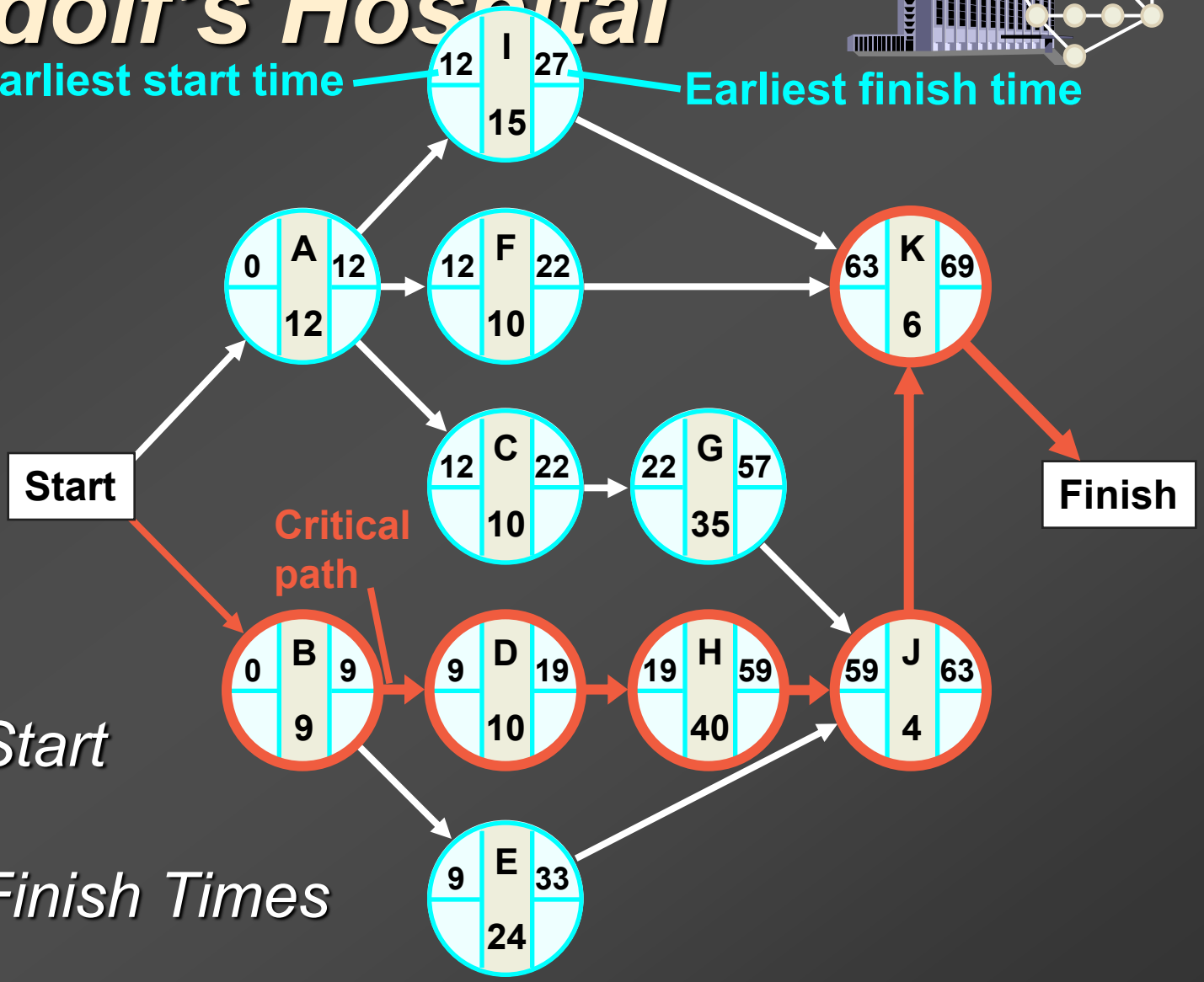

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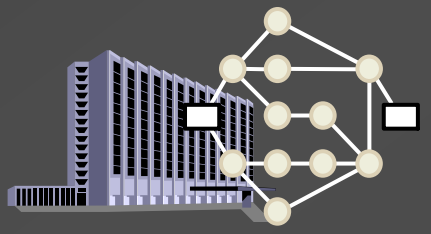

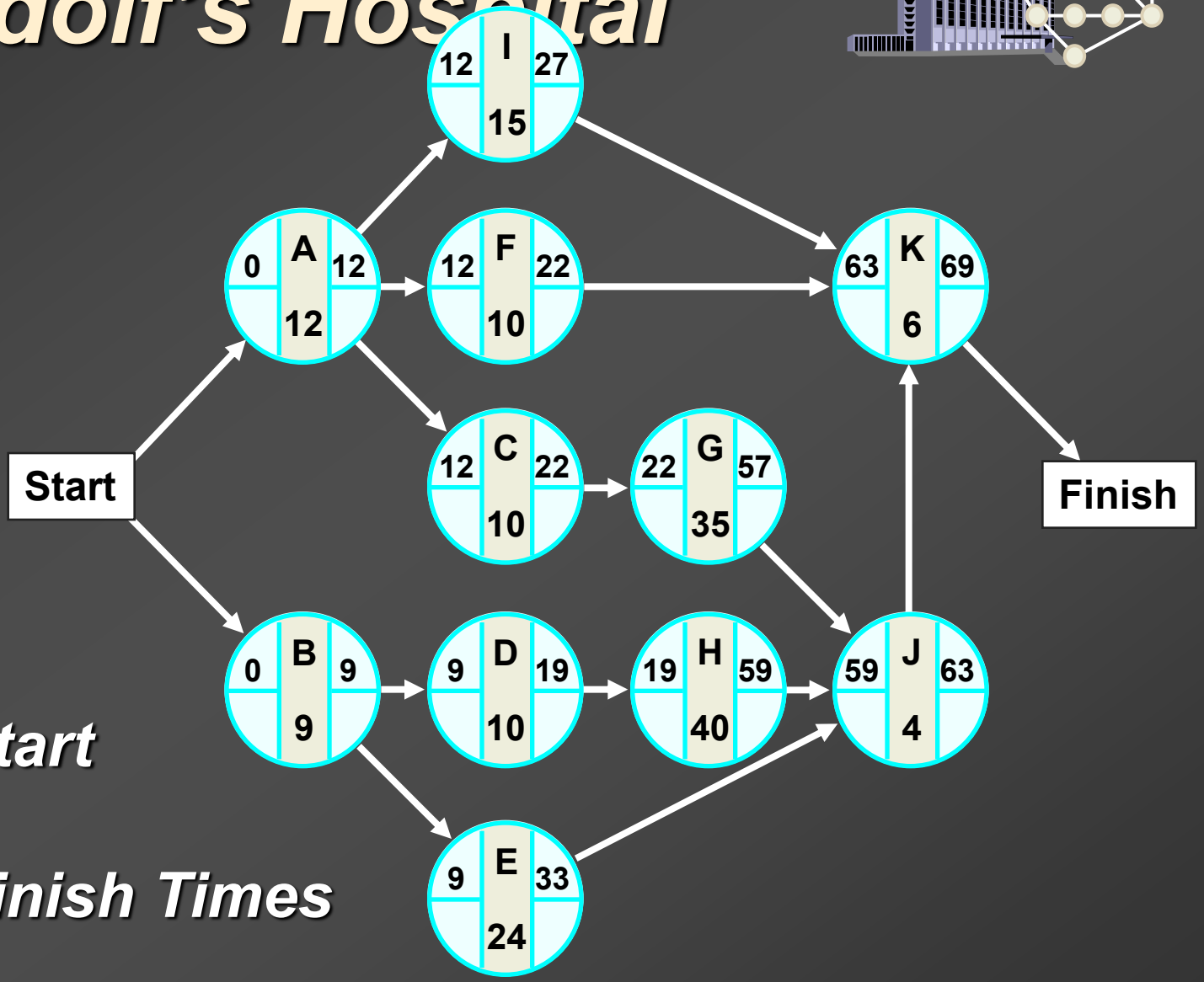

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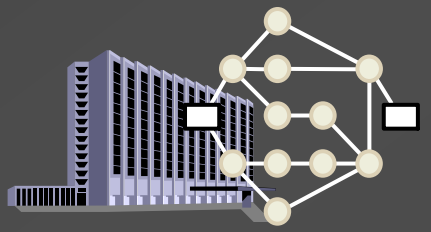

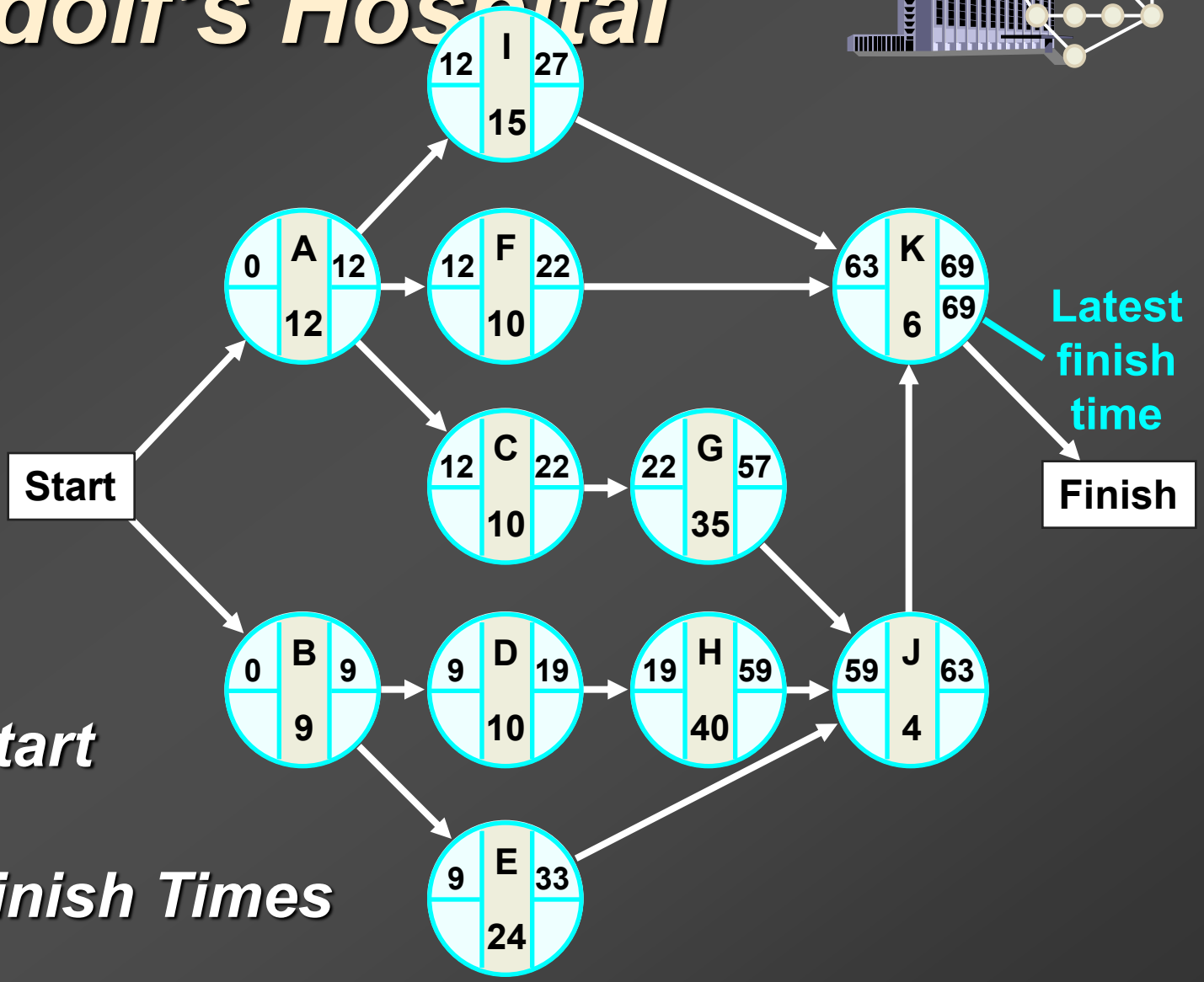

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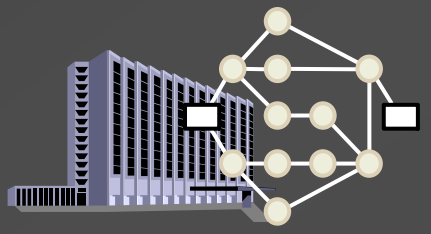

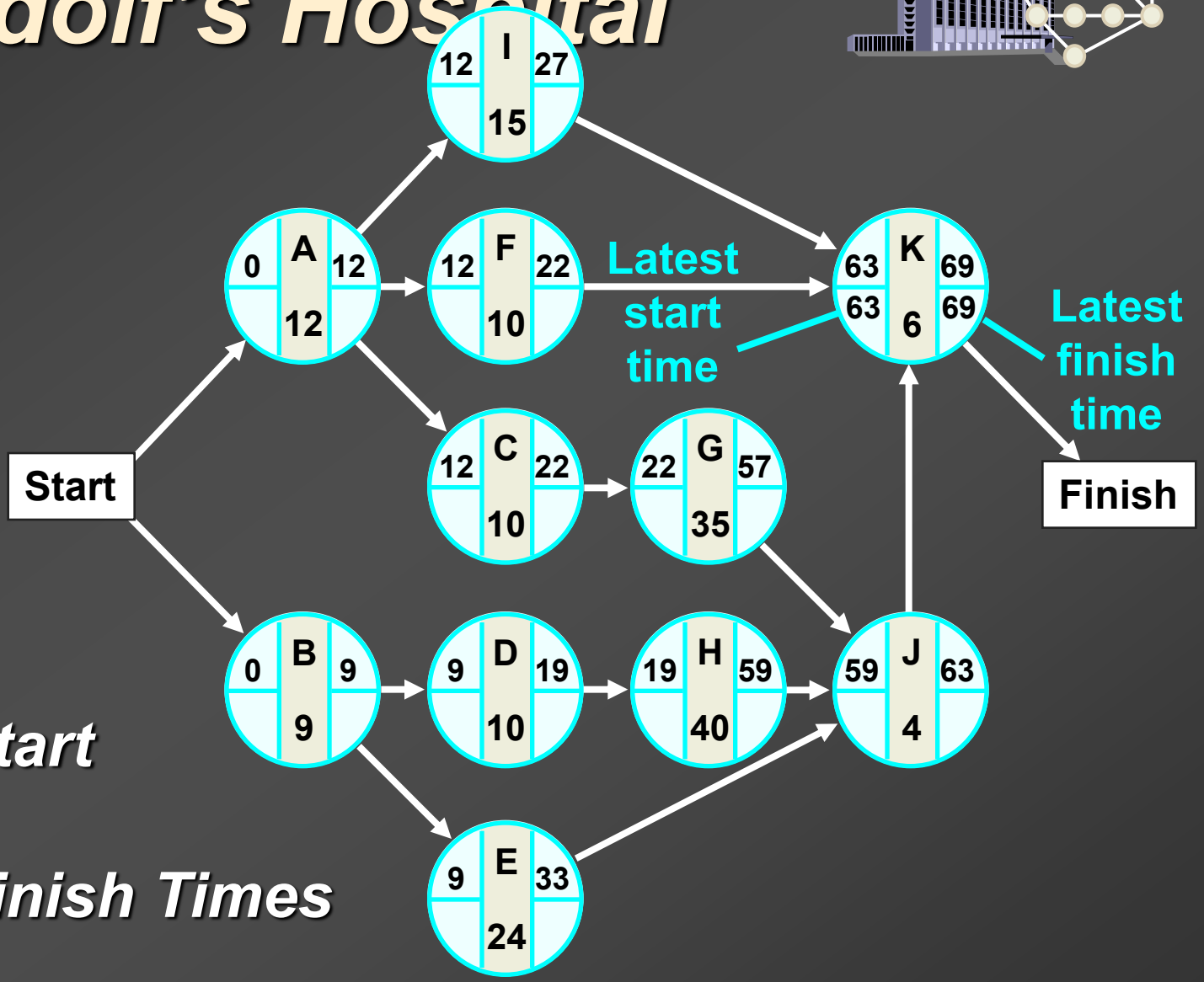

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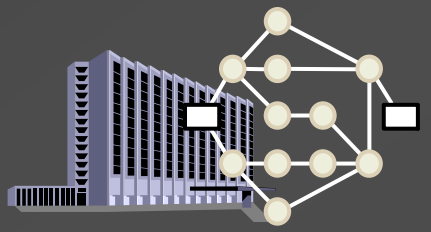

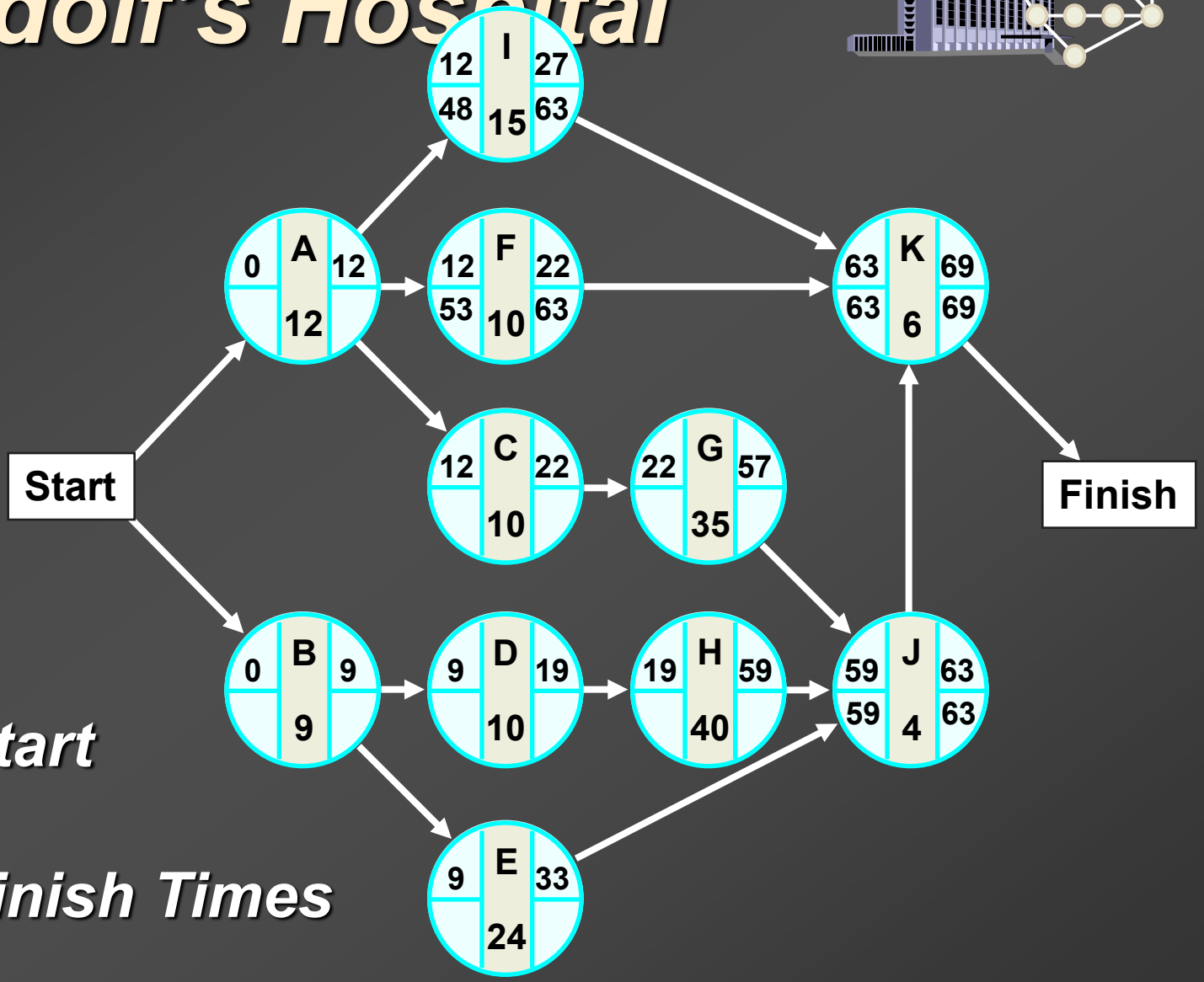

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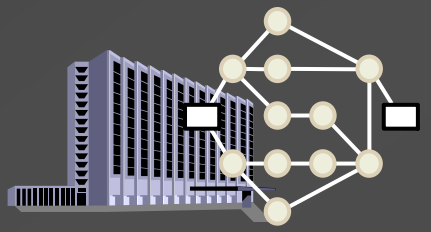

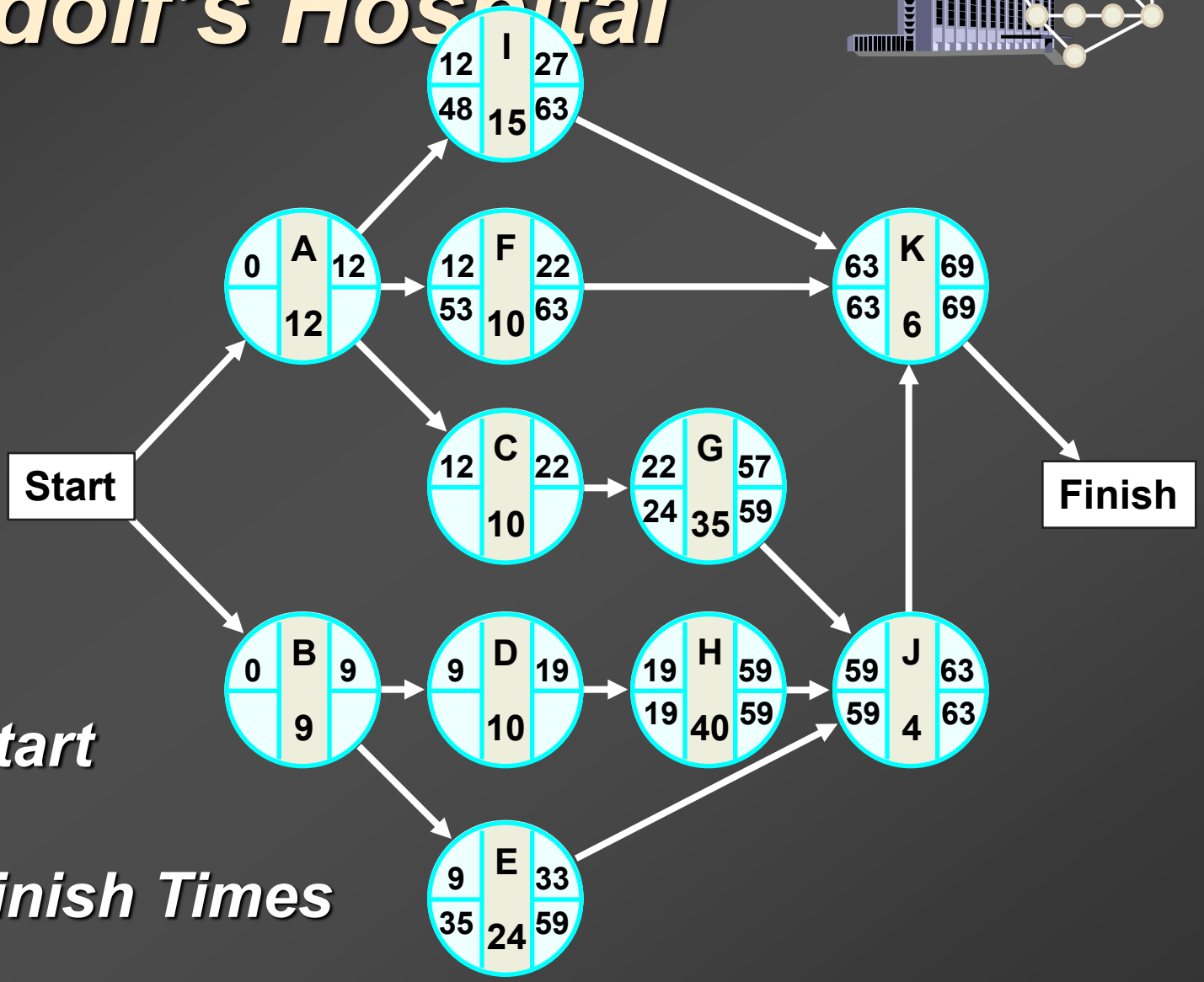

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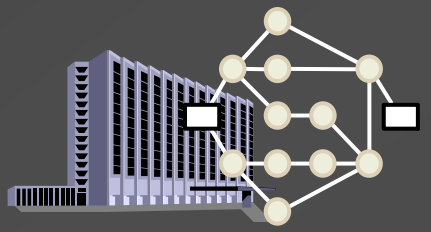

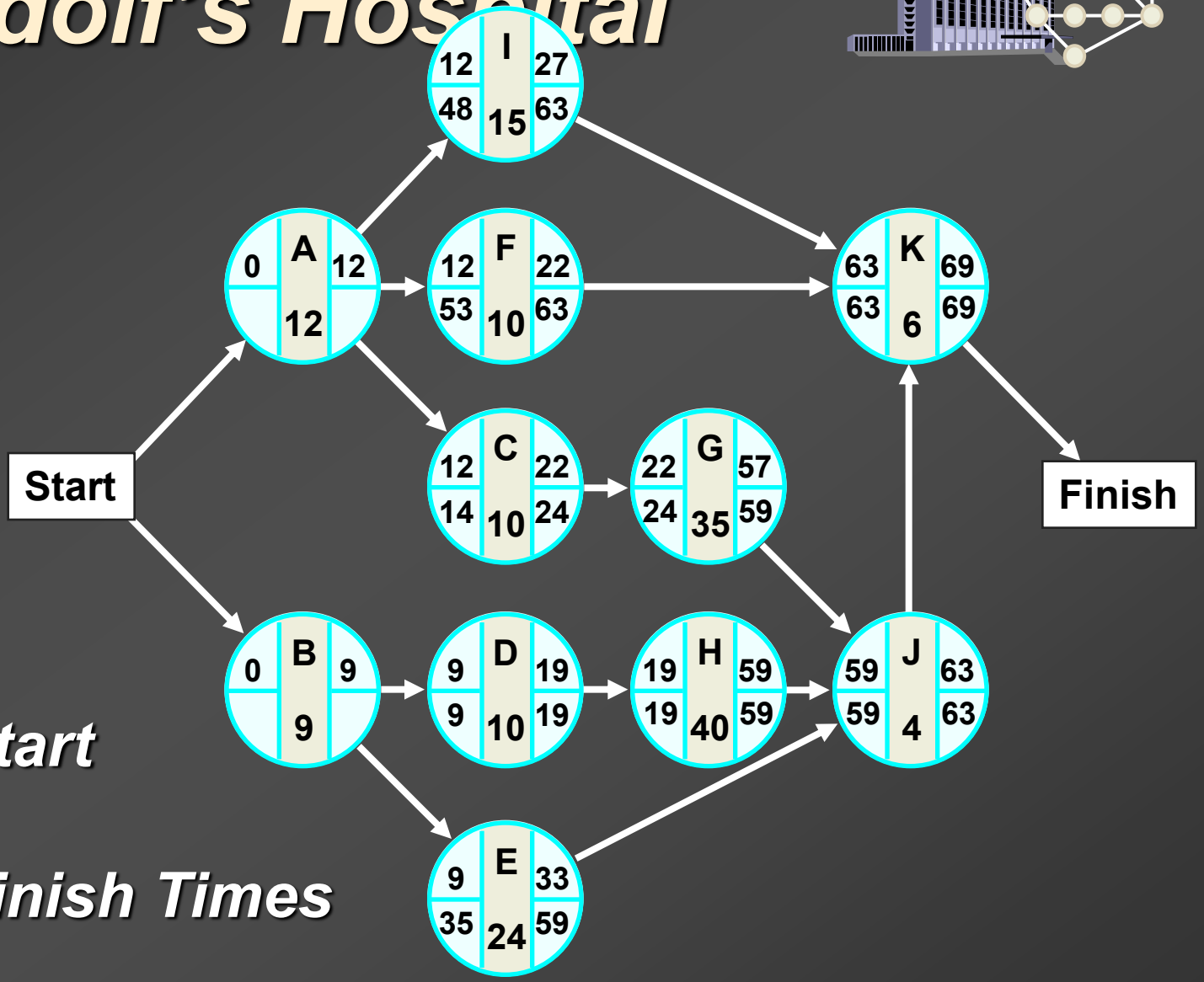

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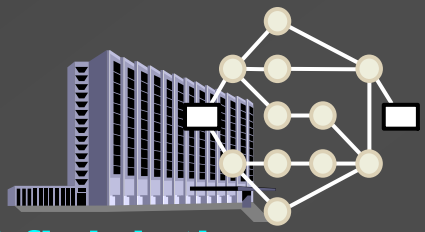

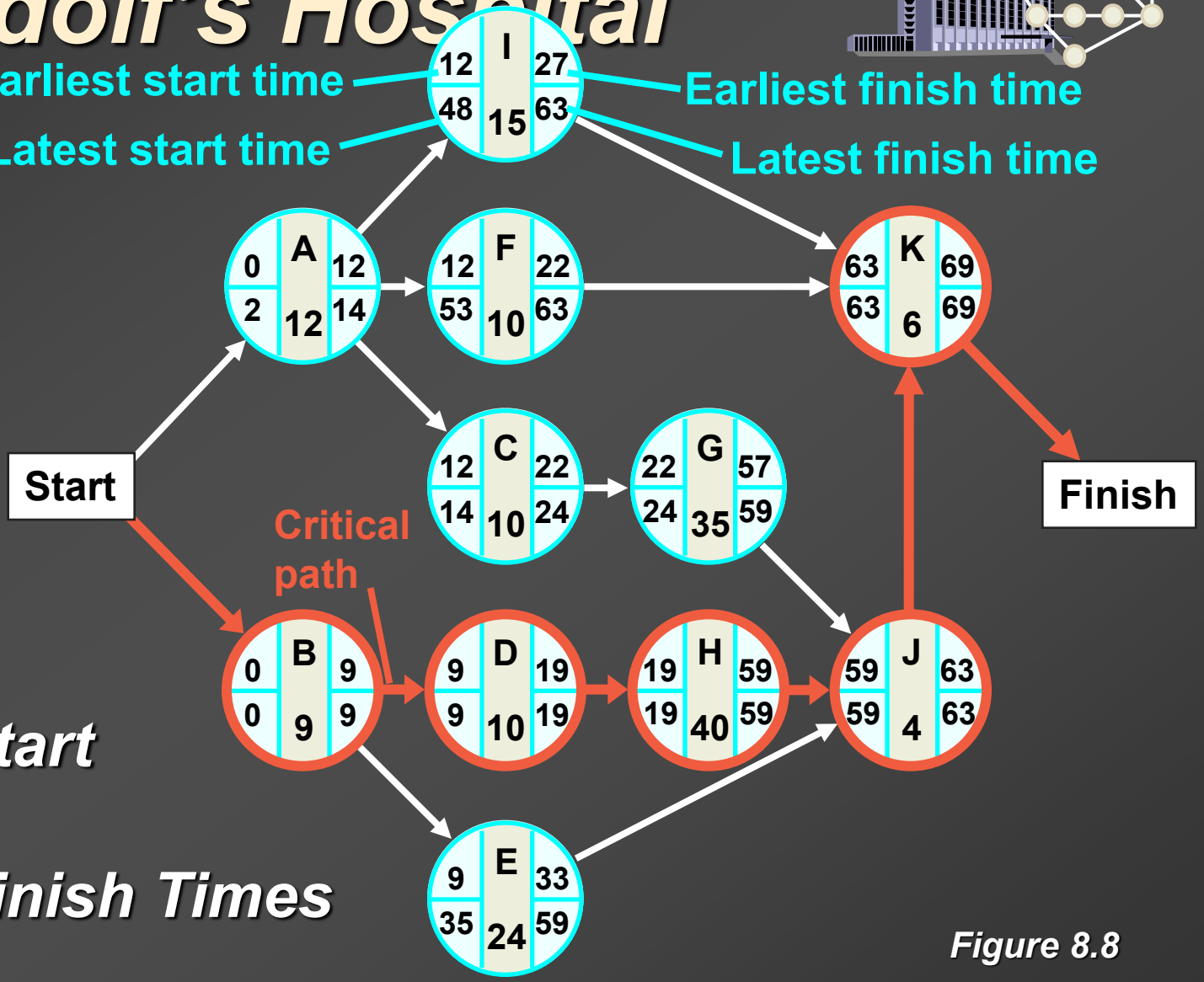

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Figure 8.8

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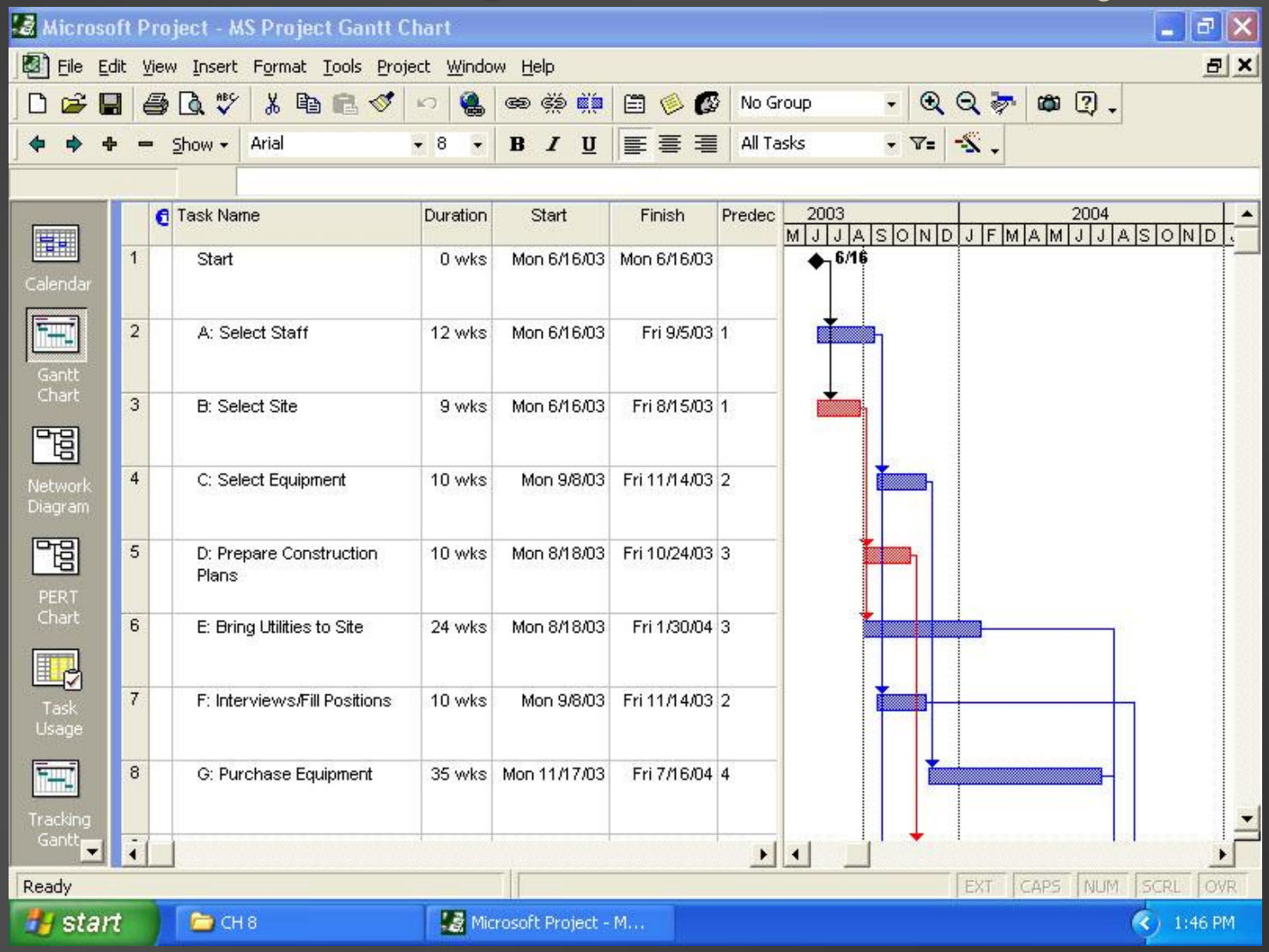
Gantt Charts



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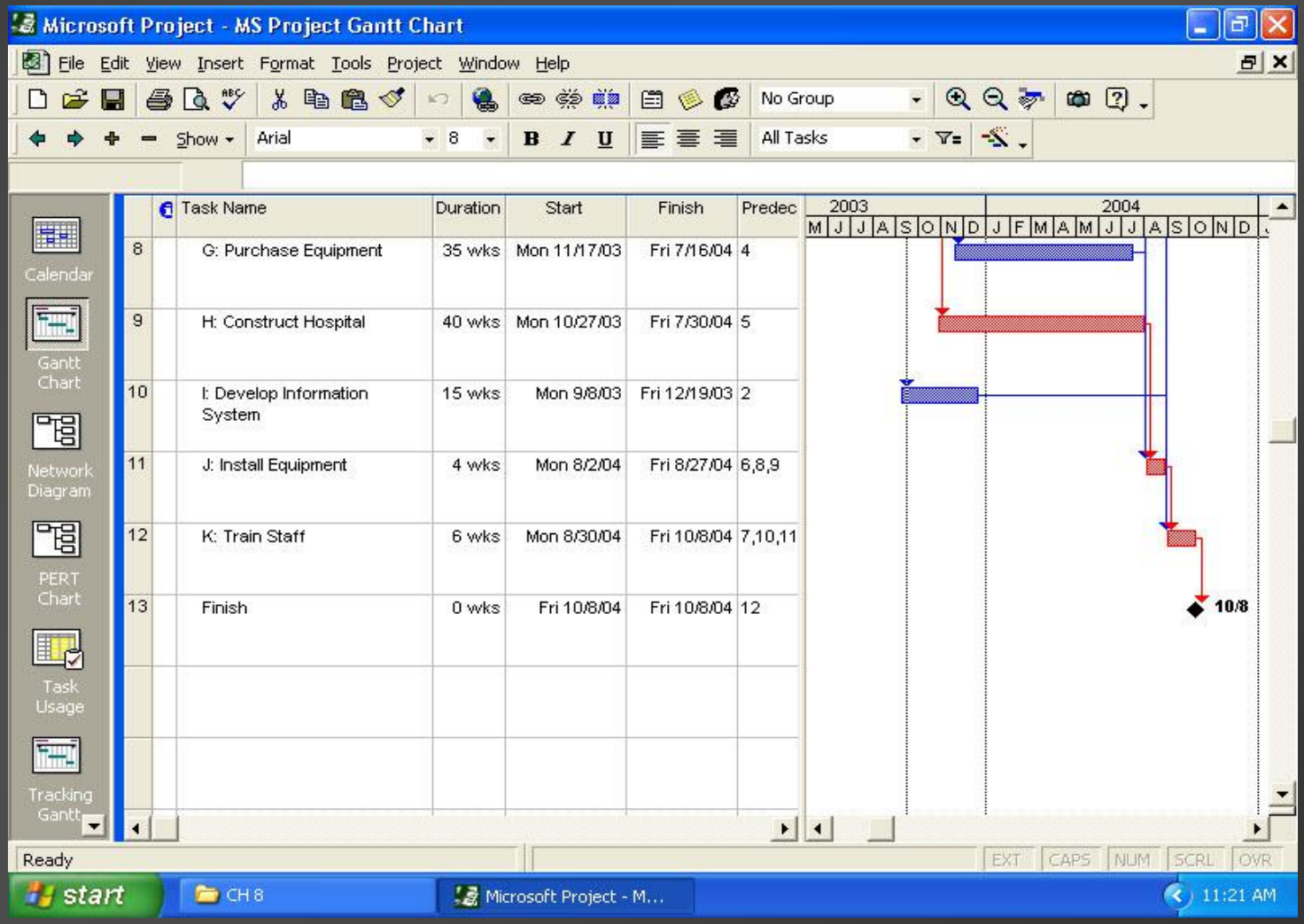
Gantt Charts



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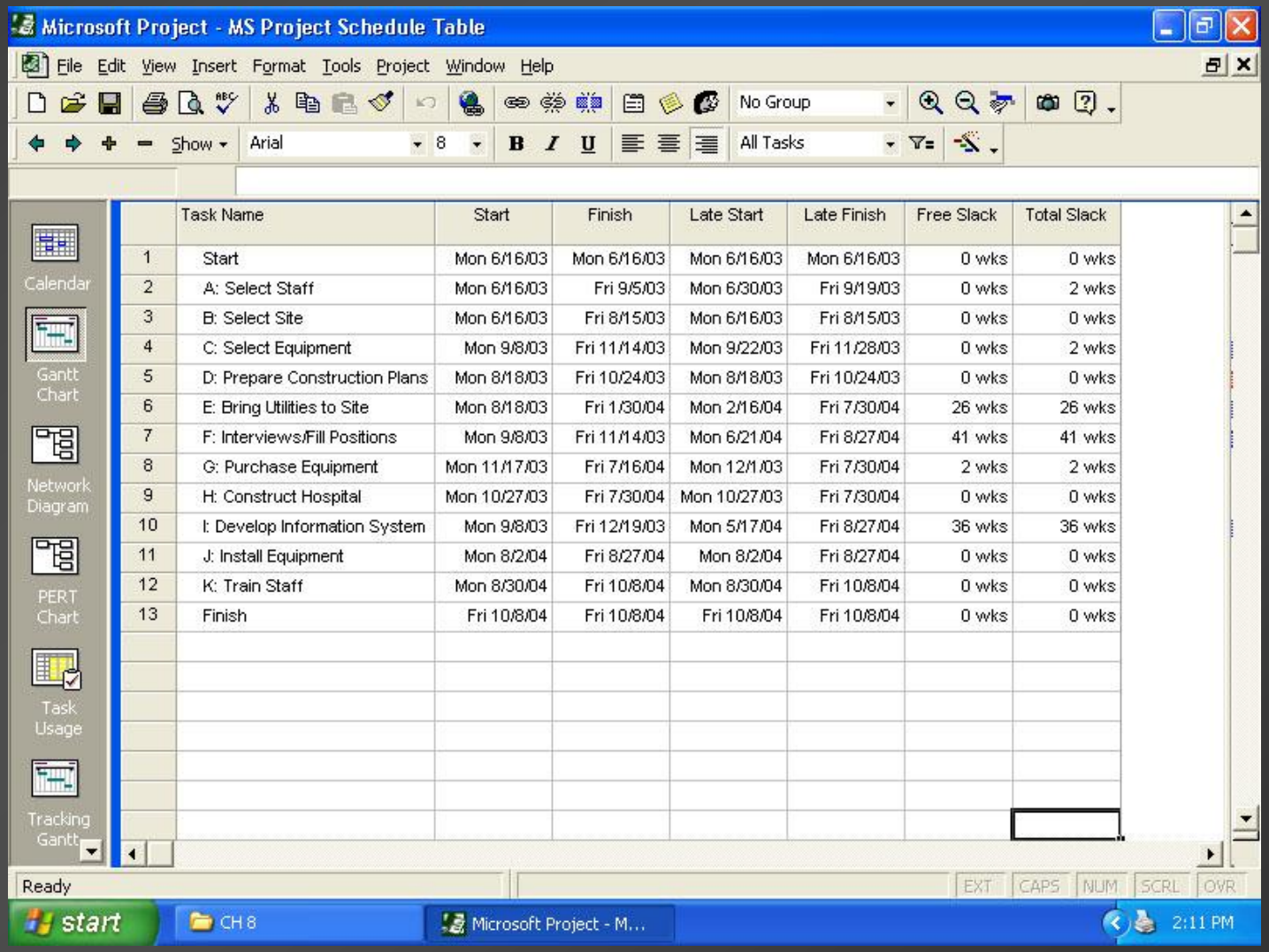
Activity Slack



	Task Name	Start	Finish	Late Start	Late Finish	Free Slack	Total Slack
1	Start	Mon 6/16/03	Mon 6/16/03	Mon 6/16/03	Mon 6/16/03	0 wks	0 wks
2	A: Select Staff	Mon 6/16/03	Fri 9/5/03	Mon 6/30/03	Fri 9/19/03	0 wks	2 wks
3	B: Select Site	Mon 6/16/03	Fri 8/15/03	Mon 6/16/03	Fri 8/15/03	0 wks	0 wks
4	C: Select Equipment	Mon 9/8/03	Fri 11/14/03	Mon 9/22/03	Fri 11/28/03	0 wks	2 wks
5	D: Prepare Construction Plans	Mon 8/18/03	Fri 10/24/03	Mon 8/18/03	Fri 10/24/03	0 wks	0 wks
6	E: Bring Utilities to Site	Mon 8/18/03	Fri 1/30/04	Mon 2/16/04	Fri 7/30/04	26 wks	26 wks
7	F: Interviews/Fill Positions	Mon 9/8/03	Fri 11/14/03	Mon 6/21/04	Fri 8/27/04	41 wks	41 wks
8	G: Purchase Equipment	Mon 11/17/03	Fri 7/16/04	Mon 12/1/03	Fri 7/30/04	2 wks	2 wks
9	H: Construct Hospital	Mon 10/27/03	Fri 7/30/04	Mon 10/27/03	Fri 7/30/04	0 wks	0 wks
10	I: Develop Information System	Mon 9/8/03	Fri 12/19/03	Mon 5/17/04	Fri 8/27/04	36 wks	36 wks
11	J: Install Equipment	Mon 8/2/04	Fri 8/27/04	Mon 8/2/04	Fri 8/27/04	0 wks	0 wks
12	K: Train Staff	Mon 8/30/04	Fri 10/8/04	Mon 8/30/04	Fri 10/8/04	0 wks	0 wks
13	Finish	Fri 10/8/04	Fri 10/8/04	Fri 10/8/04	Fri 10/8/04	0 wks	0 wks

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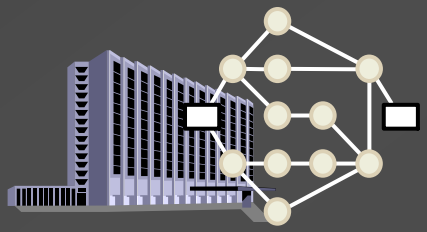

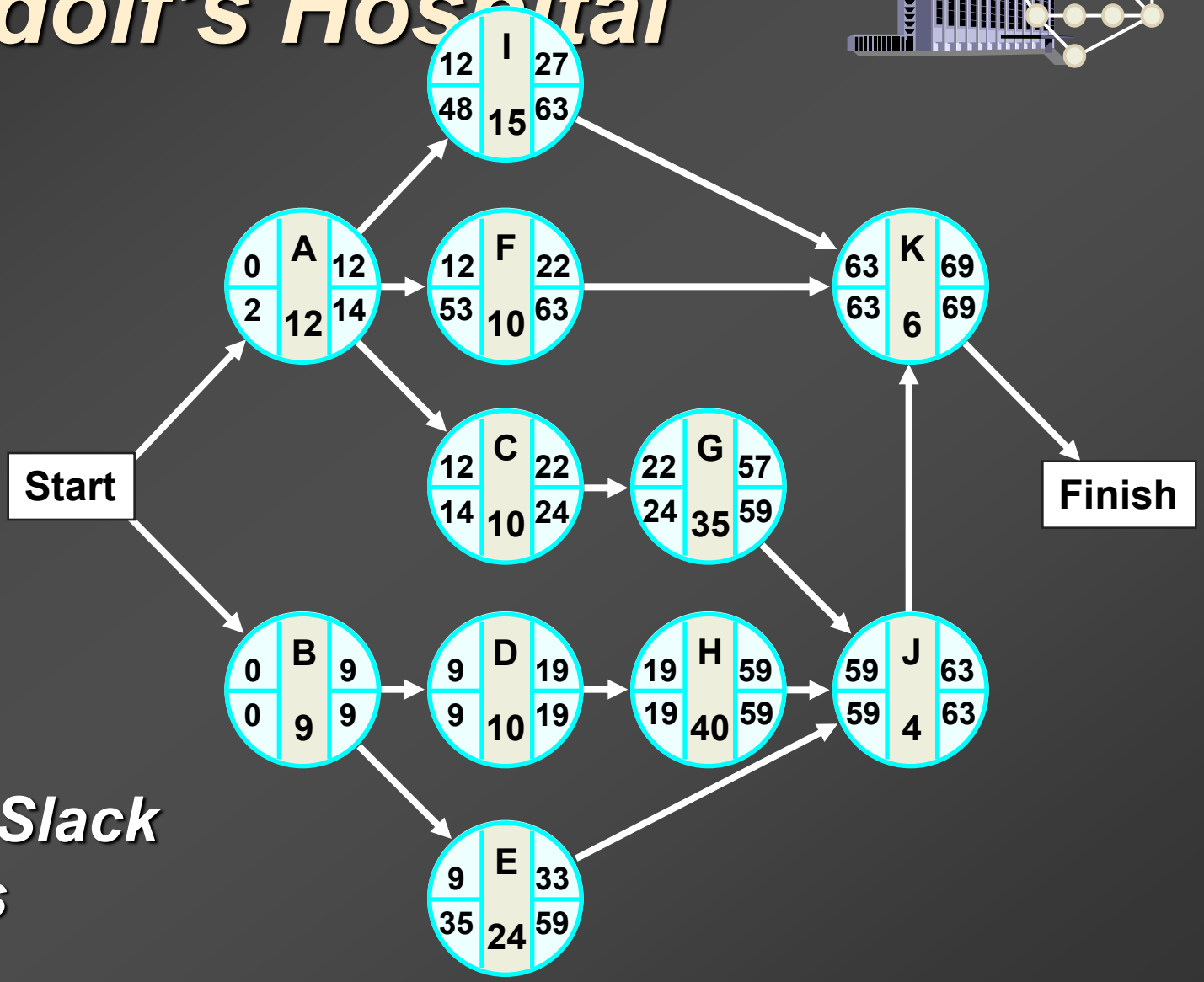

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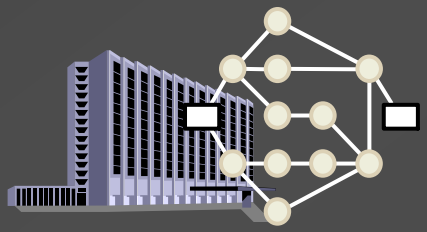
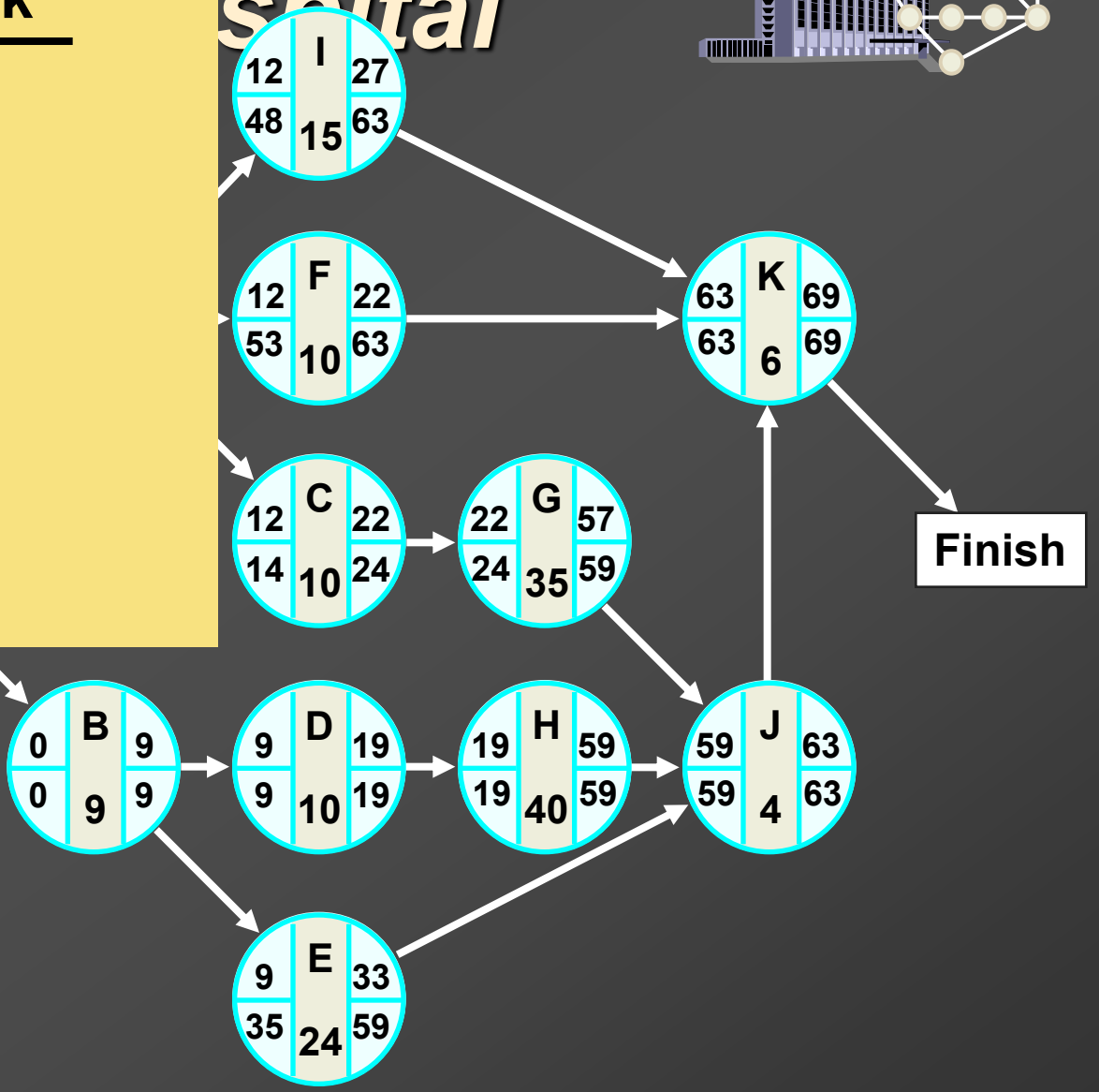
Activity Slack





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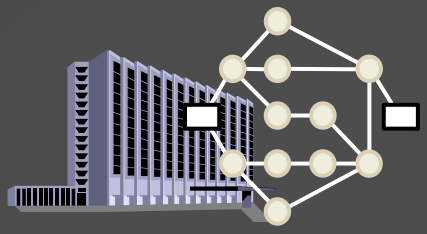
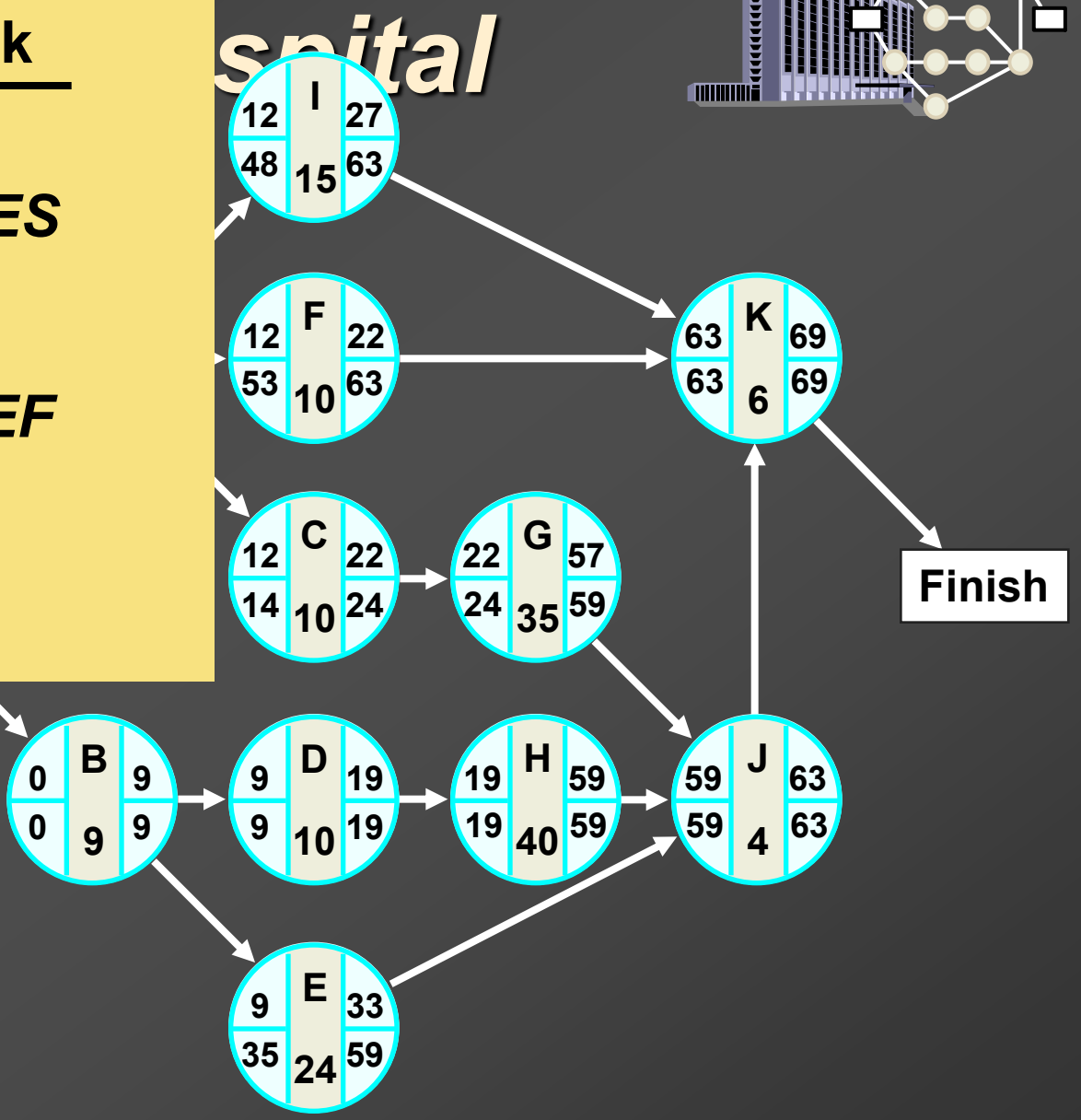
Activity Slack

Slack = *LS* – *ES*

or

Slack = *LF* – *EF*





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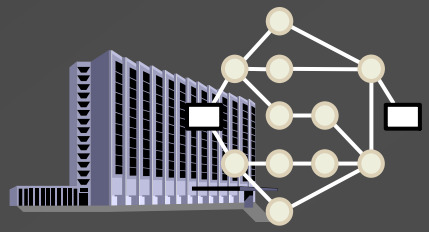
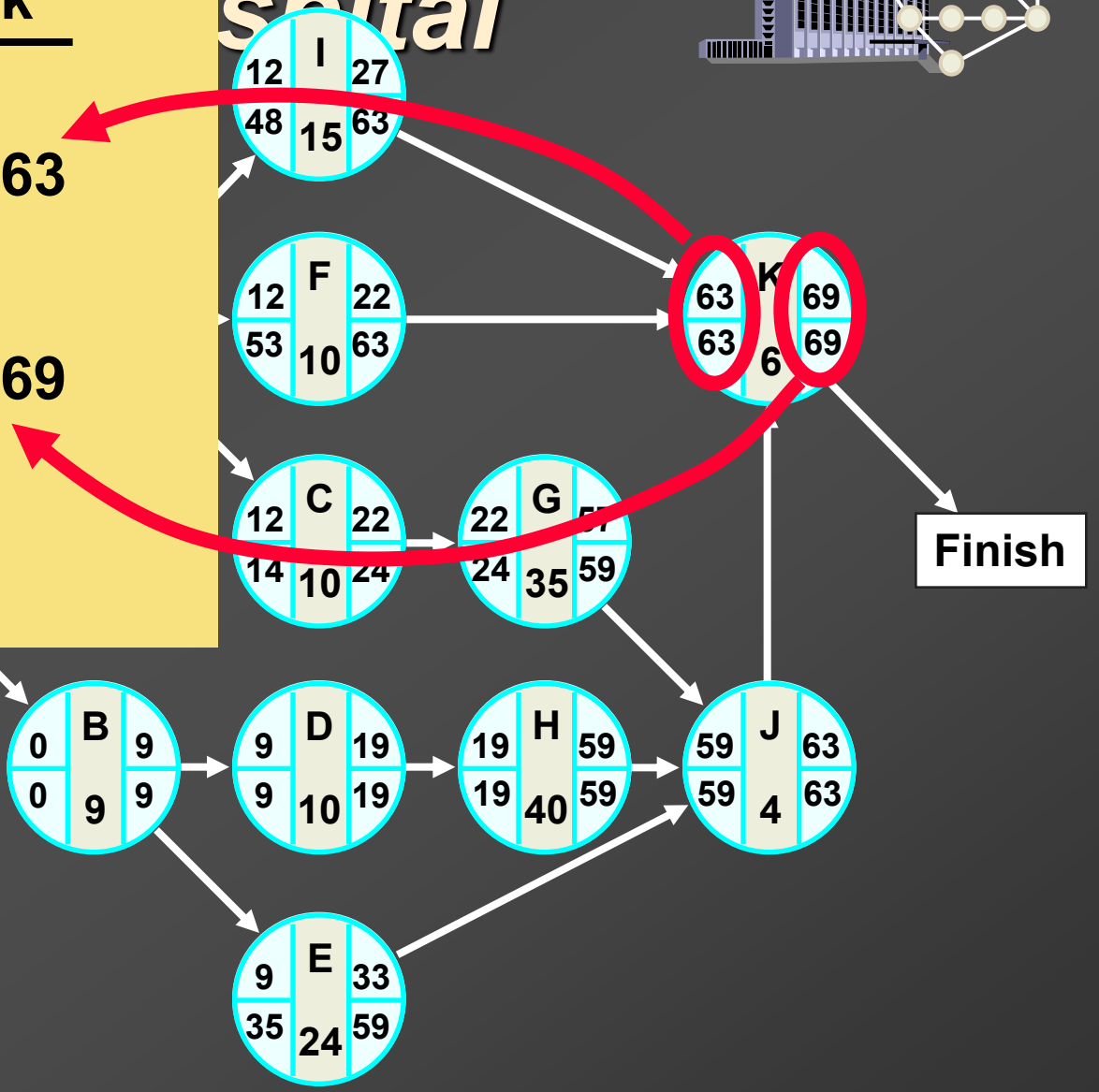
Activity Slack

$Slack_K = 63 - 63$

or

$Slack_K = 69 - 69$





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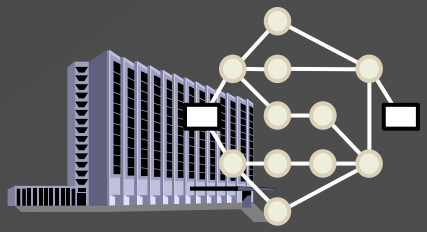
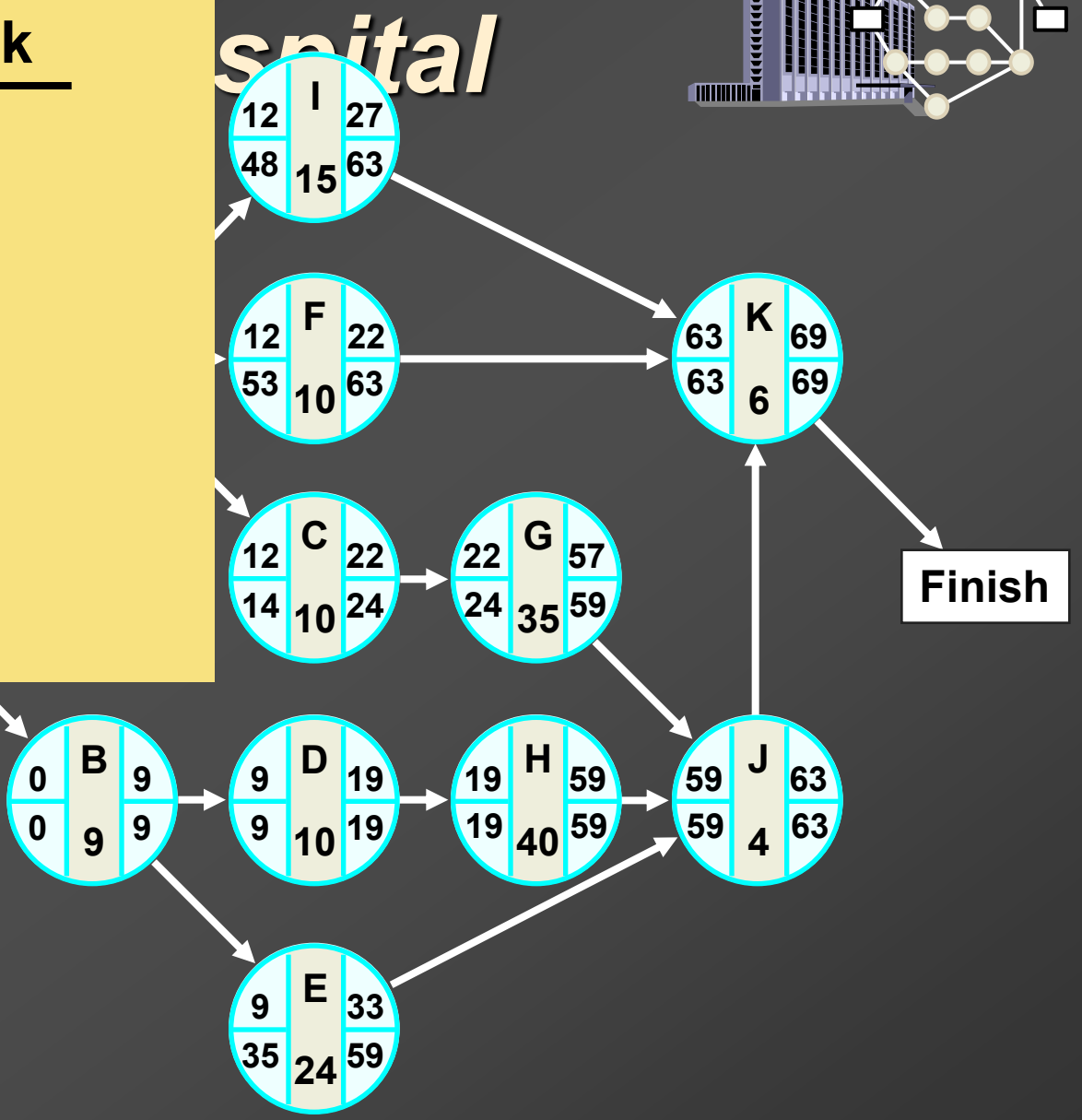
Activity Slack

$Slack_K = 0$

or

$Slack_K = 0$





Activity Slack Analysis

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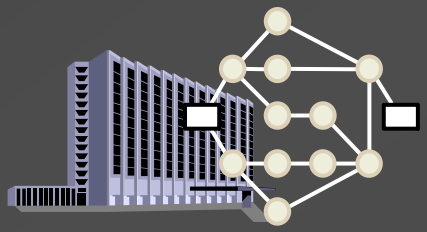
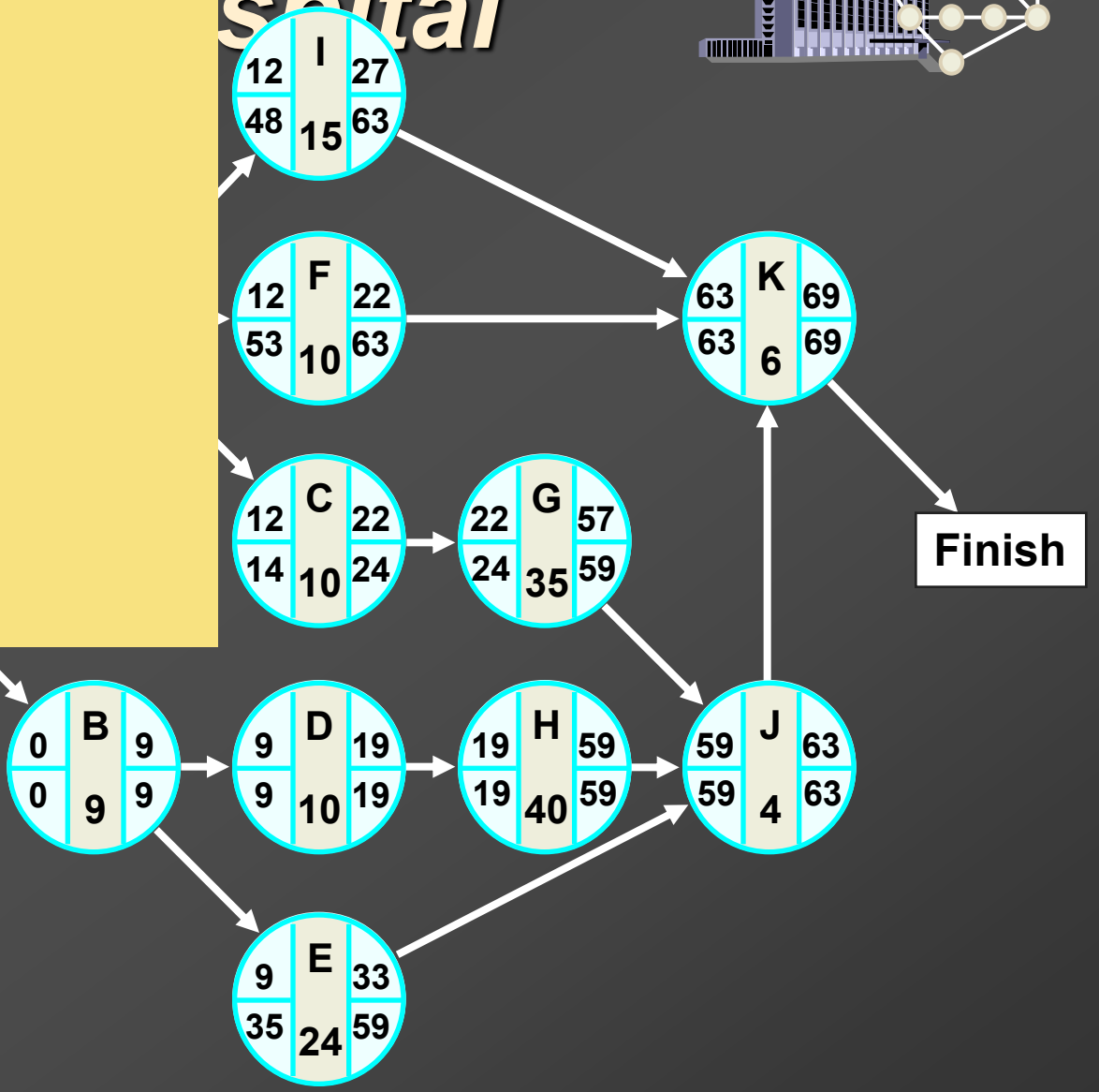
Activity Slack Analysis





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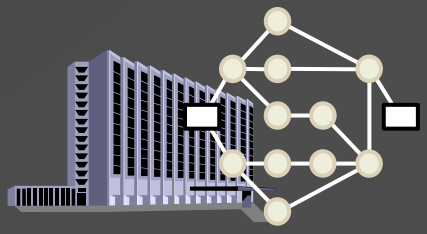
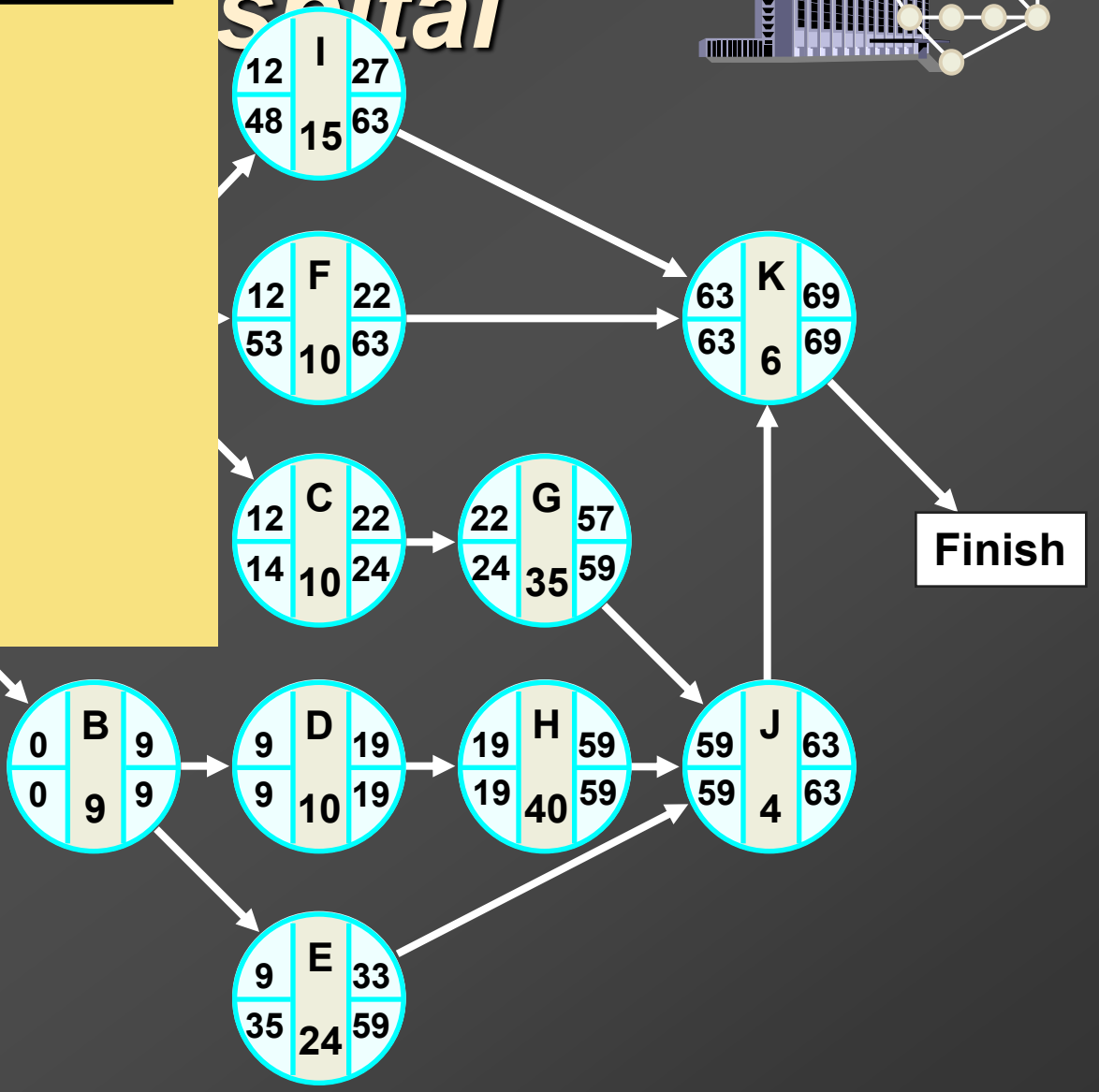
Node	Duration	*ES*	*LS*	Slack





Activity Slack Analysis

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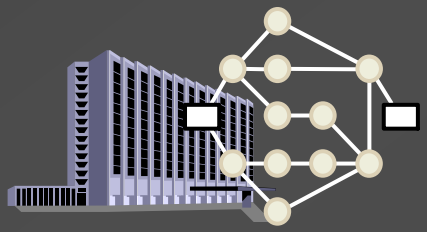
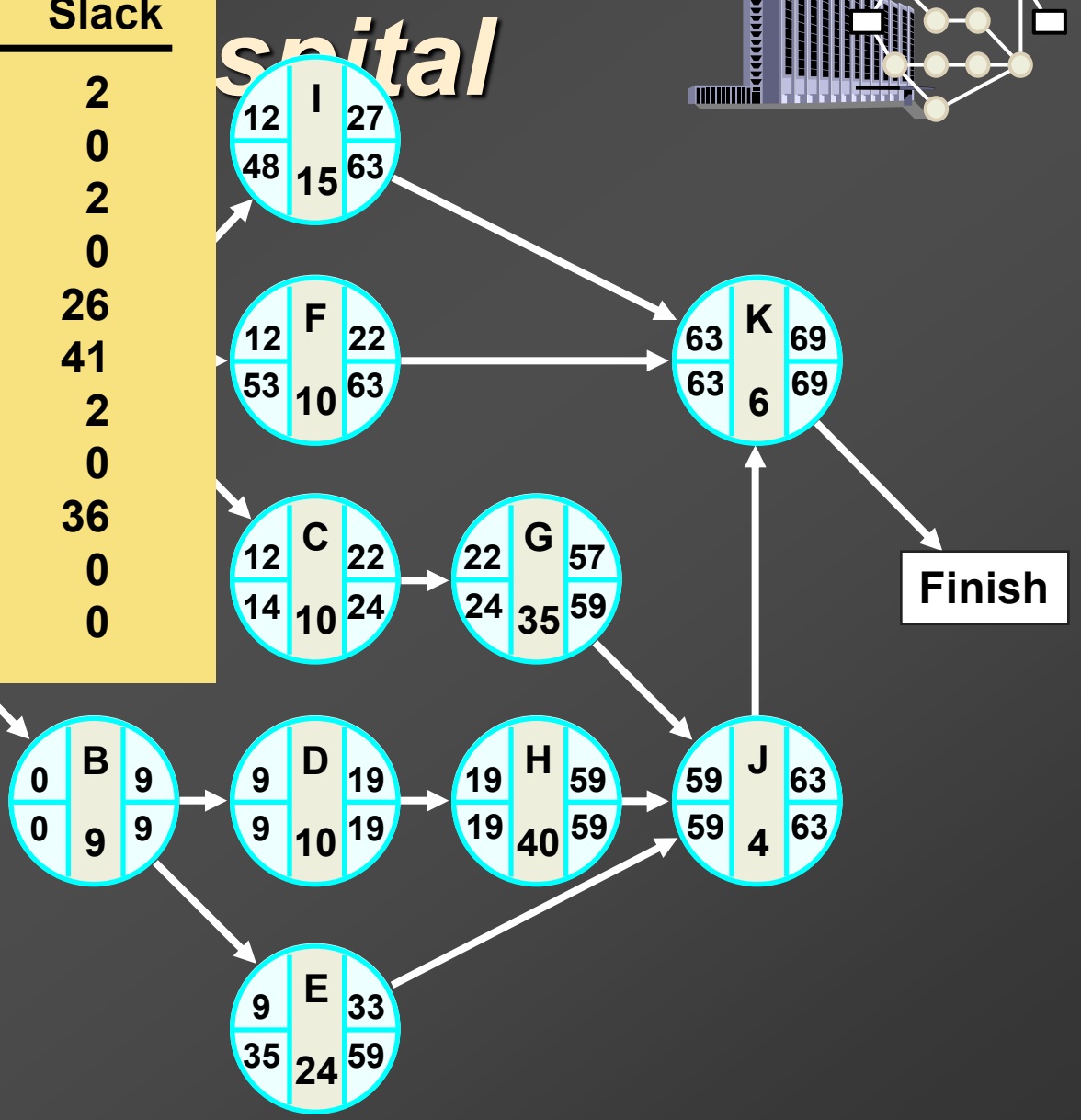
Node	Duration	*ES*	*LS*	Slack
A	12	0	2	2
B	9	0	0	0
C	10	12	14	2
D	10	9	9	0
E	24	9	35	26
F	10	12	53	41
G	35	22	24	2
H	40	19	19	0
I	15	12	48	36
J	4	59	59	0
K	6	63	63	0





Activity Slack Analysis

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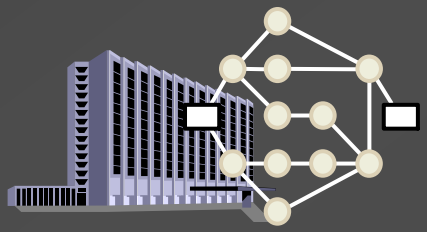
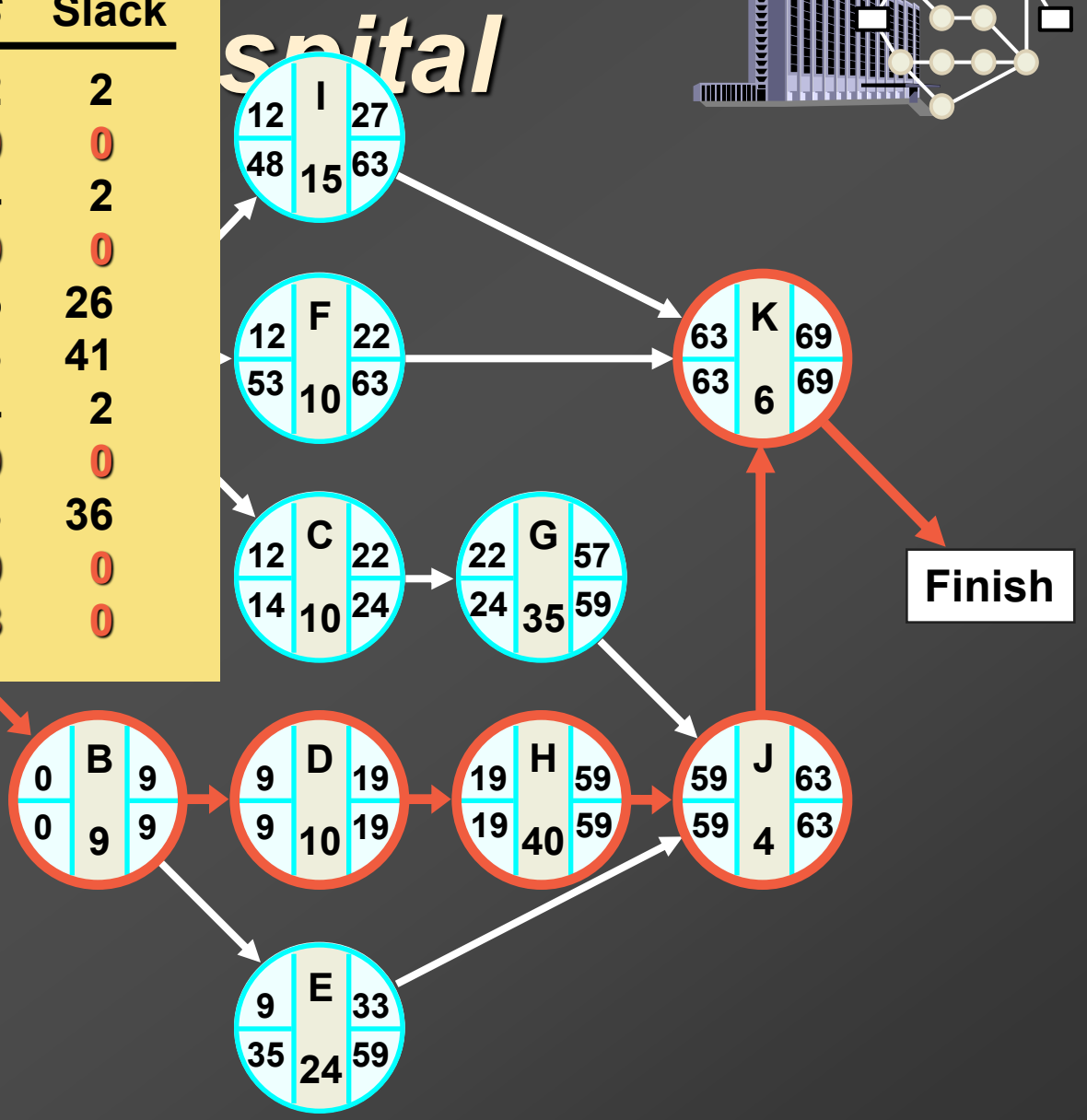
Node	Duration	*ES*	*LS*	Slack
A	12	0	2	2
B	9	0	0	0
C	10	12	14	2
D	10	9	9	0
E	24	9	35	26
F	10	12	53	41
G	35	22	24	2
H	40	19	19	0
I	15	12	48	36
J	4	59	59	0
K	6	63	63	0





Critical Path

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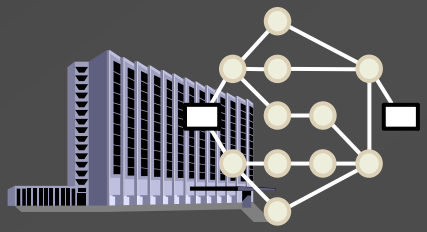

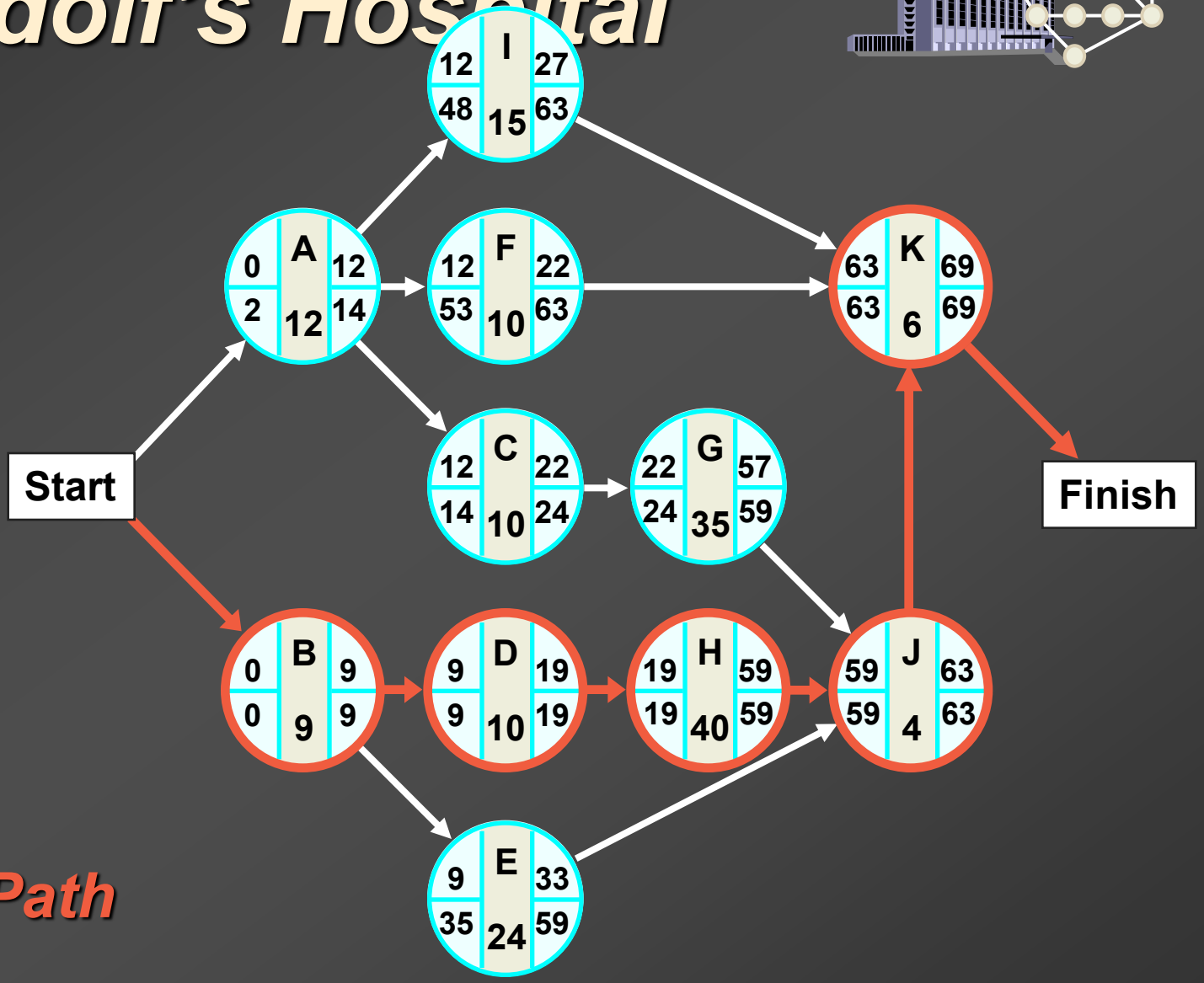

Critical Path

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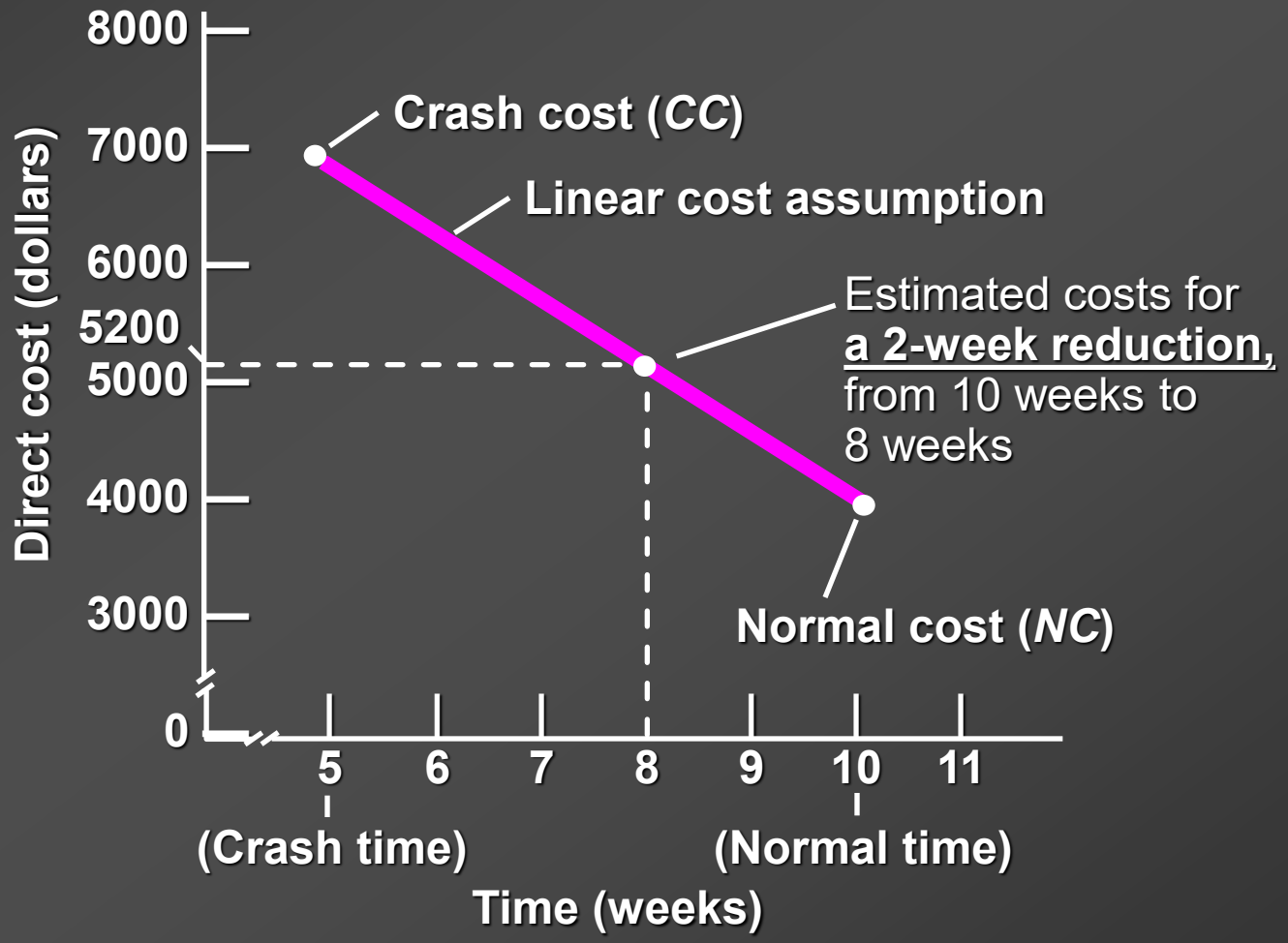
Cost-Time Relationships in Cost Analysis



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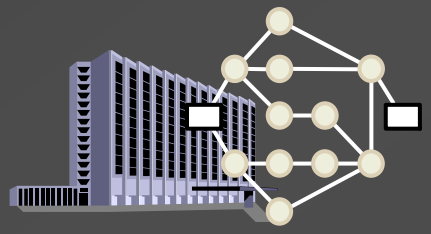

TABLE 8.1 DIRECT COST AND TIME DATA FOR THE ST. ADOLF'S HOSPITAL PROJECT

Activity	Normal Time (*NT*)	Normal Cost (*NC*)	Crash Time (*CT*)	Crash Cost (*CC*)	Maximum Time Reduction (wk)	Cost of Crashing per Week
A	12	$ 12,000	11	$ 13,000	1	$ 1,000
B	9	50,000	7	64,000	2	7,000
C	10	4,000	5	7,000	5	600
D	10	16,000	8	20,000	2	2,000
E	24	120,000	14	200,000	10	8,000
F	10	10,000	6	16,000	4	1,500
G	35	500,000	25	530,000	10	3,000
H	40	1,200,000	35	1,260,000	5	12,000
I	15	40,000	10	52,500	5	2,500
J	4	10,000	1	13,000	2	1,000
K	6	30,000	5	34,000	1	4,000
	Totals	$1,992,000		$2,209,000		

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Probabilistic Time Estimates

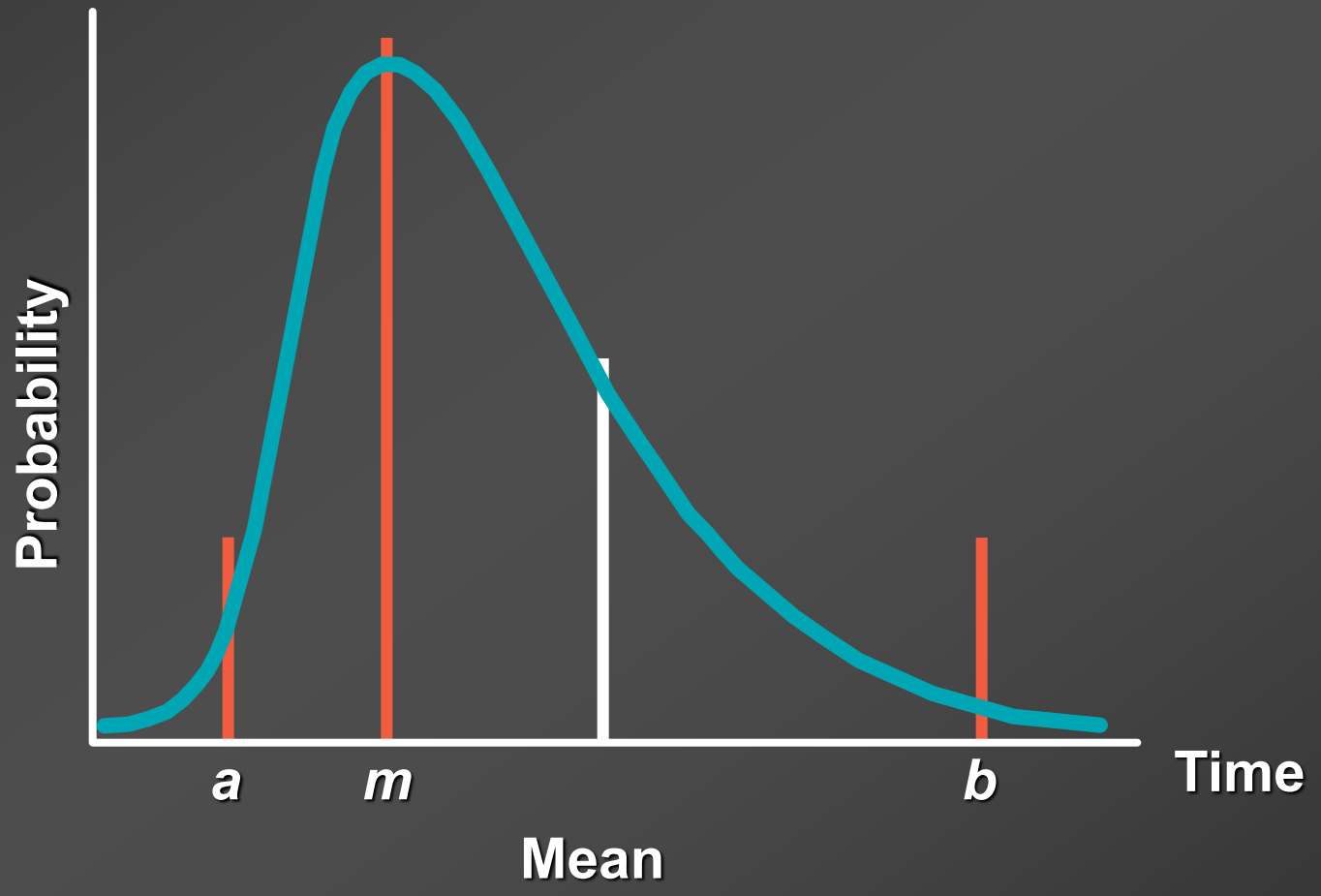

Figure 8.12 (a) Beta Distribution

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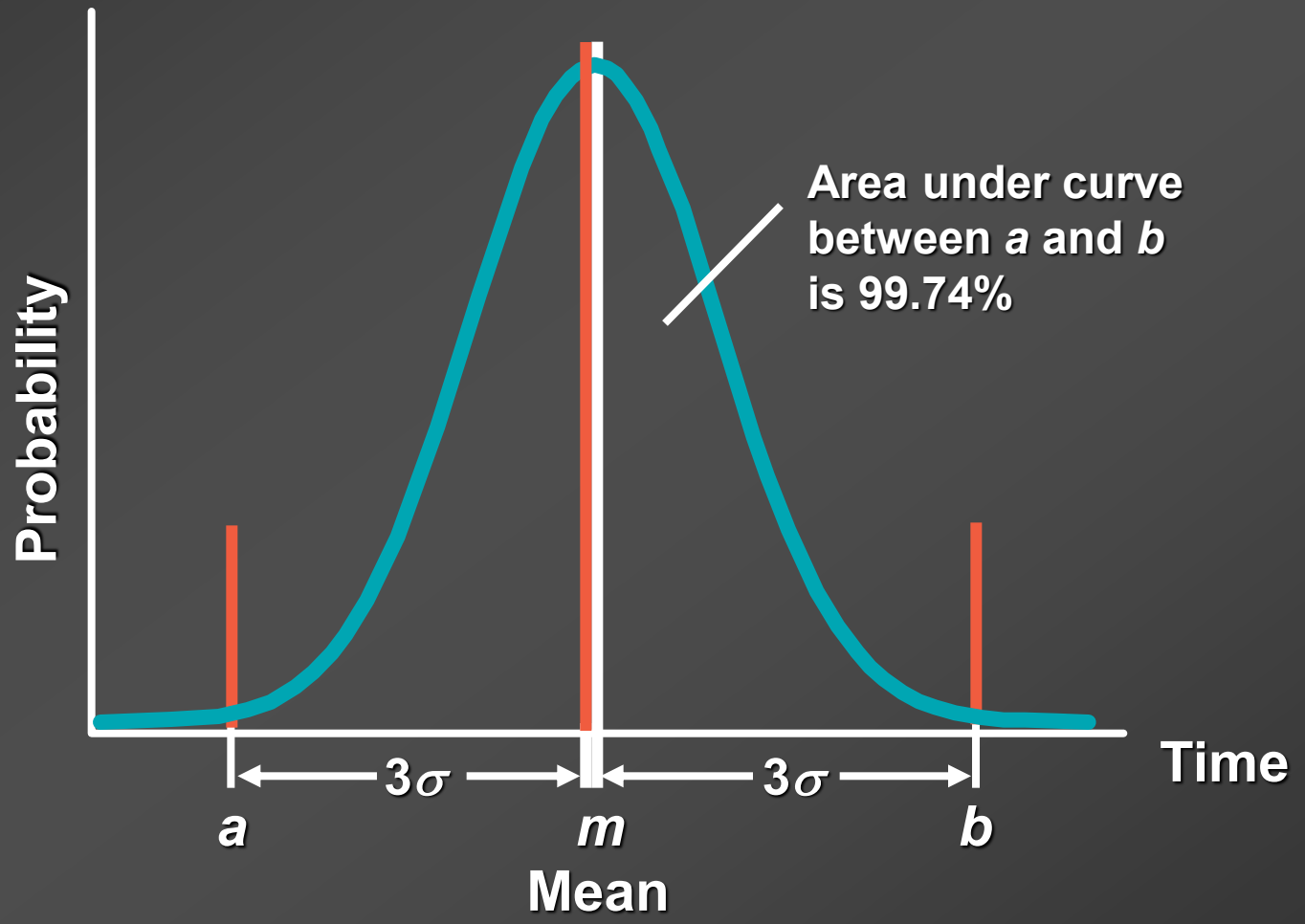
Probabilistic Time Estimates



) Normal Distribution

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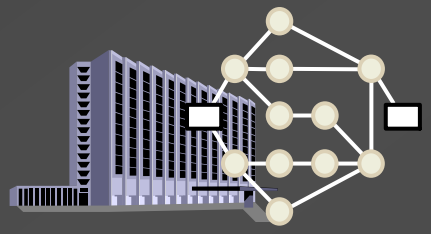
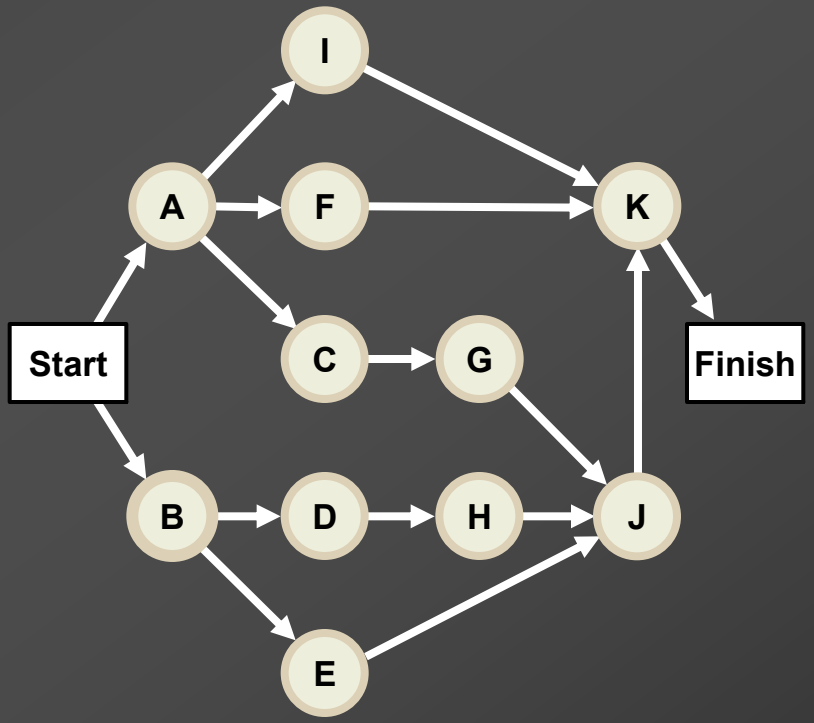


Probabilistic Time Estimates



Mean

$$t_e = \frac{a + 4m + b}{6}$$

Variance

$$\sigma^2 = \left(\frac{b - a}{6}\right)^2$$

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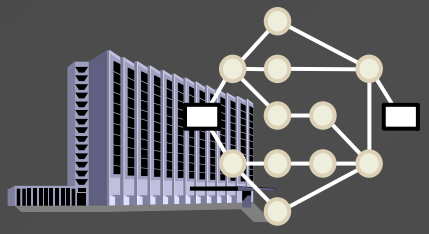
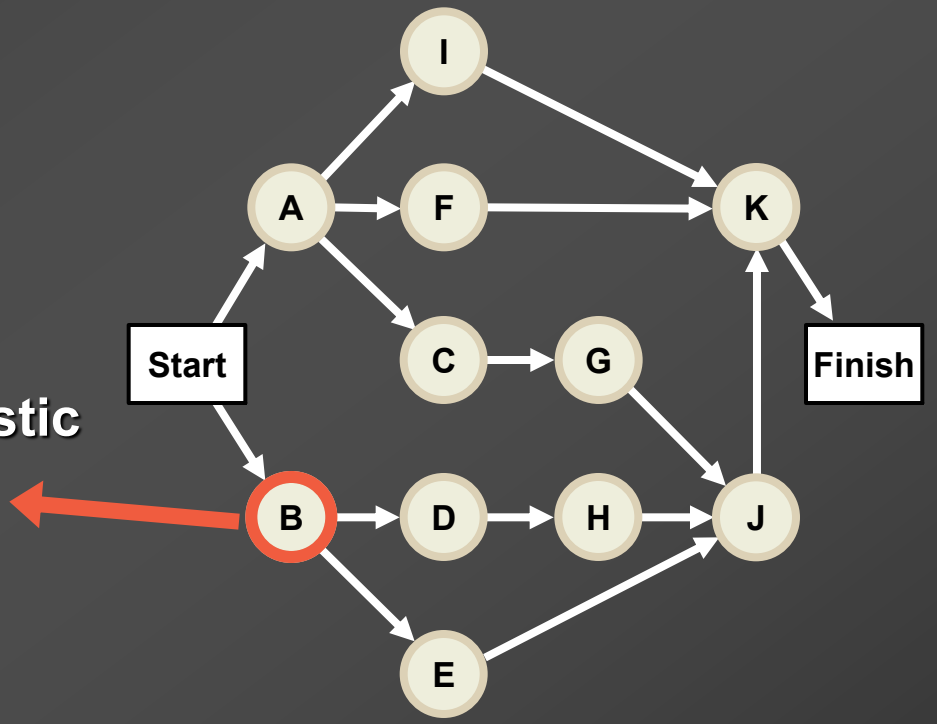


Probabilistic Time Estimates

Activity B		
Optimistic (*a*)	Most Likely (*m*)	Pessimistic (*b*)
7	8	15



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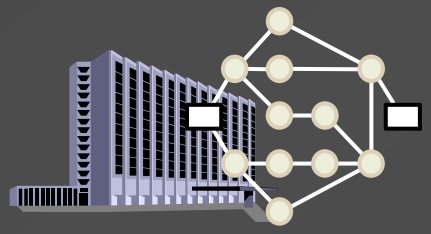


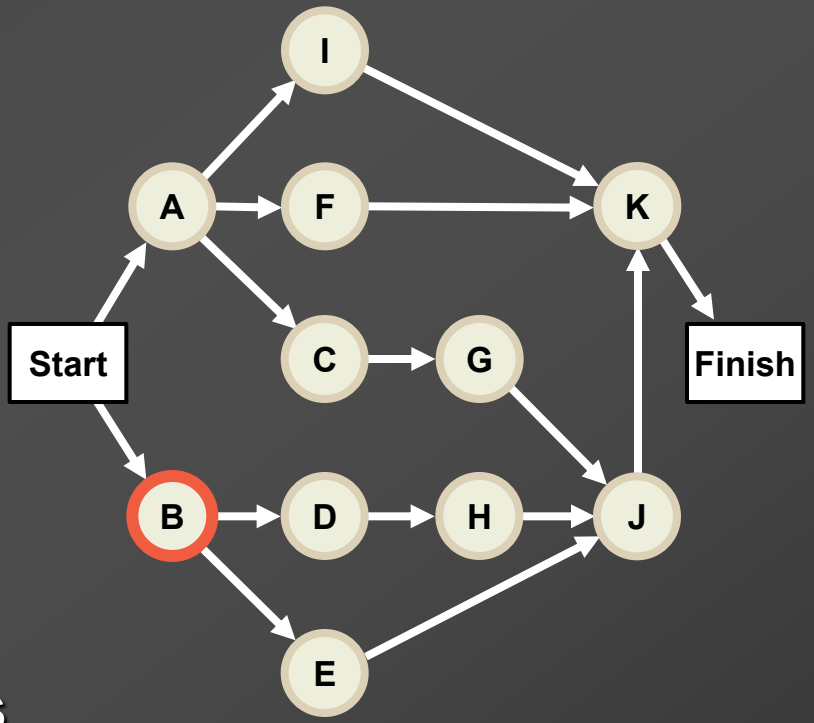
Probabilistic Time Estimates

Activity B

Optimistic (*a*)	Most Likely (*m*)	Pessimistic (*b*)
7	8	15

$$t_e = \frac{7 + 4(8) + 15}{6} = 9 \text{ weeks}$$

$$\sigma^2 = \left(\frac{15 - 7}{6} \right)^2 = 1.78$$



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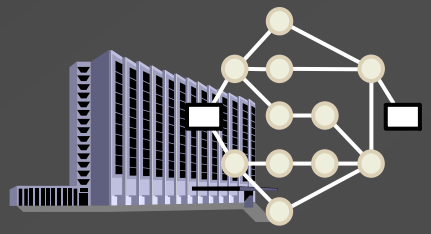

Activity	Time Estimates (wk)			Activity Statistics	
	Optimistic (a)	Likely (m)	Pessimistic (b)	Expected Time (t_e)	Variance (σ^2)
A	11	12	13	12	0.11
B	7	8	15	9	1.78
C	5	10	15	10	2.78
D	8	9	16	10	1.78
E	14	25	30	24	7.11
F	6	9	18	10	4.00
G	25	36	41	35	7.11
H	35	40	45	40	2.78
I	10	13	28	15	9.00
J	1	2	15	4	5.44
K	5	6	7	6	0.11

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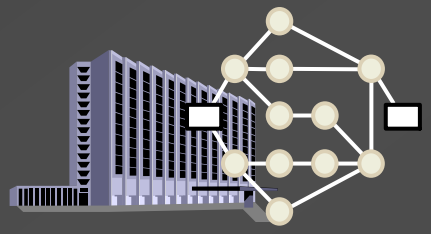

Probabilities

Critical Path = B - D - H - J - K

$T = 72$ days $\qquad T_E = 69$ days

$\sigma^2 = \Sigma$ (variances of activities) $\qquad z = \dfrac{T - T_E}{\sqrt{\sigma^2}}$

$\sigma^2 = 1.78 + 1.78 + 2.78 + 5.44 + 0.11 = 11.89$

$$z = \frac{72 - 69}{\sqrt{11.89}}$$

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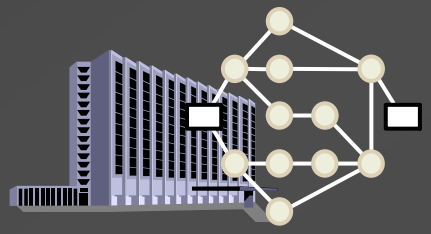
APPENDIX 2

	.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
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

St. Adolf's Hospital



Probabilities

Critical Path = B - D - H - J - K

$T = 72$ days $\qquad T_E = 69$ days

$\sigma^2 = \Sigma$ (variances of activities) $\qquad z = \dfrac{T - T_E}{\sqrt{\sigma^2}}$

$\sigma^2 = 1.78 + 1.78 + 2.78 + 5.44 + 0.11 = 11.89$

$z = \dfrac{72 - 69}{\sqrt{11.89}} = 0.87$

From Appendix 2
$P_z = .8078 \approx .81$

To Accompany Krajewski & Ritzman *Operations Management: Strategy and Analysis, Seventh Edition* © 2004 Prentice Hall, Inc. All rights reserved.

Design network decisions

- ***Complete method***
  - ***Location of supply sources and markets***
  - ***Location of potential facility sites***
  - ***Demand forecast by market***
  - ***Facility, labor and material costs by site***
  - ***Transportation costs between each pair of sites***
  - ***Inventory costs by site and as a function of quantity***
  - ***Sale price of product in different regions***
  - ***Taxes and tariffs***
  - ***Desired response time and other service factors***

Cost & Demand Data related to U.S. Petroleum

Inputs-Costs,Capacities, Demands									
Demand Region :	Production and transportation cost per 1,000,000 units					Fixed	Low	Fixed	High
Supply region	N America	S America	Europe	Asia	Africa	cost $	capacity	cost $	capacity
N.America	81	92	101	130	115	6000	10	9000	20
S. America	117	77	108	98	100	4500	10	6750	20
Europe	102	105	95	119	111	6500	10	9750	20
Asia	115	125	90	59	74	4100	10	6150	20
Africa	142	100	103	105	71	4000	10	6000	20
Demand	12	8	14	16	7				

U.S. Petroleum

with

n= number of potential plant locations/capacity (each level of capacity will count as a separate location)

m=number of markets or demand points

Dj=annual demand from market j

Ki= potential capacity of plant i

fi = annualized fixed cost of keeping factory i open

cij= cost of producing and shipping one unit from factory i to market j (cost includes production, inventory, transportation and tariffs)

yi=1 if plant is open, 0 otherwise

xij=quantity shipped from plant i to market j

U.S. Petroleum

$$\text{Min} \sum_{i=1}^{n} f_i y_i + \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij}$$

to minimize the total cost

Under conditions

$$\sum_{i=1}^{n} x_{ij} = D_j \quad \text{for } j = 1, \ldots, m$$

Demand at each regional market is satisfied

$$\sum_{j=1}^{m} x_{ij} \leq k_i y_i \quad \text{for } i = 1, \ldots, n$$

No plant can supply more than its capacity

$y_i \in \{0, 1\}$ for $i = 1, \ldots, n$, $x_{ij} \geq 0$

(0 or 1)

so each plant is either open ($y_i = 1$) or closed ($y_i = 0$)

The solution identifies the plants that are to be kept open, their capacity, and the regional allocation of the demand for these plants.