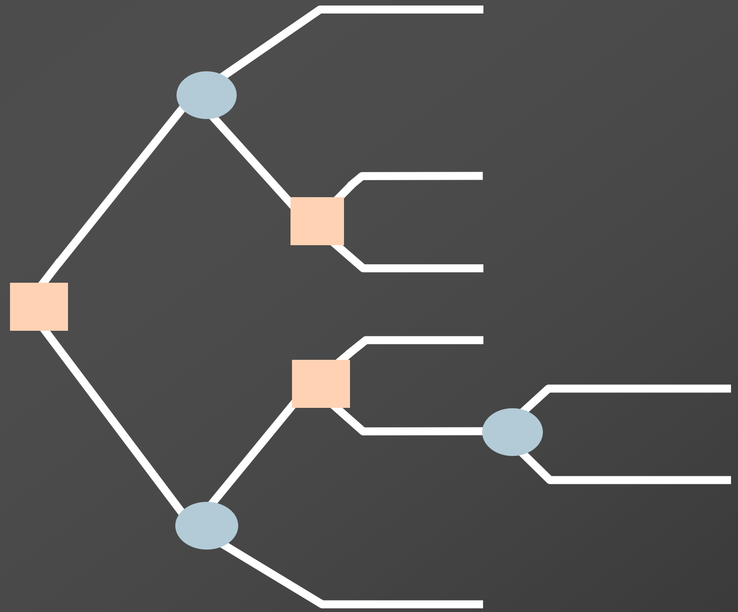
CHAPTER II – Decision making



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***

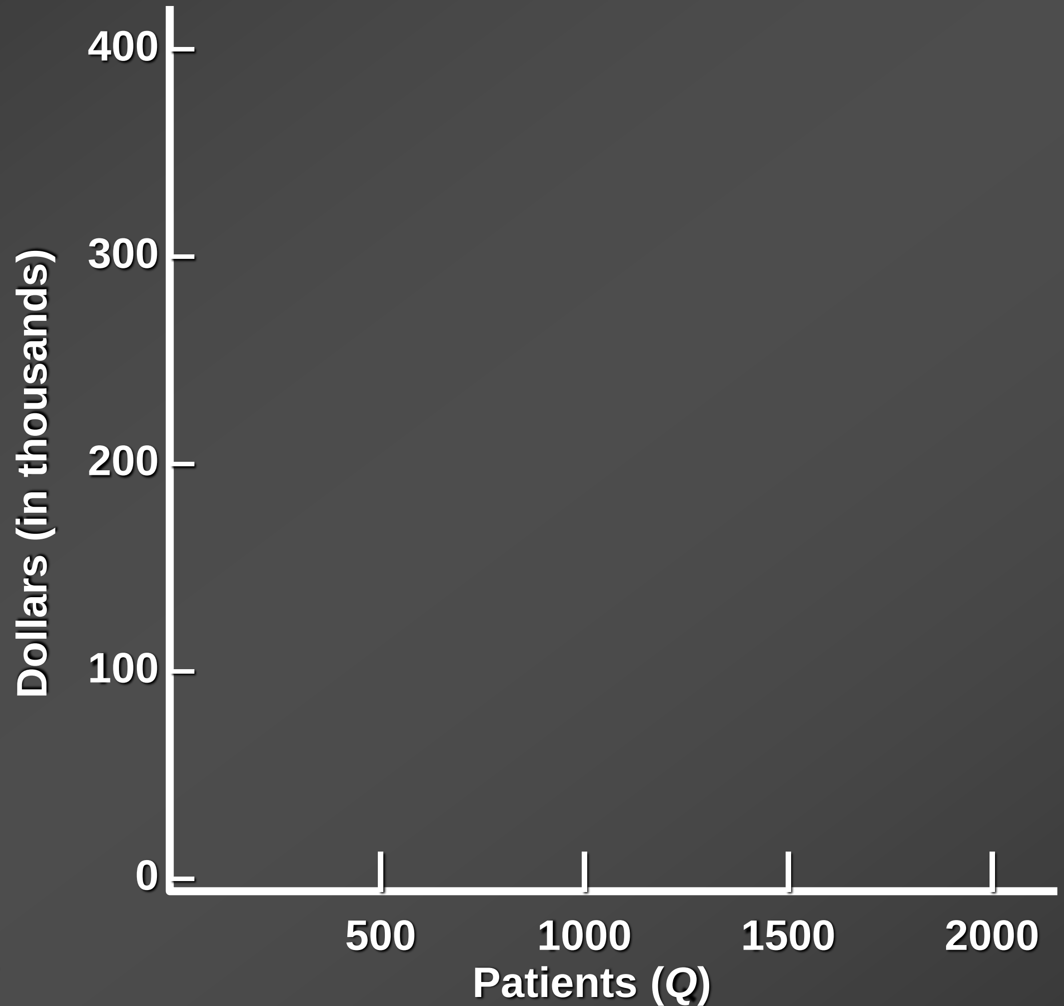
Example

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

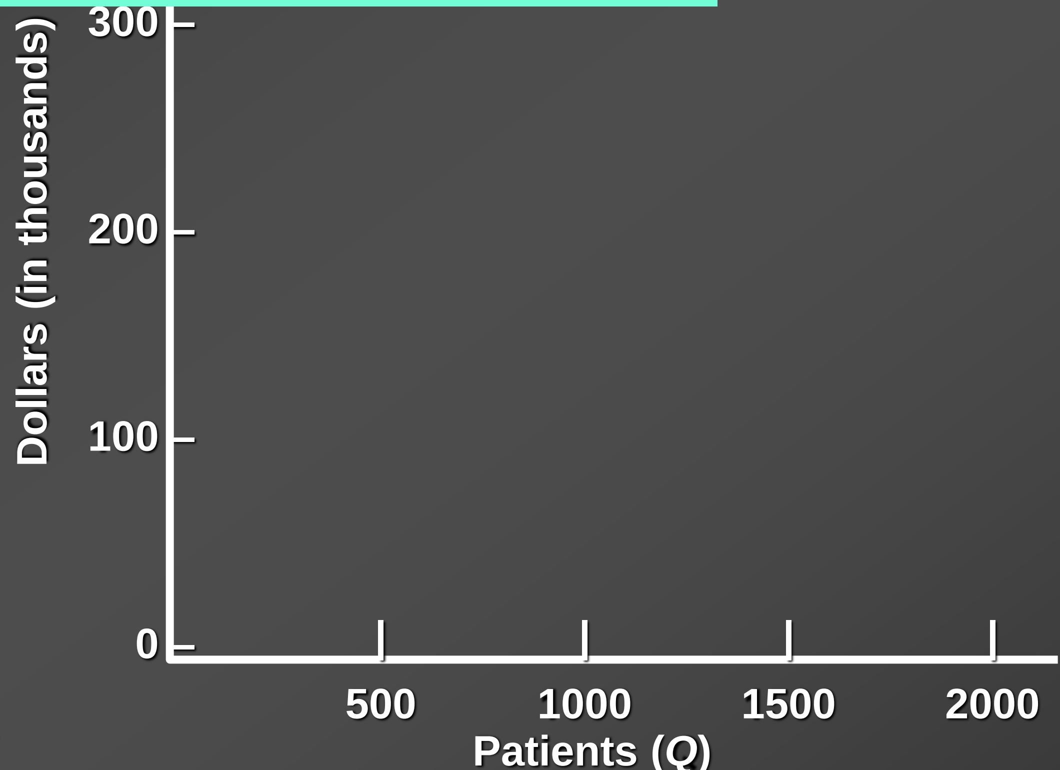
Break-Even Analysis



Example A.1

Break-Even Analysis

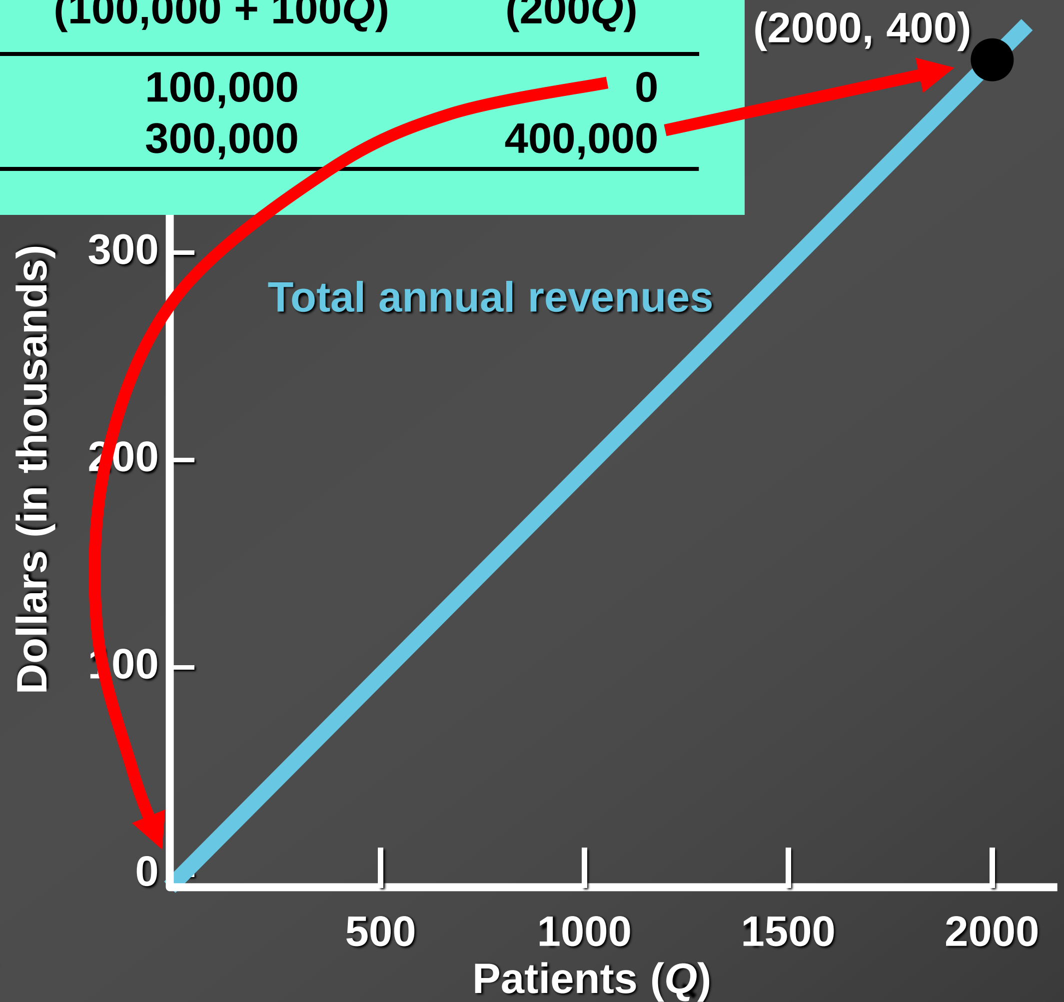
Quantity (patients) (Q)	Total Annual Cost ($) (100,000 + 100$Q$)	Total Annual Revenue ($) (200$Q$)
0	100,000	0
2000	300,000	400,000



Example A.1

Break-Even Analysis

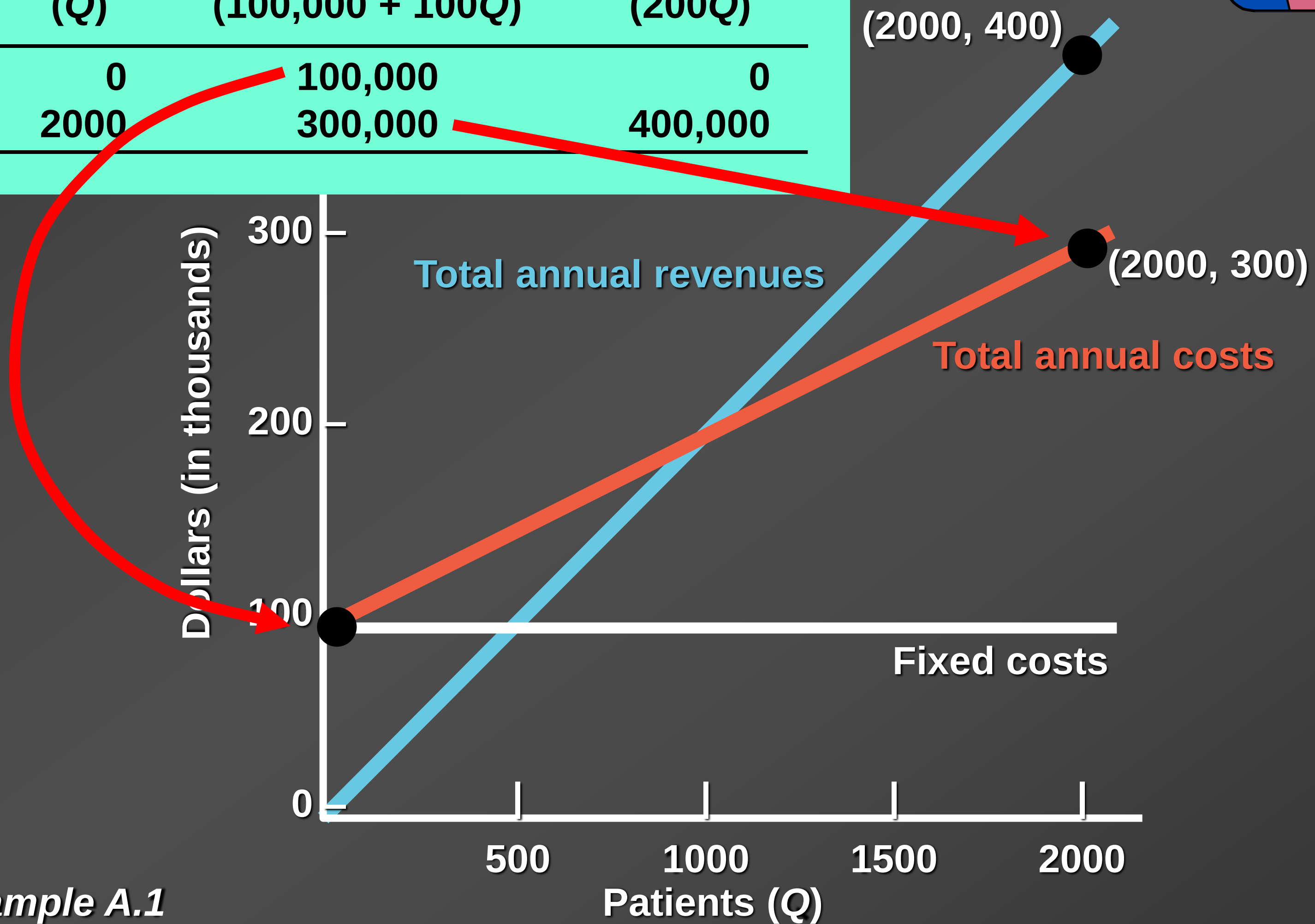
Quantity (patients) (Q)	Total Annual Cost ($) ($100{,}000 + 100Q$)	Total Annual Revenue ($) ($200Q$)
0	100,000	0
2000	300,000	400,000



Example A.1

Break-Even Analysis

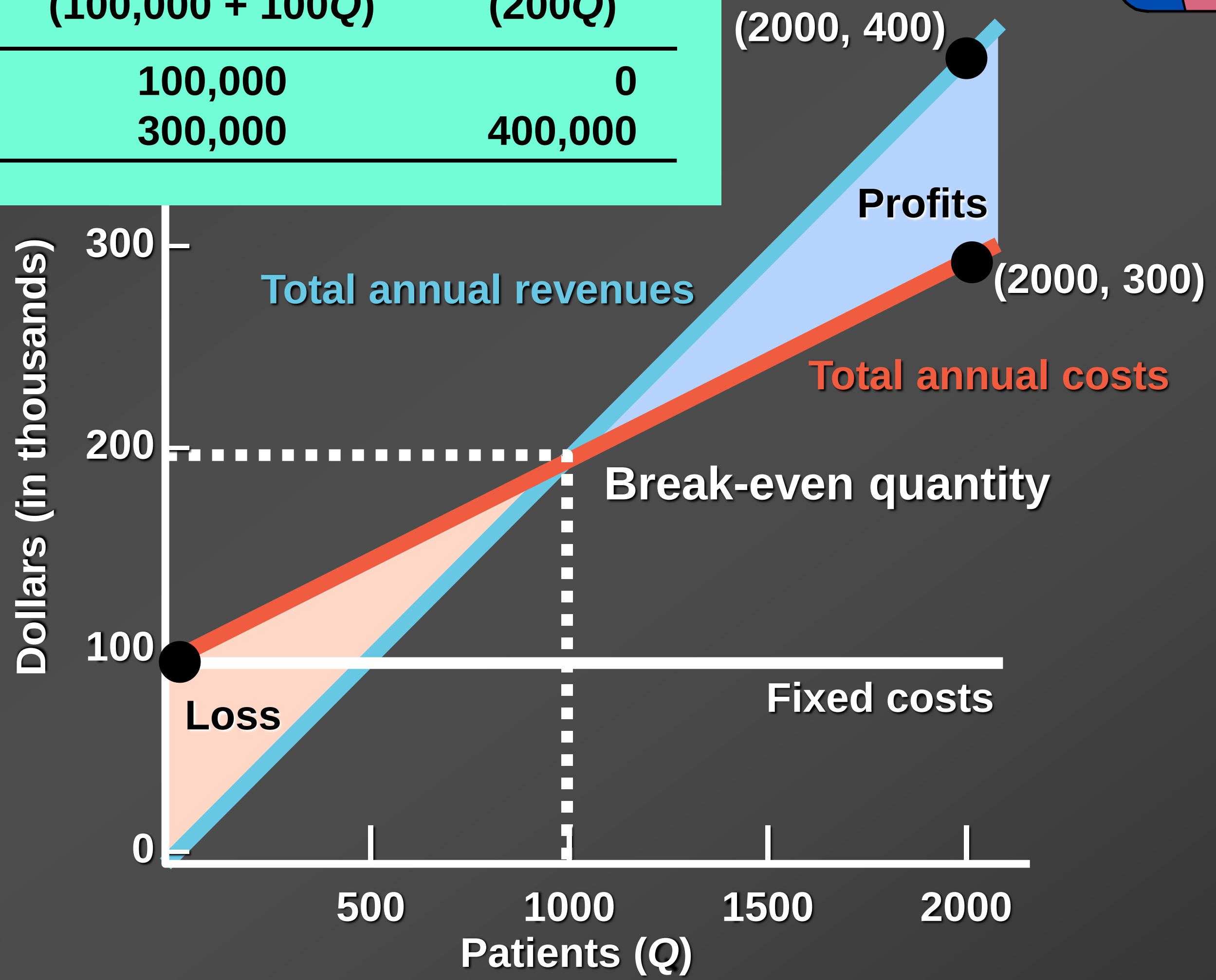
Quantity (patients) (*Q*)	Total Annual Cost ($) (100,000 + 100*Q*)	Total Annual Revenue ($) (200*Q*)
0	100,000	0
2000	300,000	400,000



Example A.1

Break-Even Analysis

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

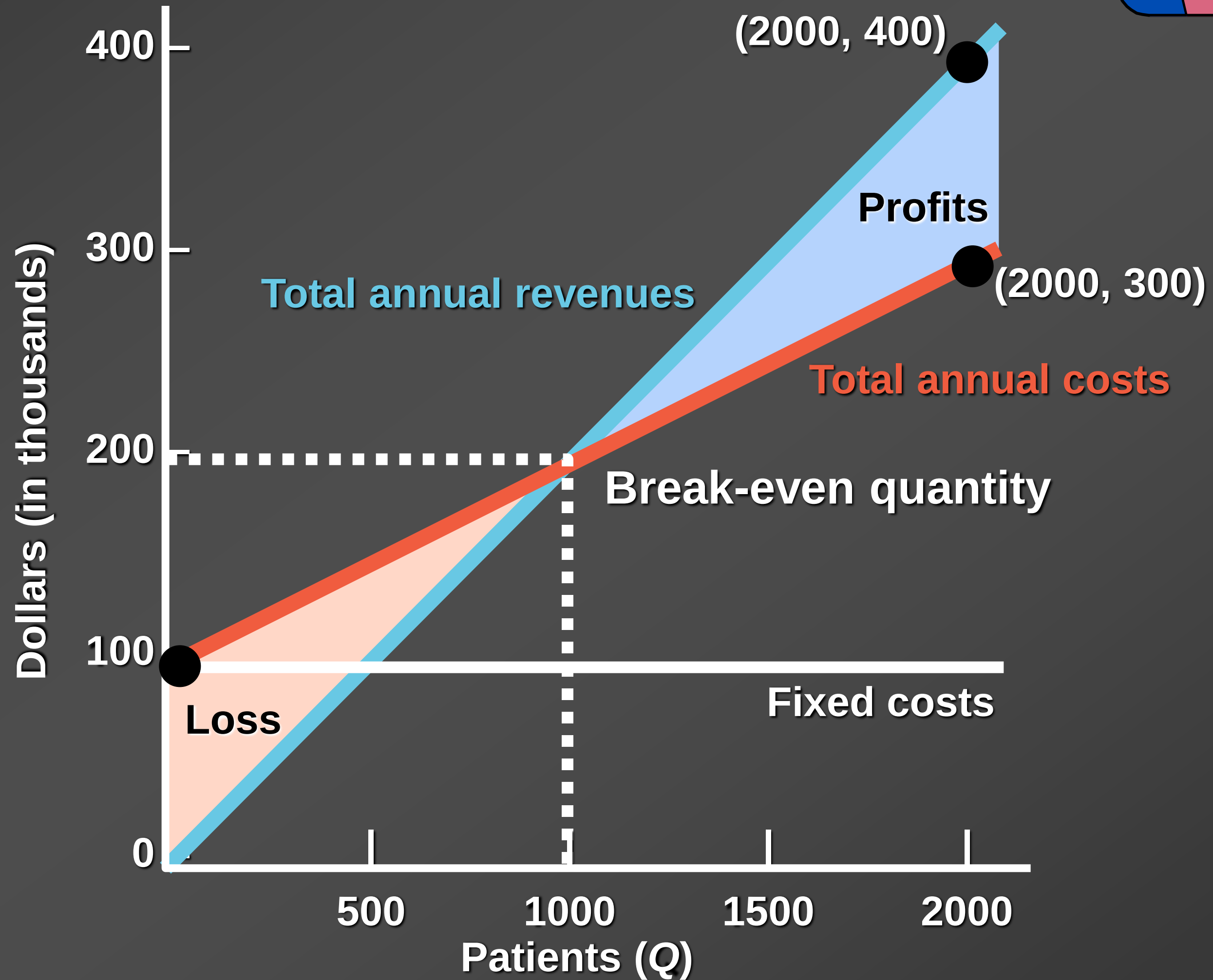
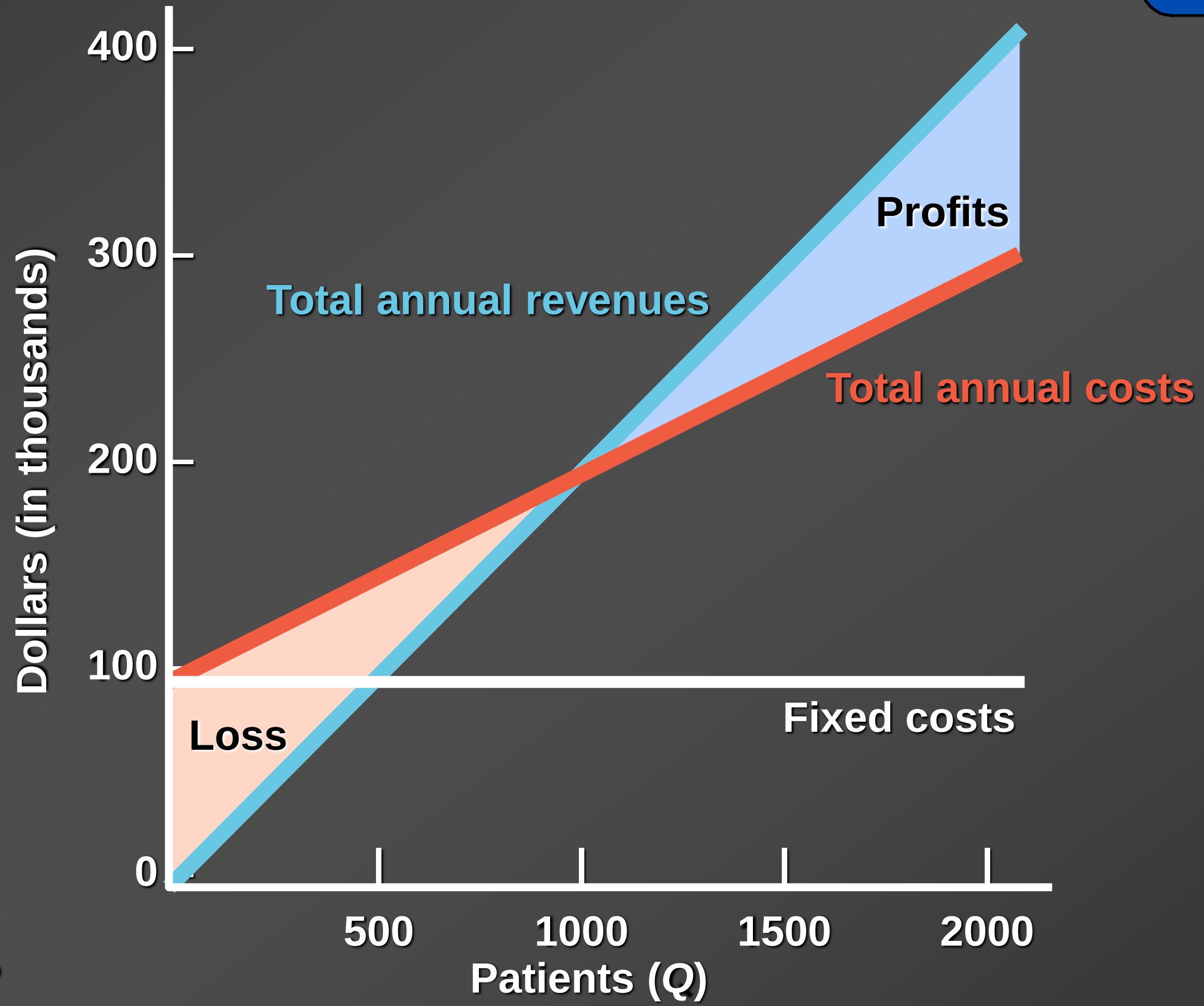


Figure A.1

Sensitivity analysis of sales forecasts

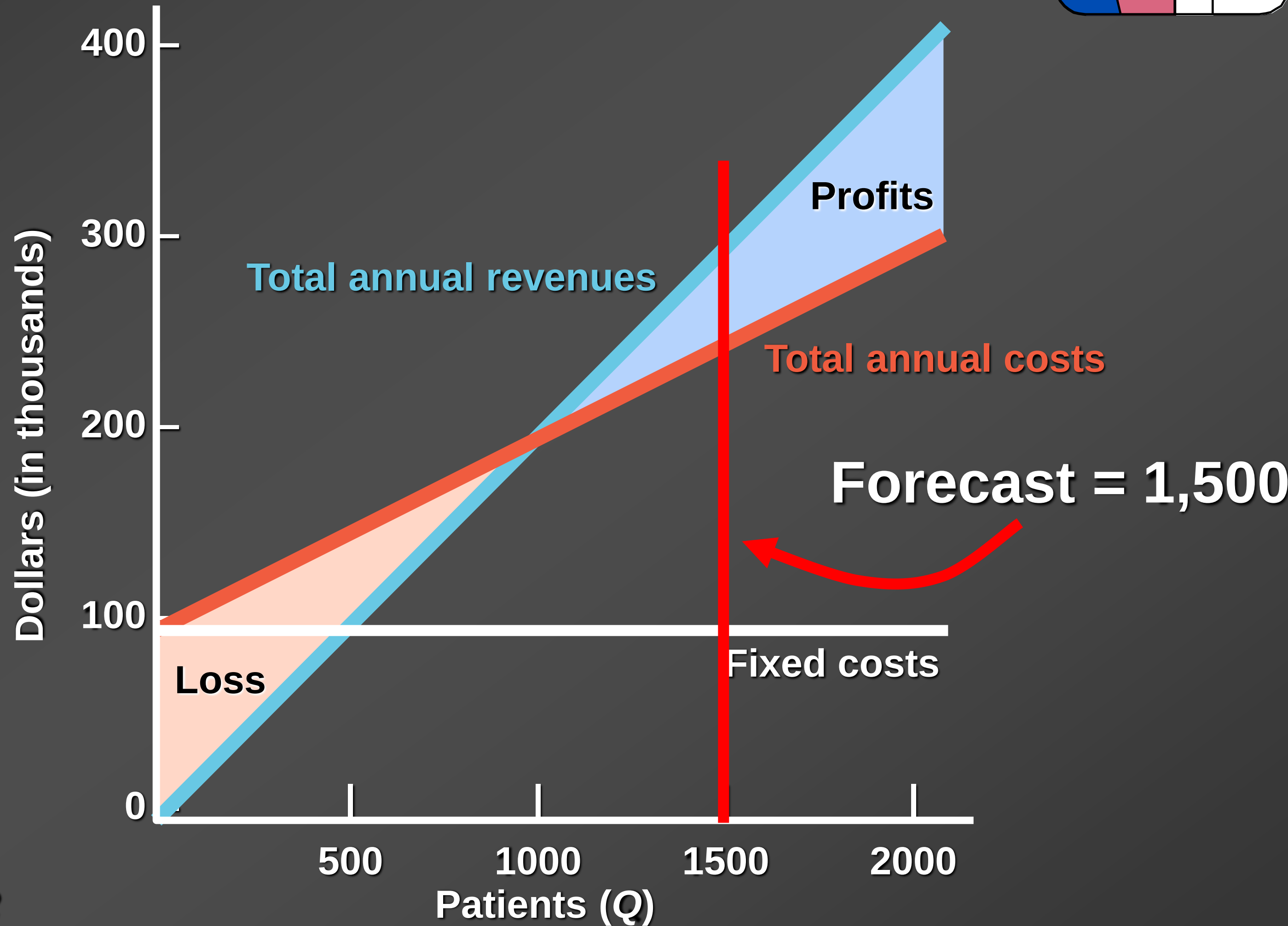
If the most pessimistic sales forecast for the proposed service in Figure A.I were 1,500 patients, what would be the procedure's total contribution to profit and overhead per year?

Sensitivity Analysis



Example A.2

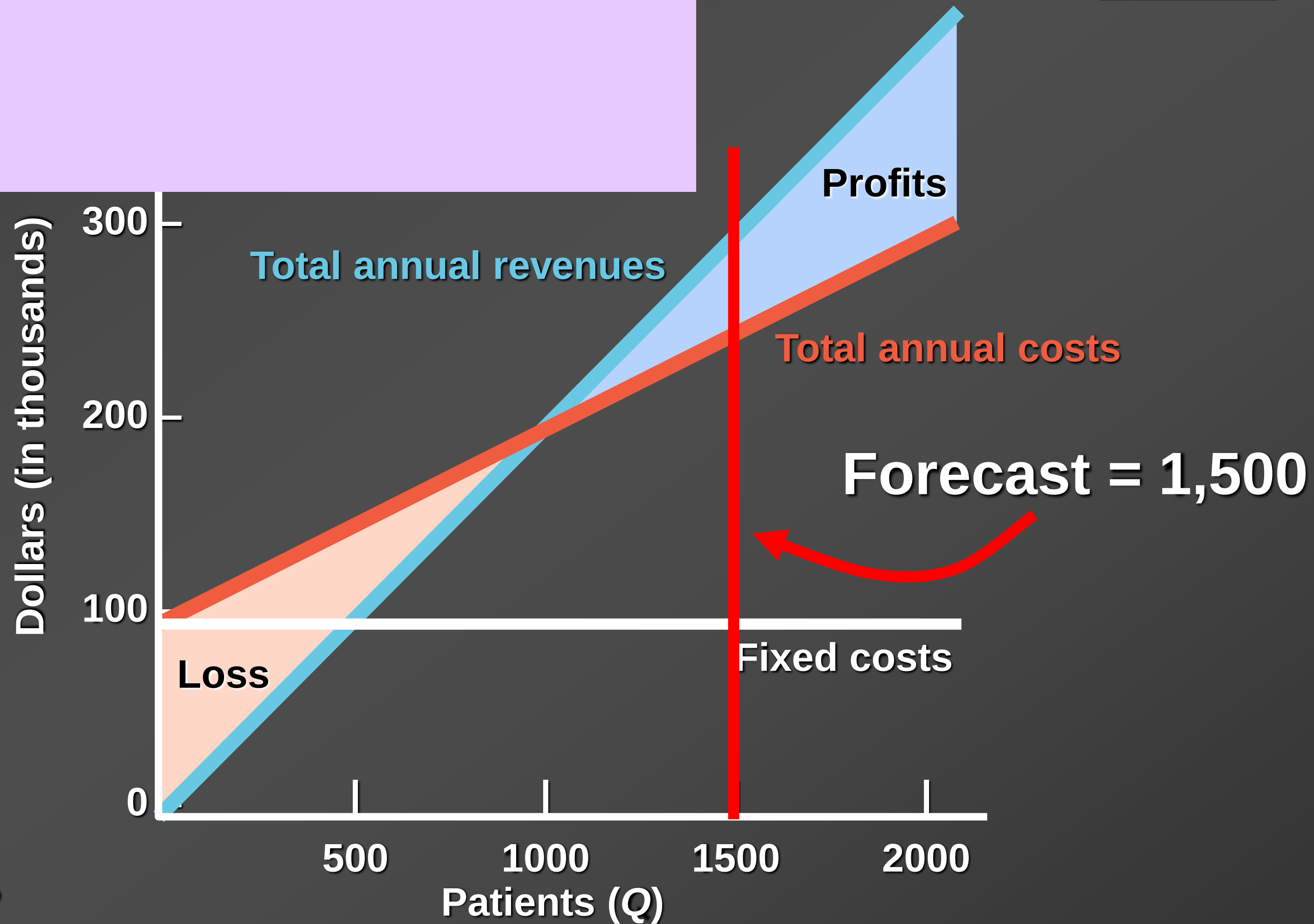
Sensitivity Analysis

Example A.2

Sensitivity Analysis

$$pQ - (F + cQ)$$



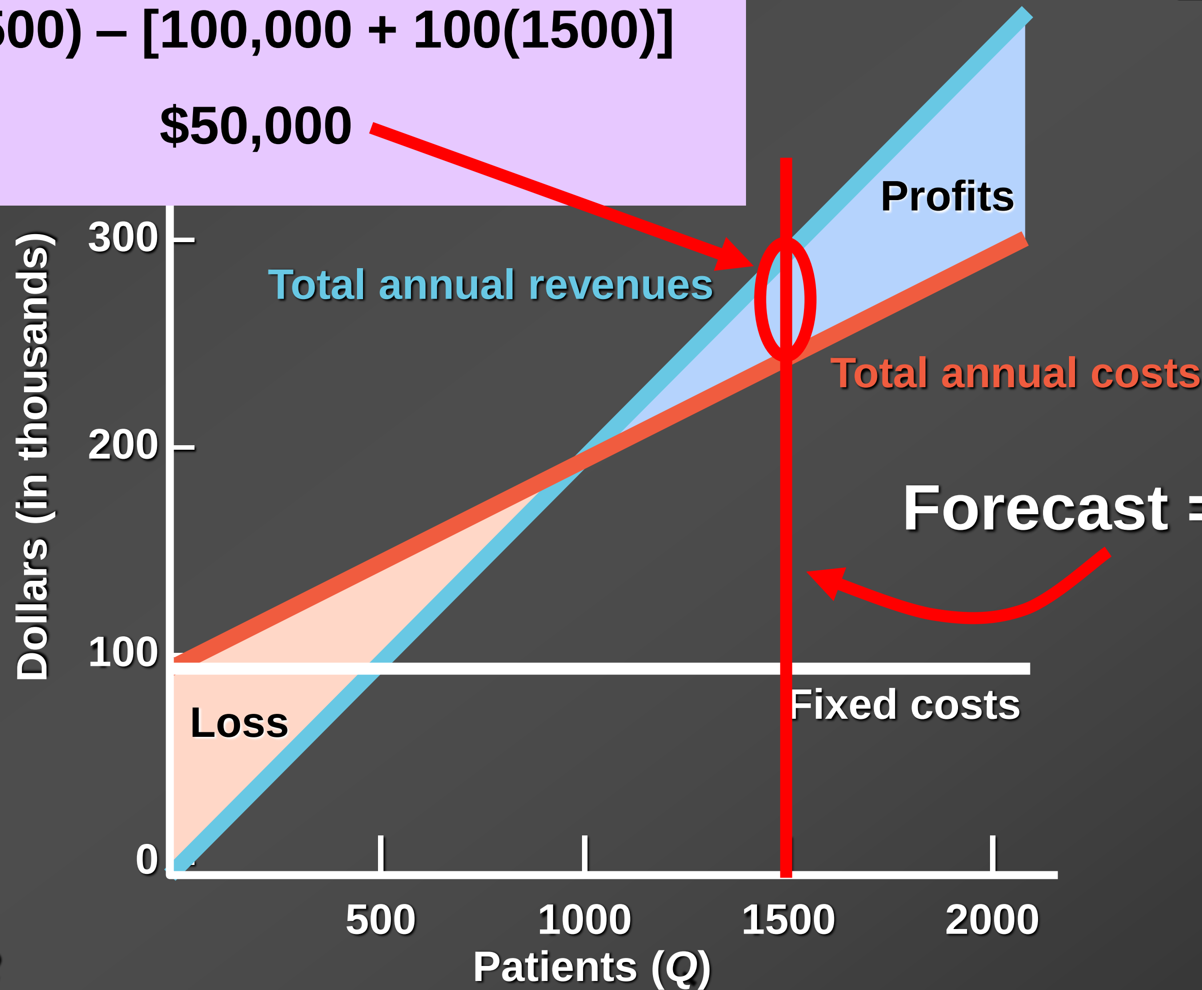
Example A.2

Sensitivity Analysis

$$pQ - (F + cQ)$$

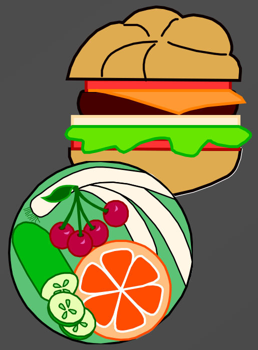
$$200(1500) - [100{,}000 + 100(1500)]$$

$$\$50{,}000$$



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

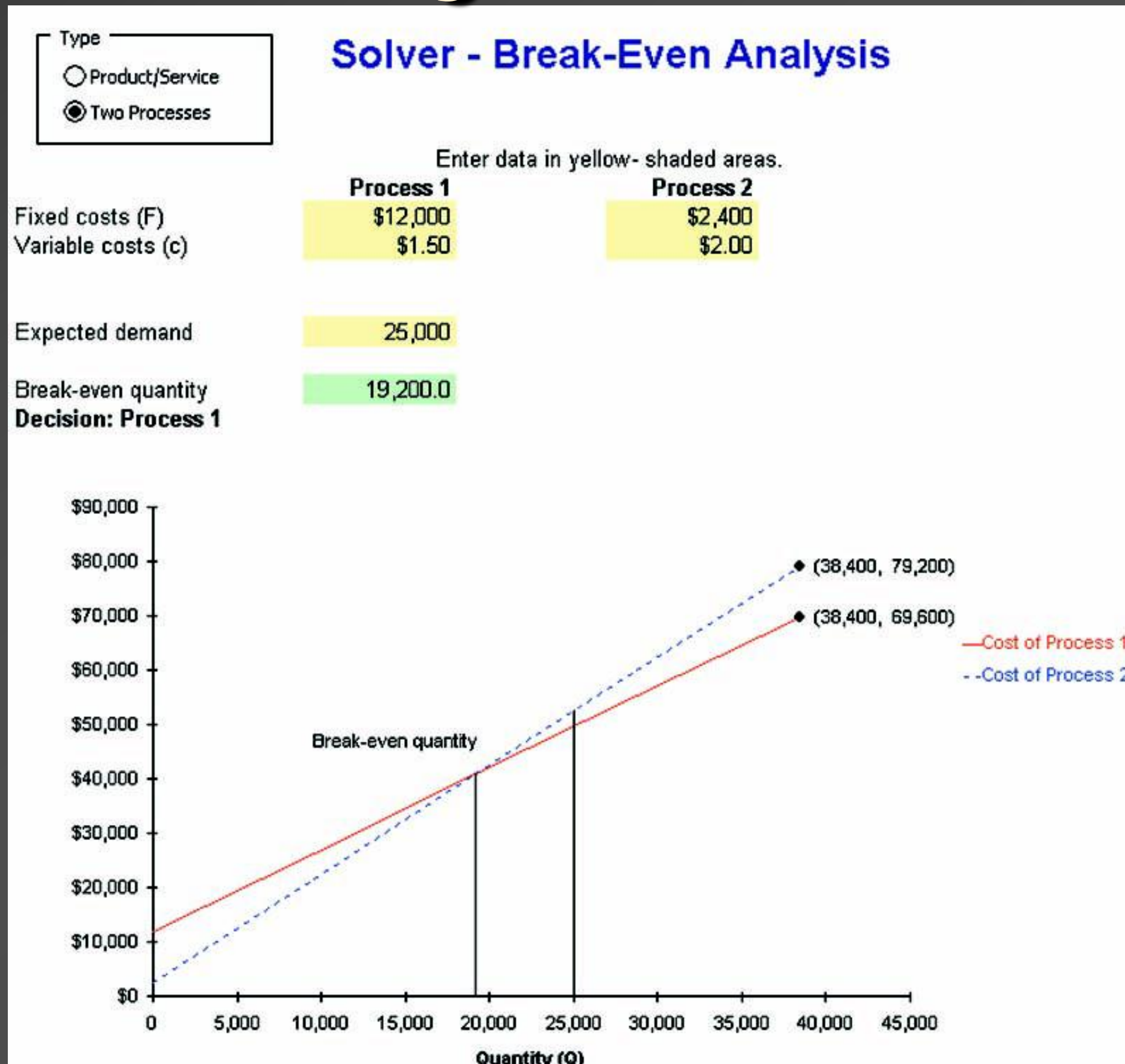
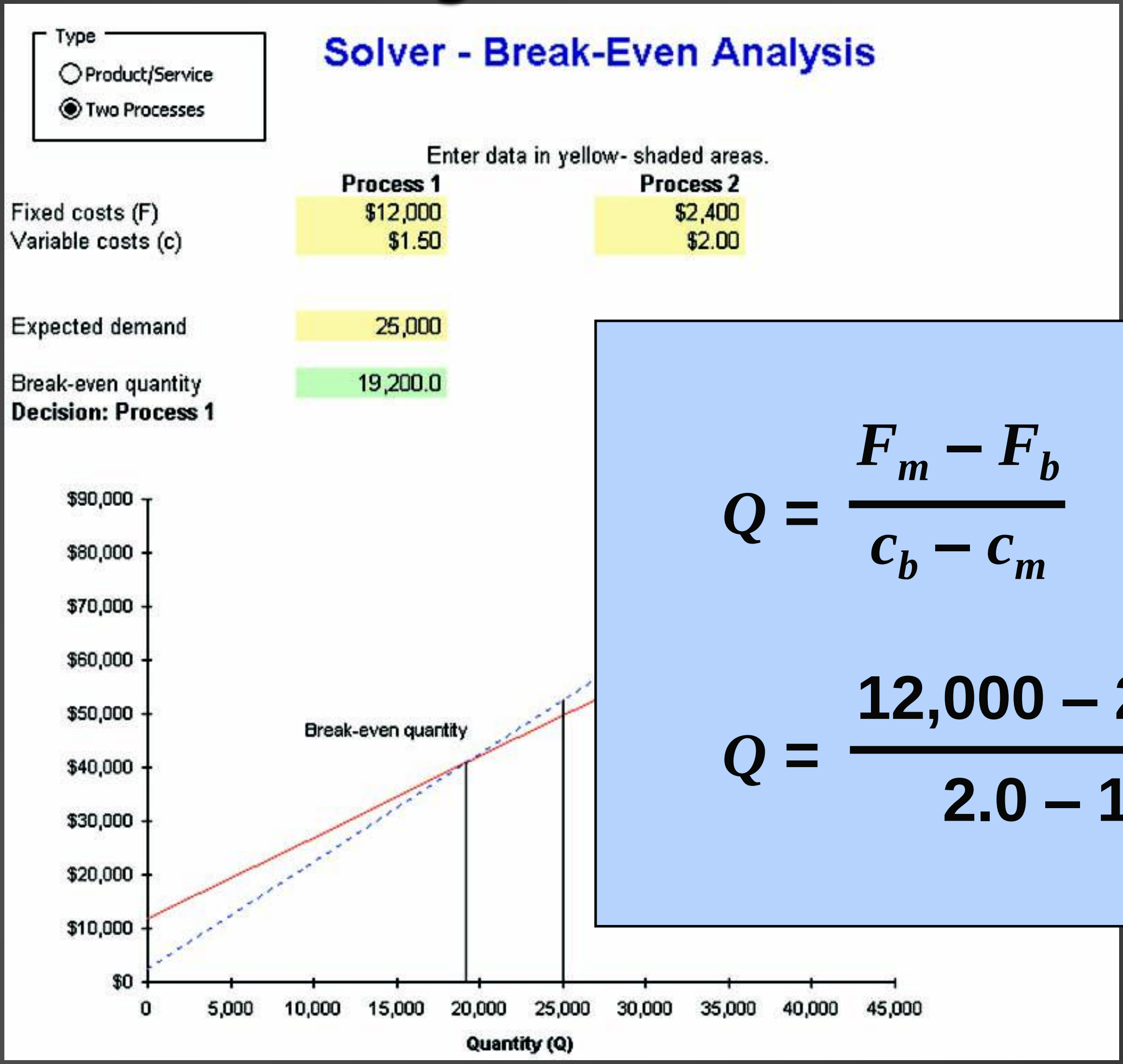


Figure A.2

Make-or-Buy Decisions

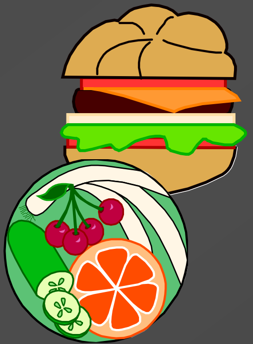


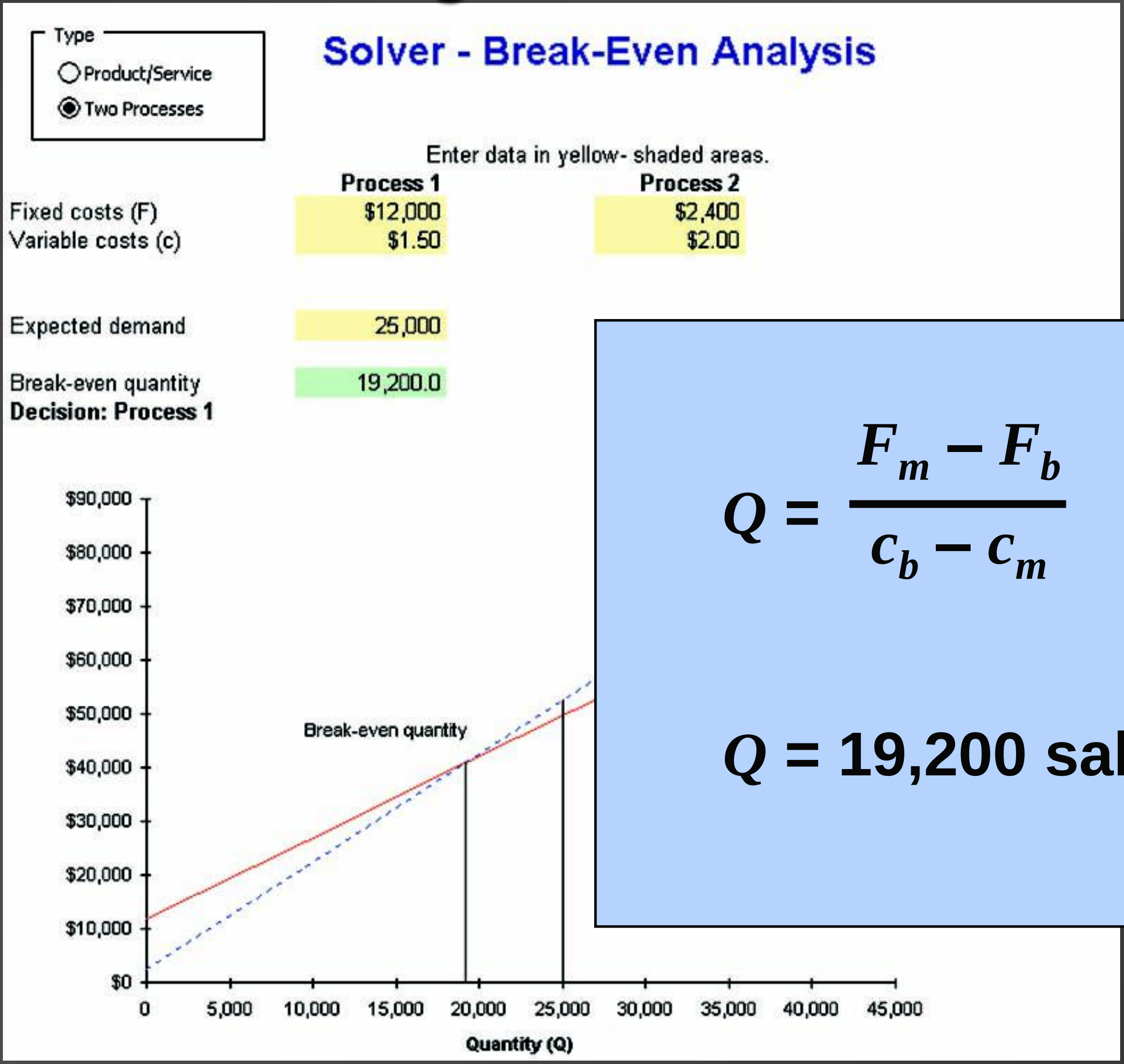
$$Q = \frac{F_m - F_b}{c_b - c_m}$$

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

Example A.3

Make-or-Buy Decisions



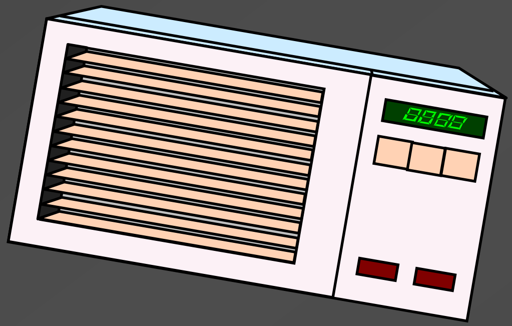


$$Q = \frac{F_m - F_b}{c_b - c_m}$$

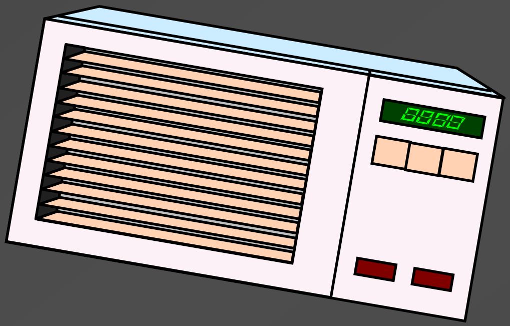
Q = 19,200 salads

Example A.3

Preference Matrix



Preference Matrix

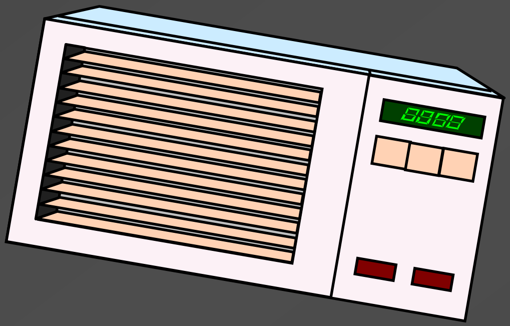


Threshold score **= 800**

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

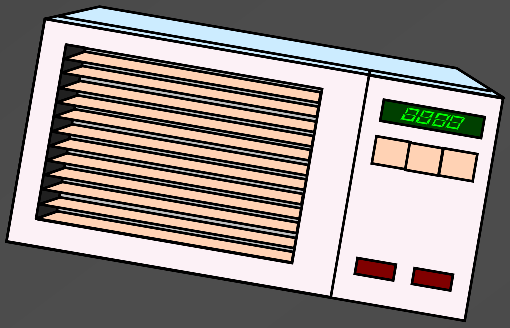


Threshold score **= 800**

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

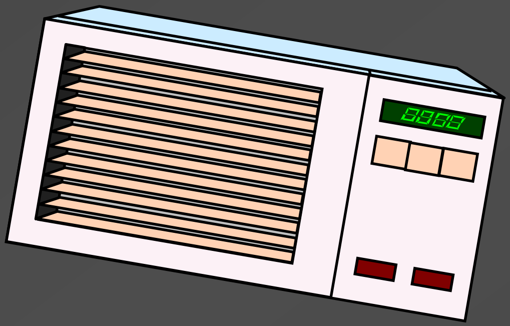


***Threshold score* = 800**

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

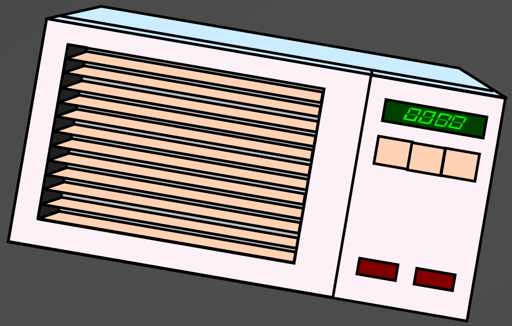


***Threshold score* = 800**

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

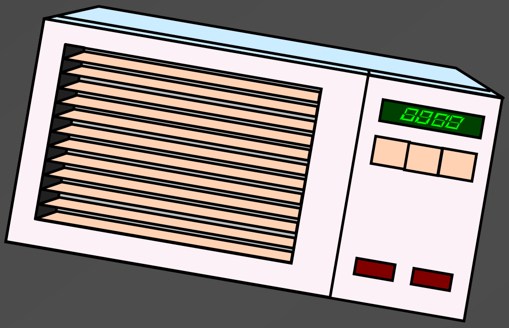


Threshold score = 800

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

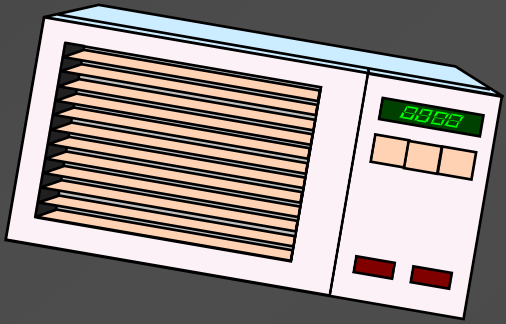
Performance Criterion	Weight (*A*)	Score (*B*)	Weighted Score (*A* x *B*)
Market potential	30	8	240
Unit profit margin	20	10	200
Operations compatibility	20	6	120
Competitive advantage	15	10	150
Investment requirement	10	2	20
Project risk	5	4	20

Weighted score = 750

< 800

Example A.4

Preference Matrix



Threshold score = 800

Performance Criterion	Weight (*A*)	Score (*B*)	Weighted Score (*A* × *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

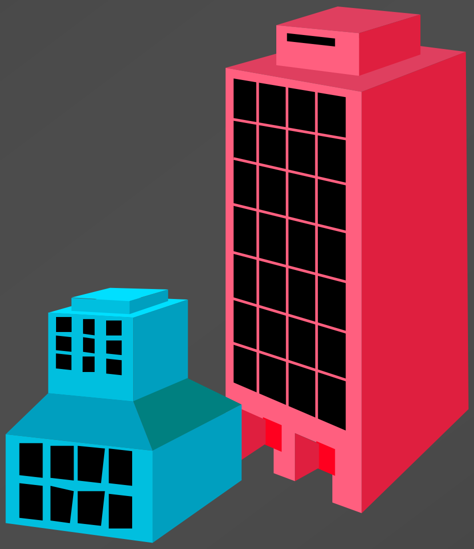
Not At This Time

Example A.4

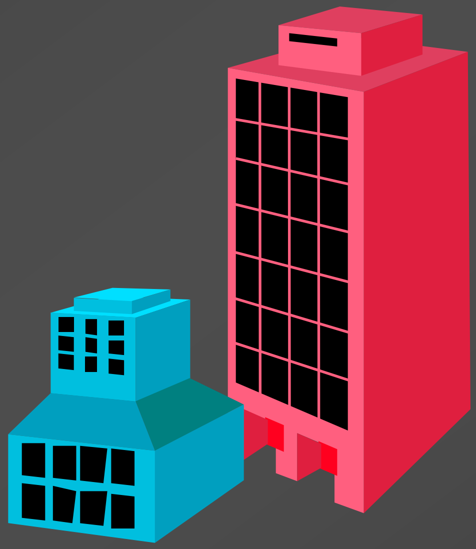
3- decision theory

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

Under Certainty



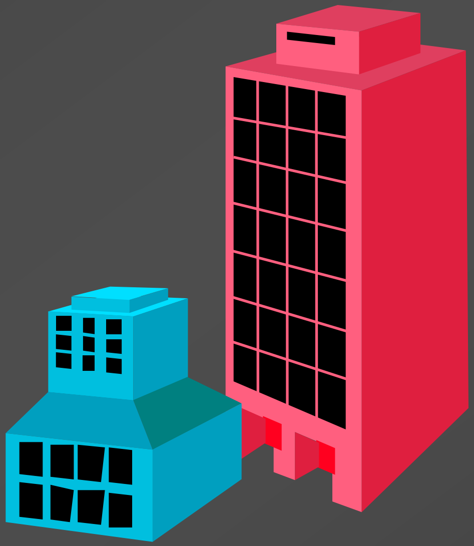
Under Certainty



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

Example A.5

Under Certainty

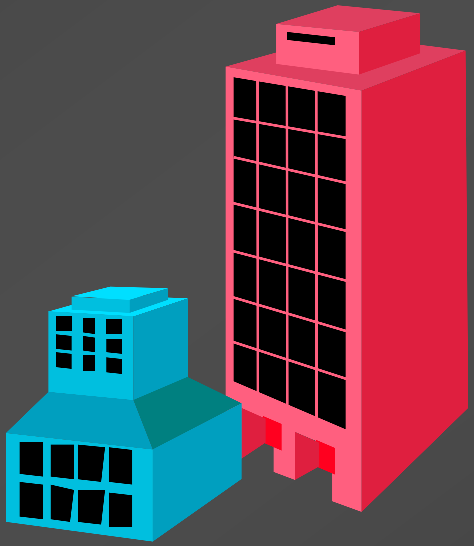


Alternative	Possible Future Demand Low	Possible Future Demand High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

If future demand will be low –

Example A.5

Under Certainty

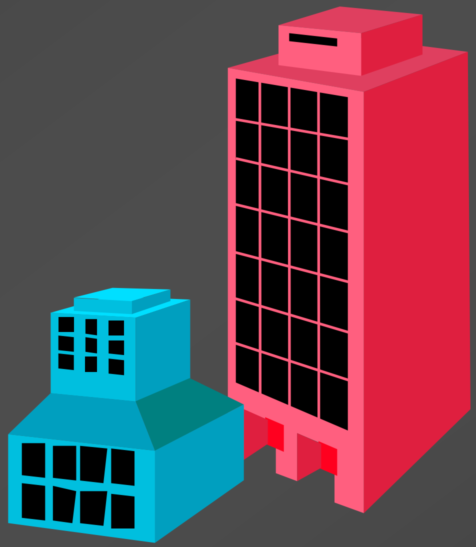


Alternative	Possible Future Demand: Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

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

Example A.5

Under Certainty



Alternative	Possible Future Demand Low	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

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

Example A.6

Under Uncertainty

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

Maximin – Small

Best of the worst

Example A.6

Under Uncertainty

	Possible Future Demand	
Alternative	**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

	Possible Future Demand	
Alternative	**Low**	**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	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

	Possible Future Demand	
Alternative	**Low**	**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

	Possible Future Demand	
Alternative	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	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	High Demand
Small facility	200 – 200 = 0	800 – 270 = 530
Large facility	200 – 160 = 40	800 – 800 = 0

Best worst regret

Example A.6

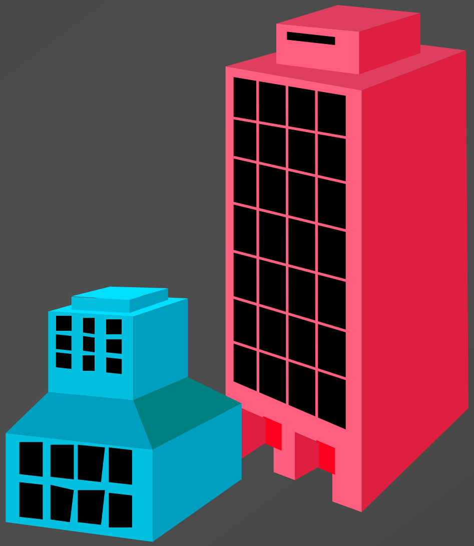
Under Uncertainty

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



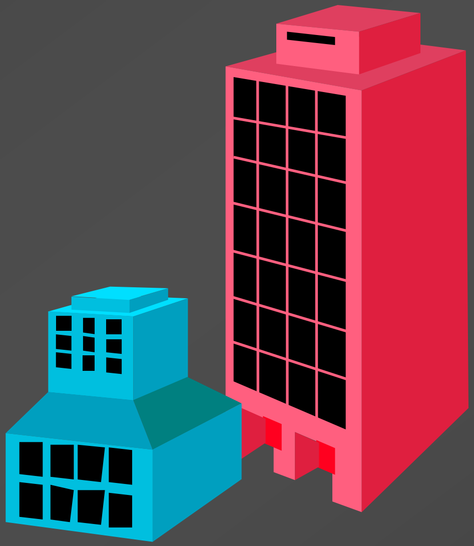
	Possible Future Demand	
Alternative	**Low**	**High**
Small facility	200	270
Large facility	160	800
Do nothing	0	0

$P_{small} = 0.4$

$P_{large} = 0.6$

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

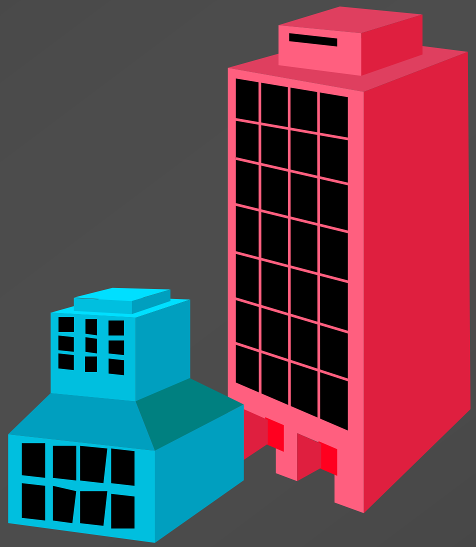
$P_{\text{small}} = 0.4$

$P_{\text{large}} = 0.6$

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

Example A.7

Under Risk



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

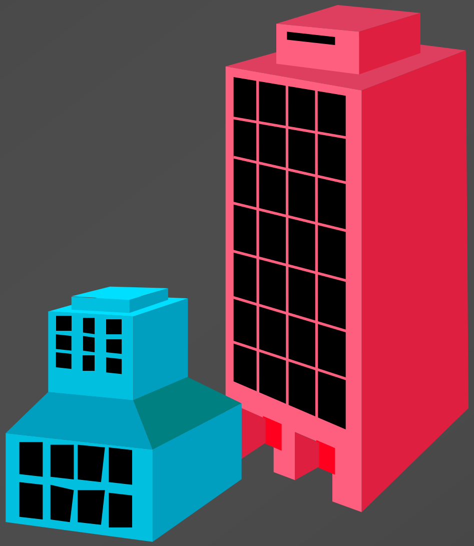
$P_{\text{small}} = 0.4$

$P_{\text{large}} = 0.6$

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

$P_{\text{small}} = 0.4$

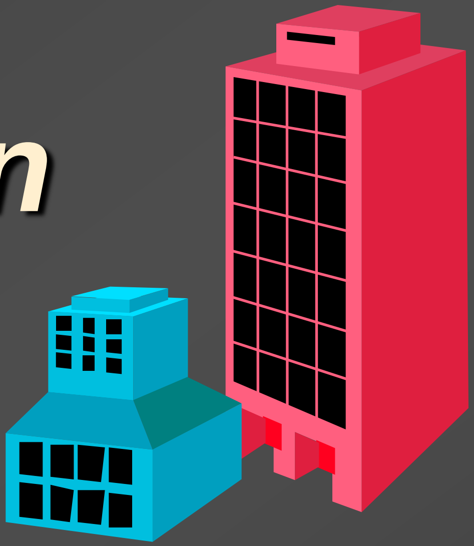
$P_{\text{large}} = 0.6$

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



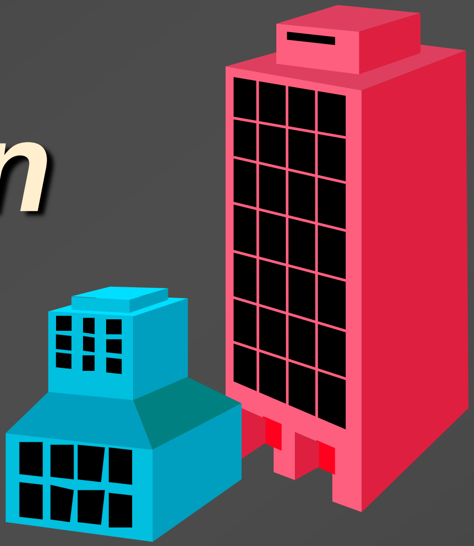
	Possible Future Demand	
Alternative	Low	High
Small facility	200	270
Large facility	160	800
Do nothing	0	0

$P_{\text{small}} = 0.4$

$P_{\text{large}} = 0.6$

Example A.8

Perfect Information



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

$P_{small} = 0.4$

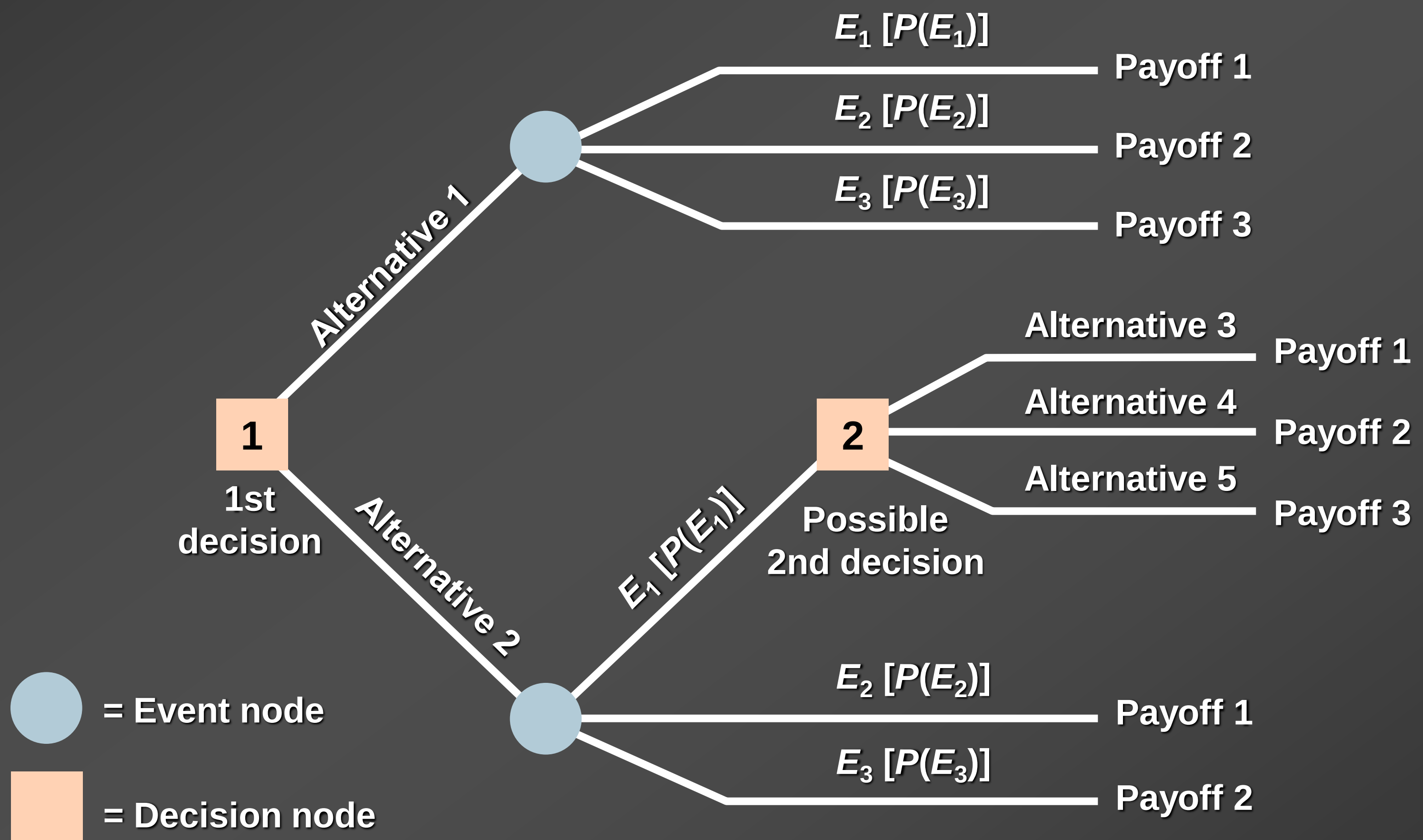
$P_{large} = 0.6$

Event	Best Payoff
Low demand	200
High demand	800

Example A.8

Decision Trees

Decision Trees

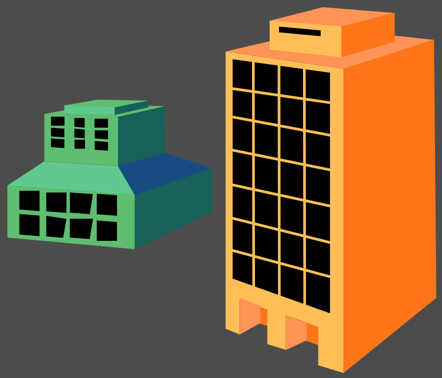


E_i = Event *i*

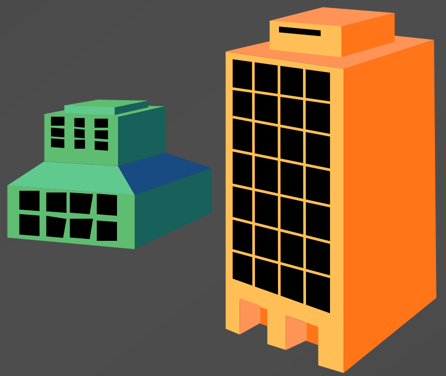
$P(E_i)$ = Probability of event *i*

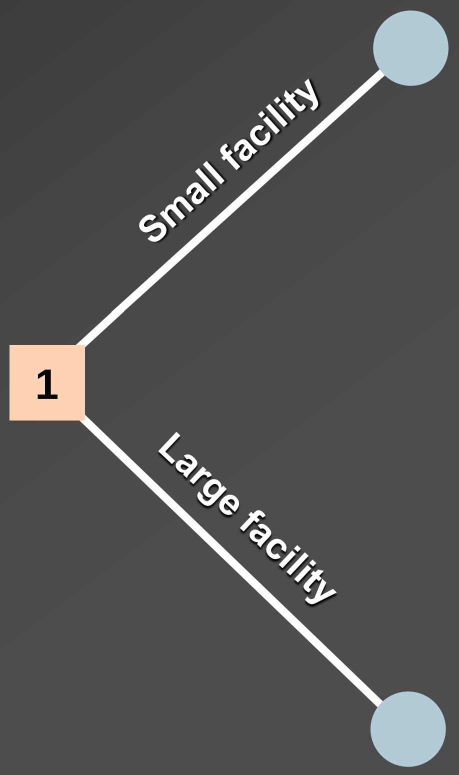
Figure A.5

Decision Trees



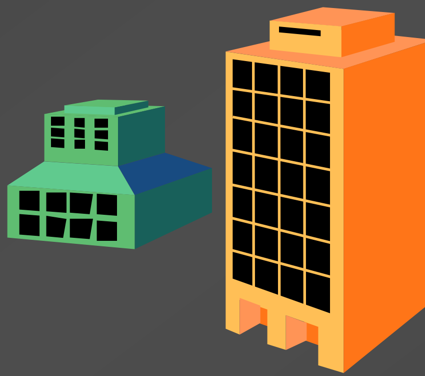
Decision Trees

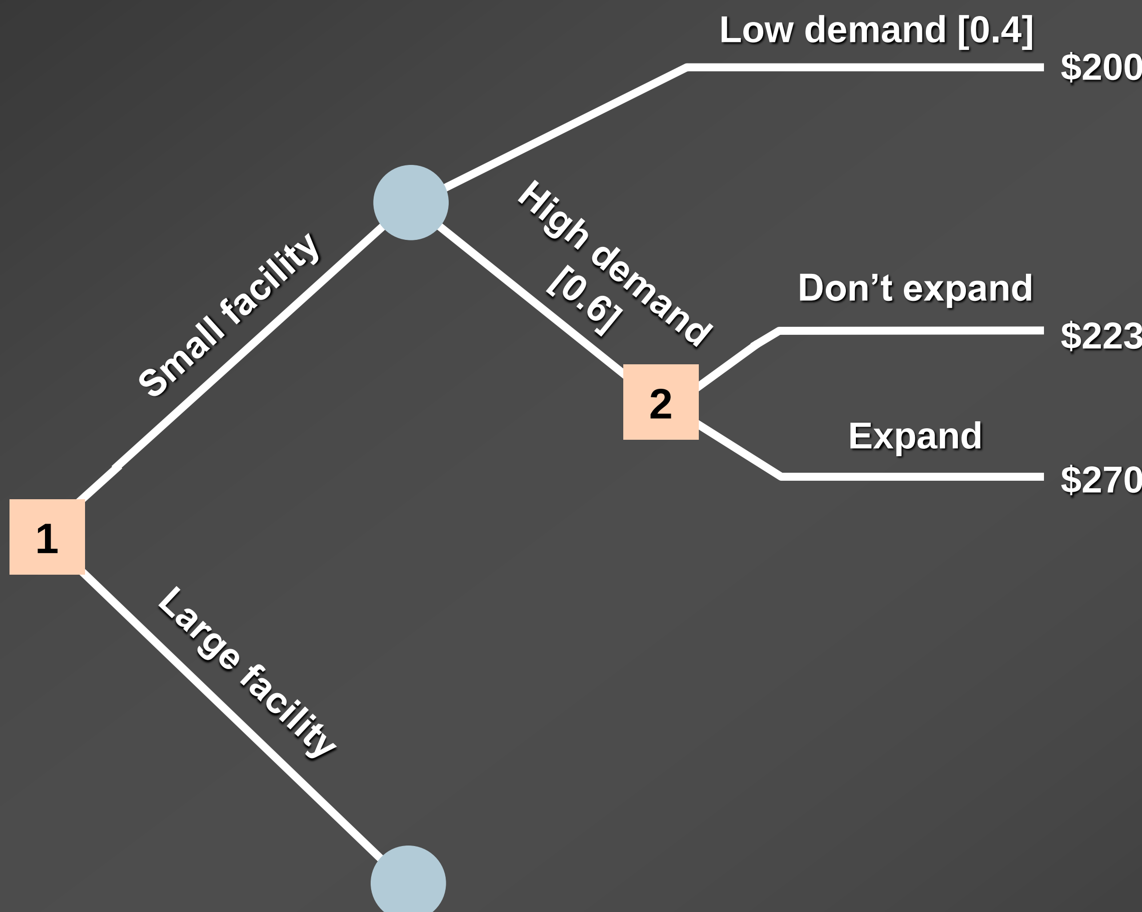




Example A.9

Decision Trees





Example A.9

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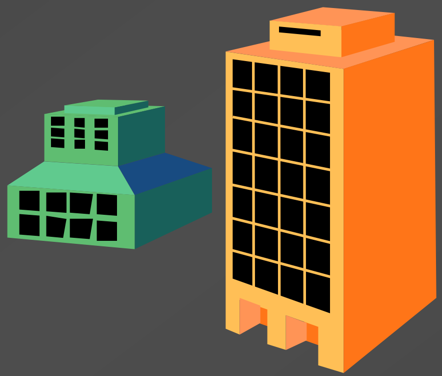

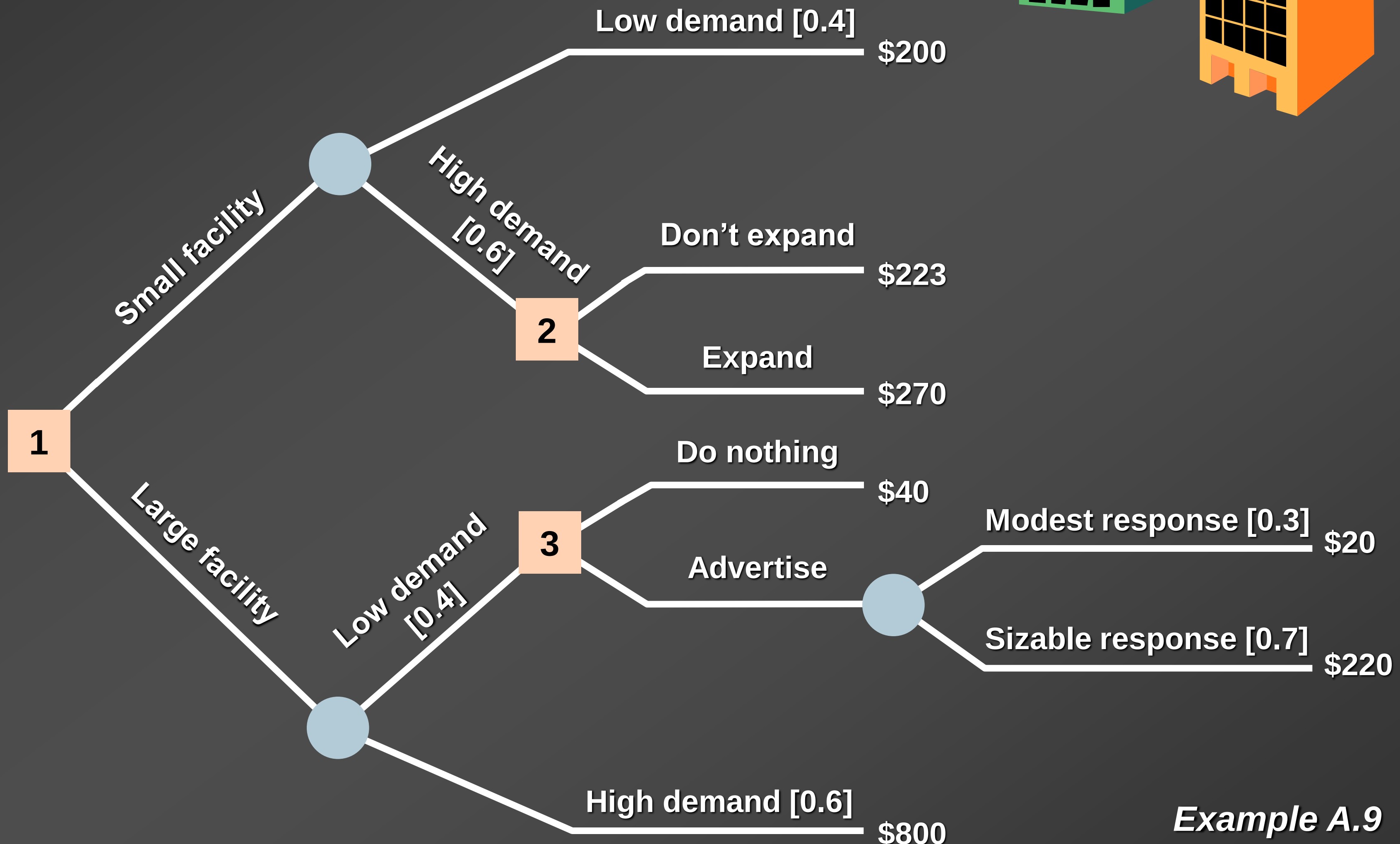

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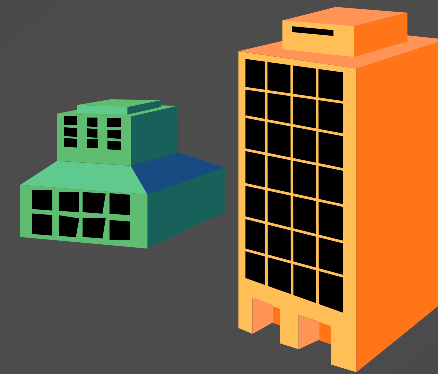

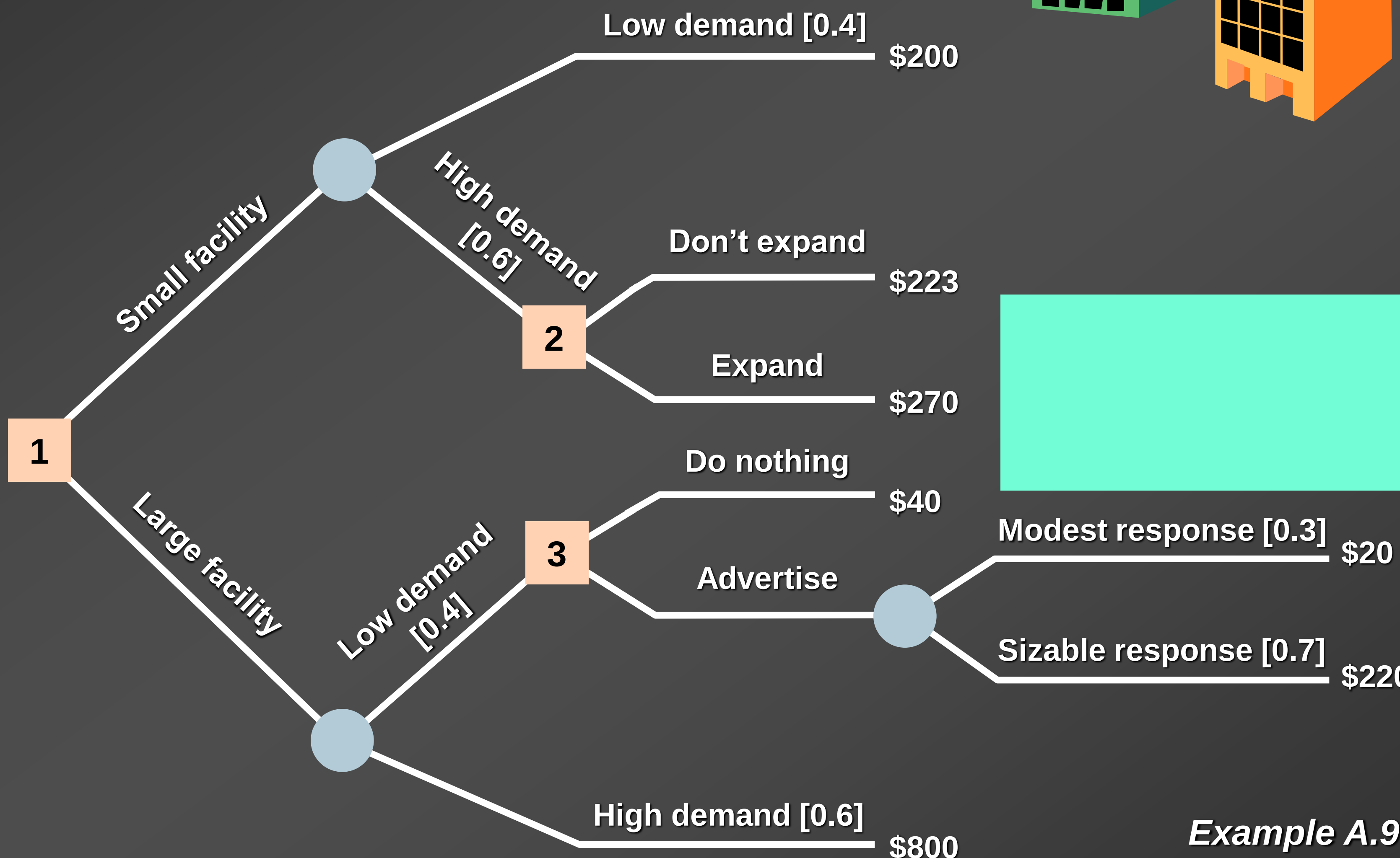

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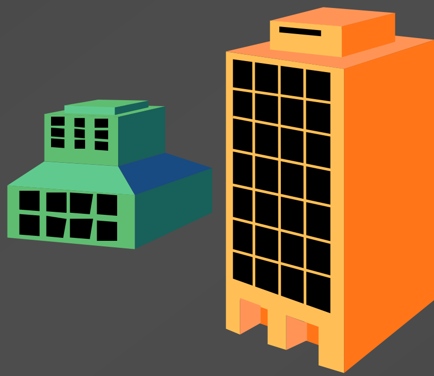

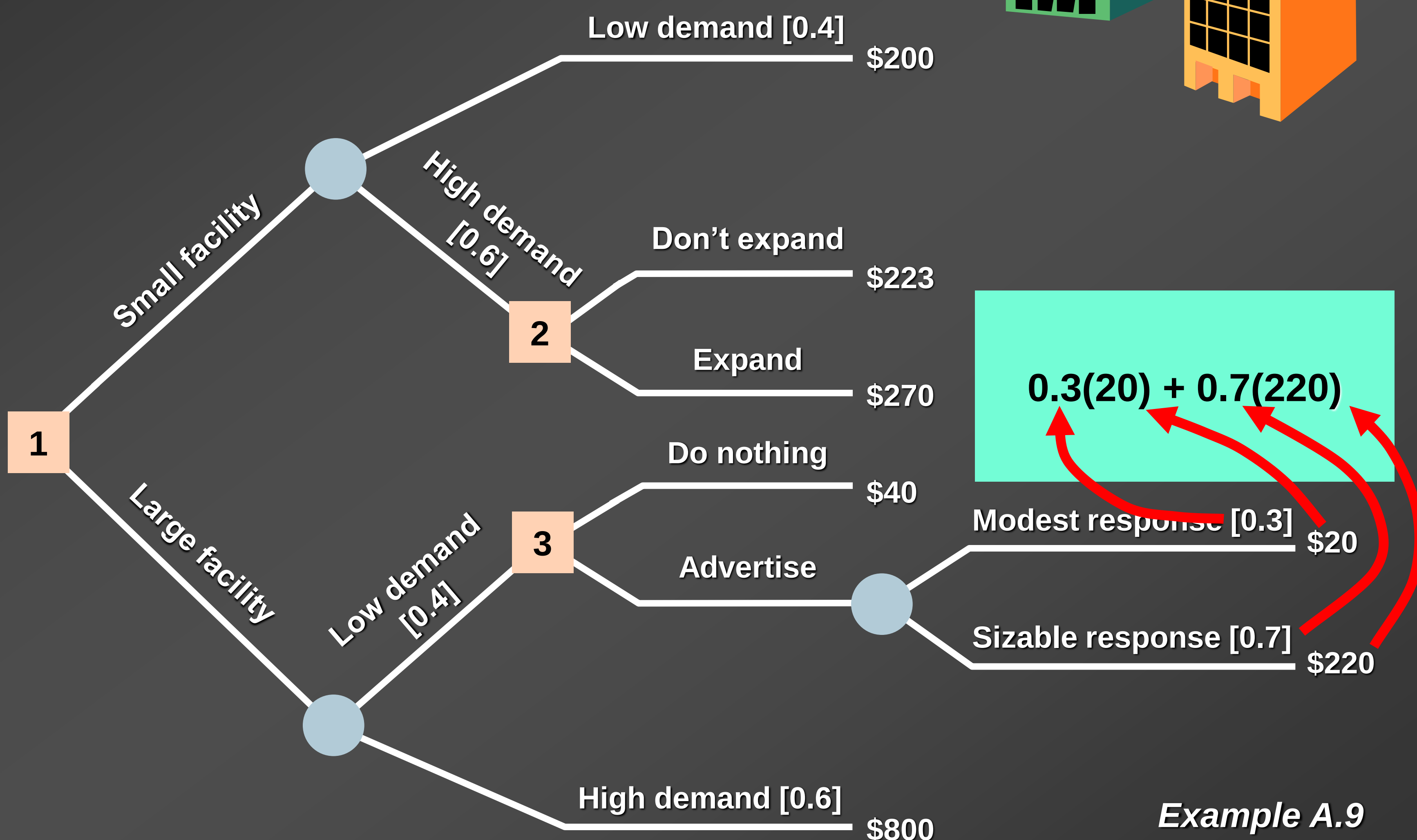

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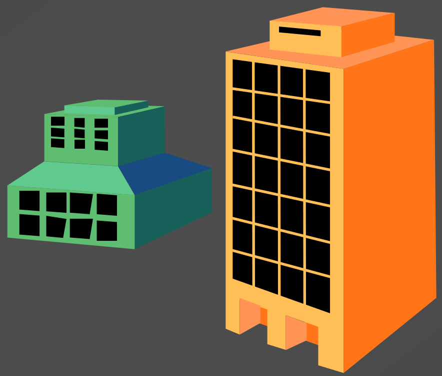

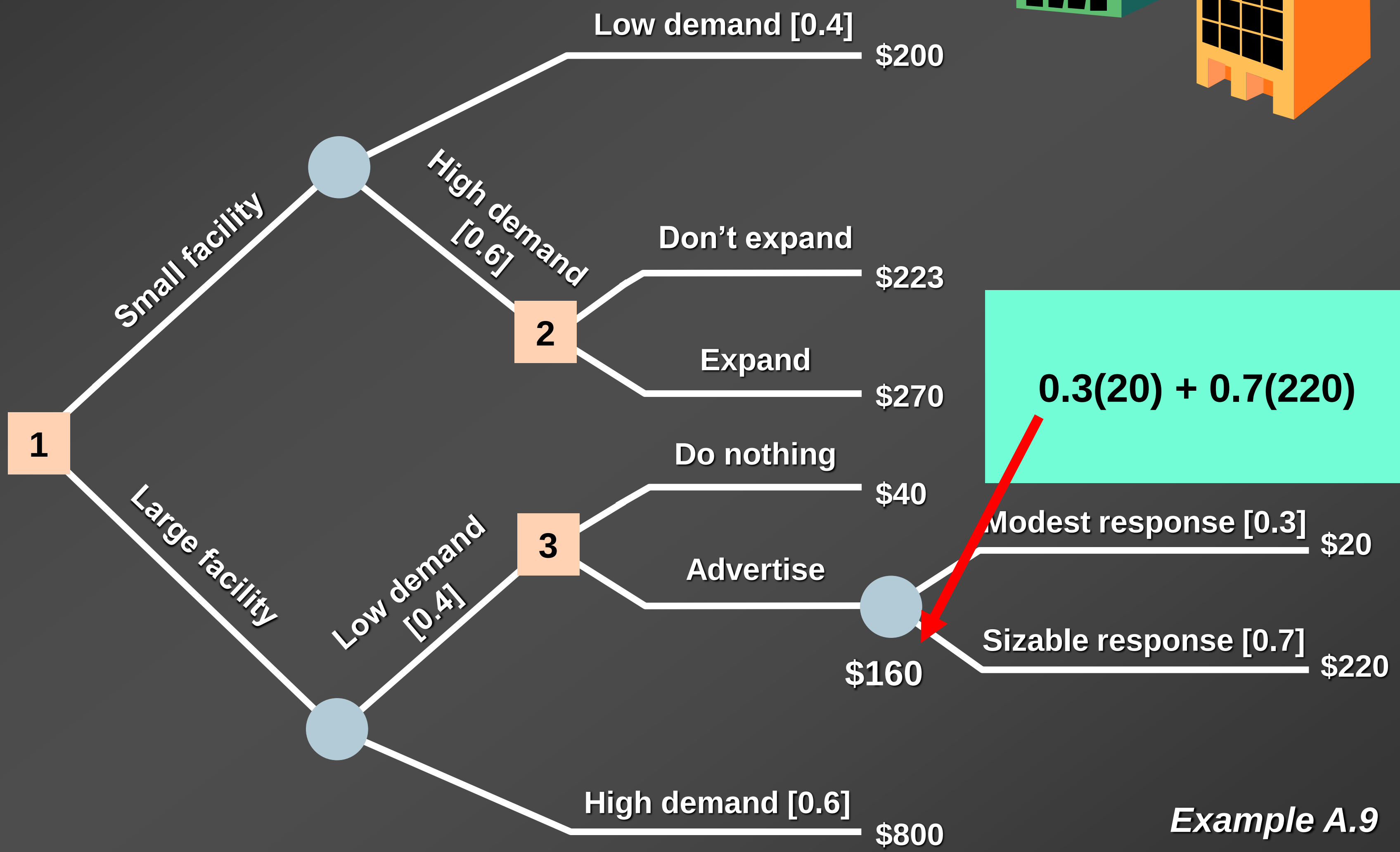

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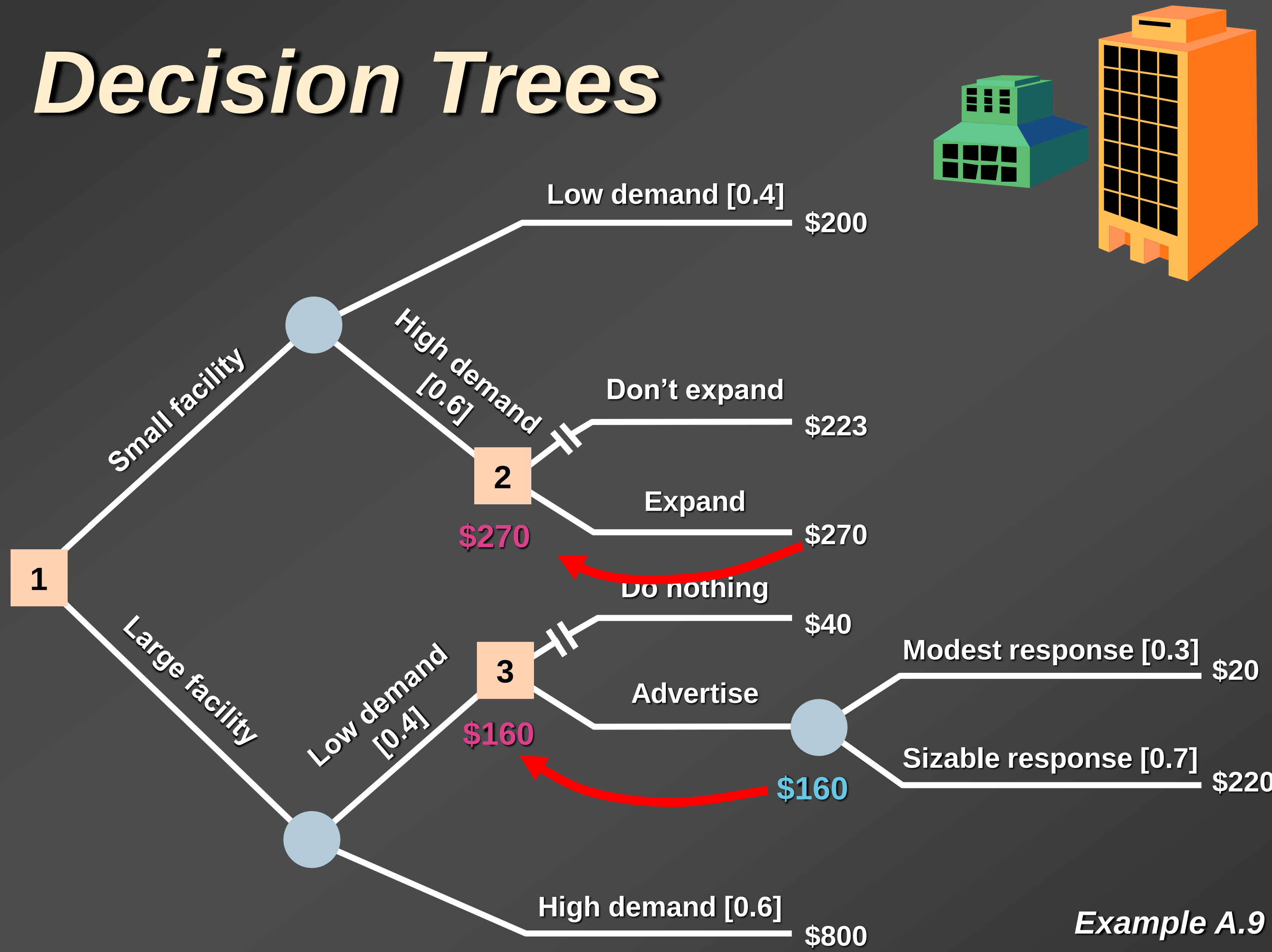

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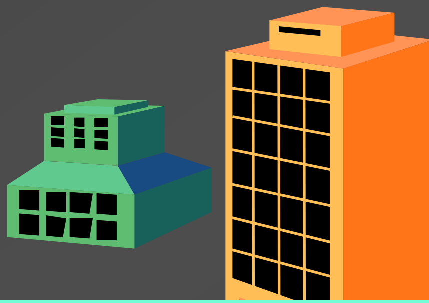

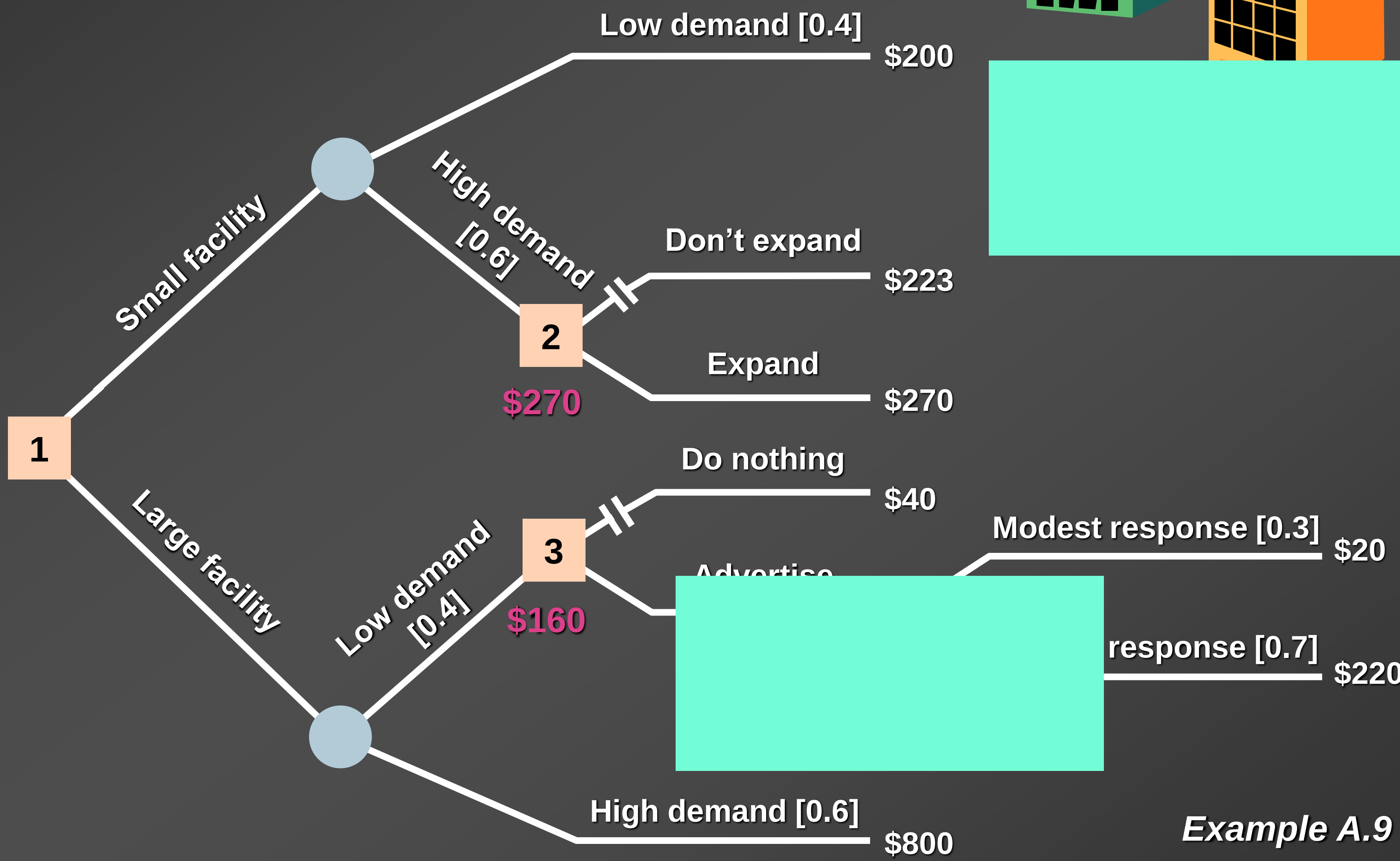

Example A.9

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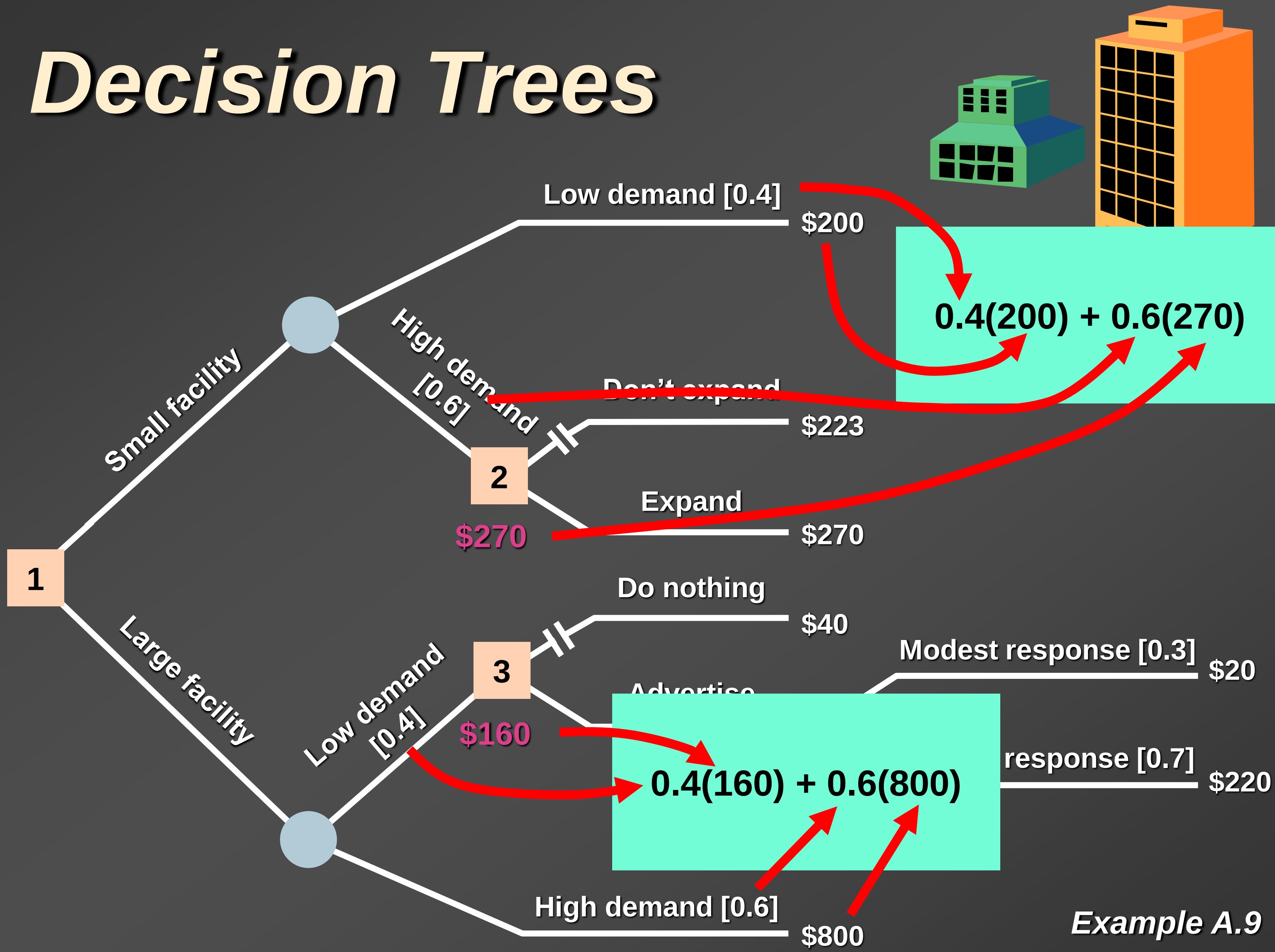

Example A.9

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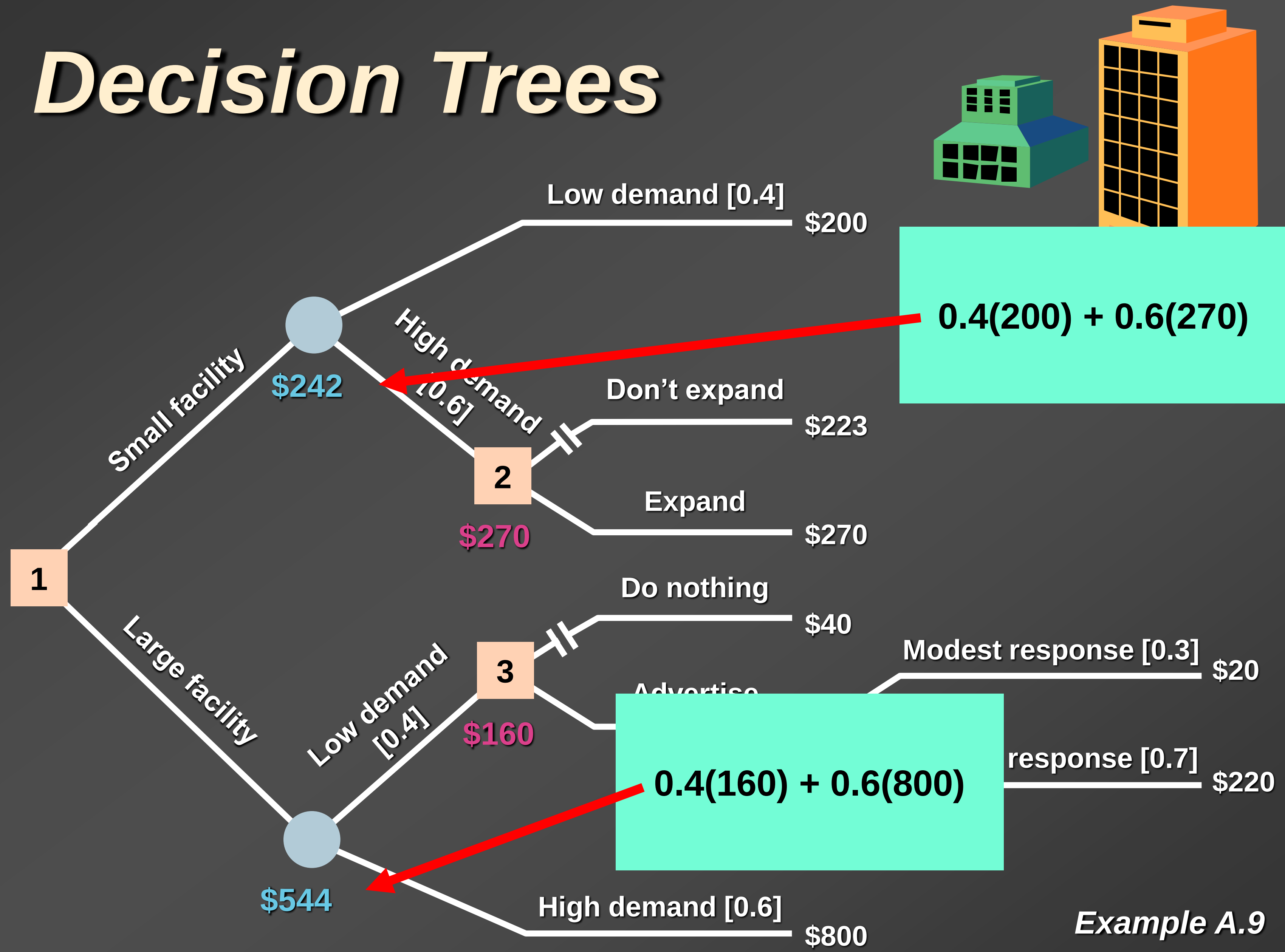

Example A.9

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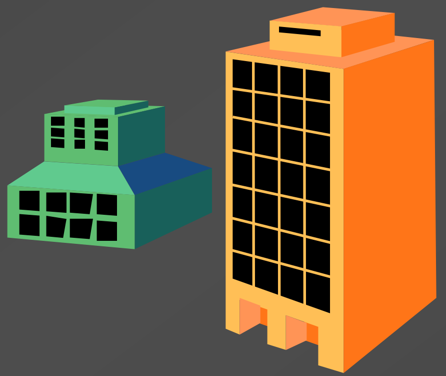
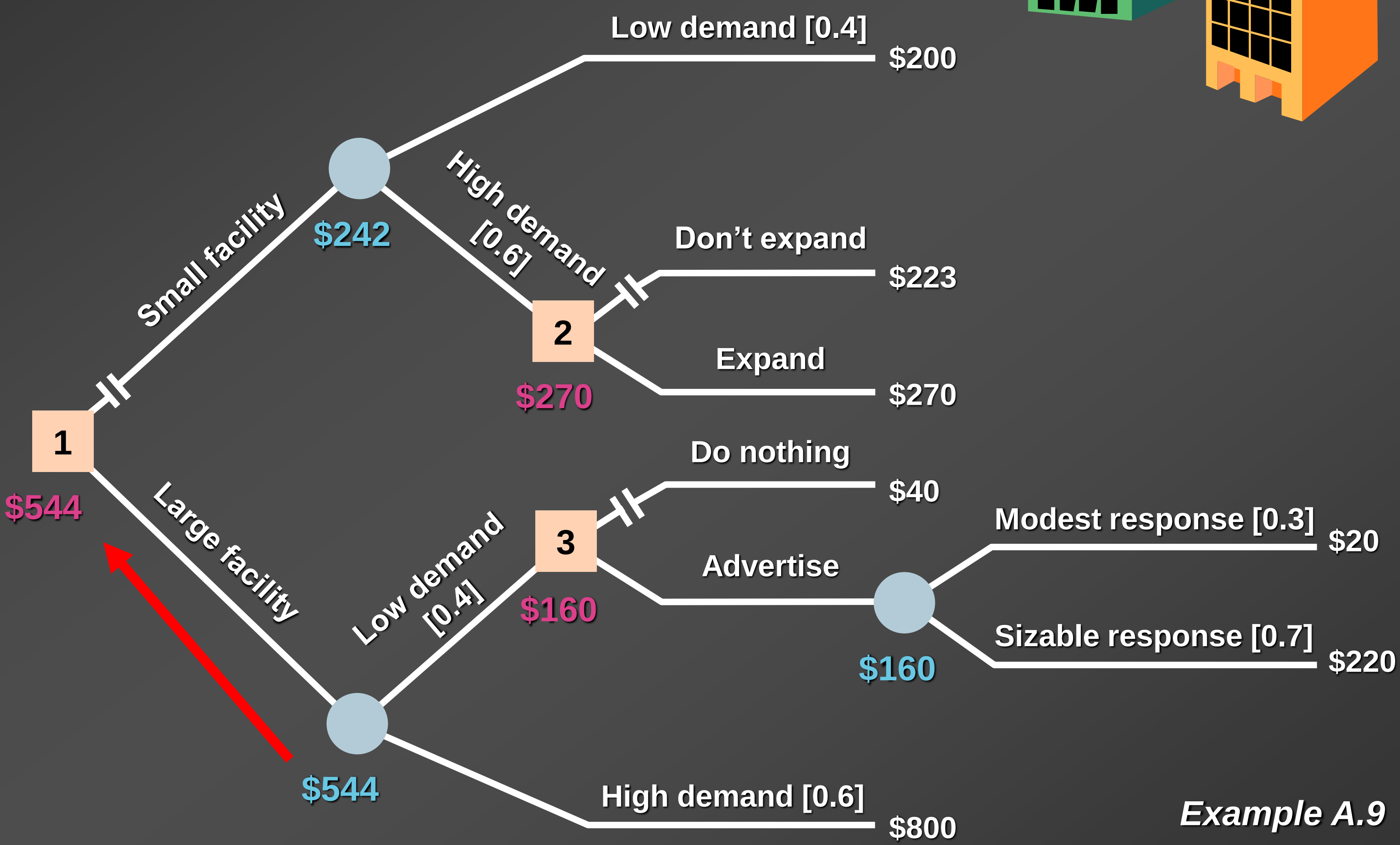




Example A.9

Decision Trees

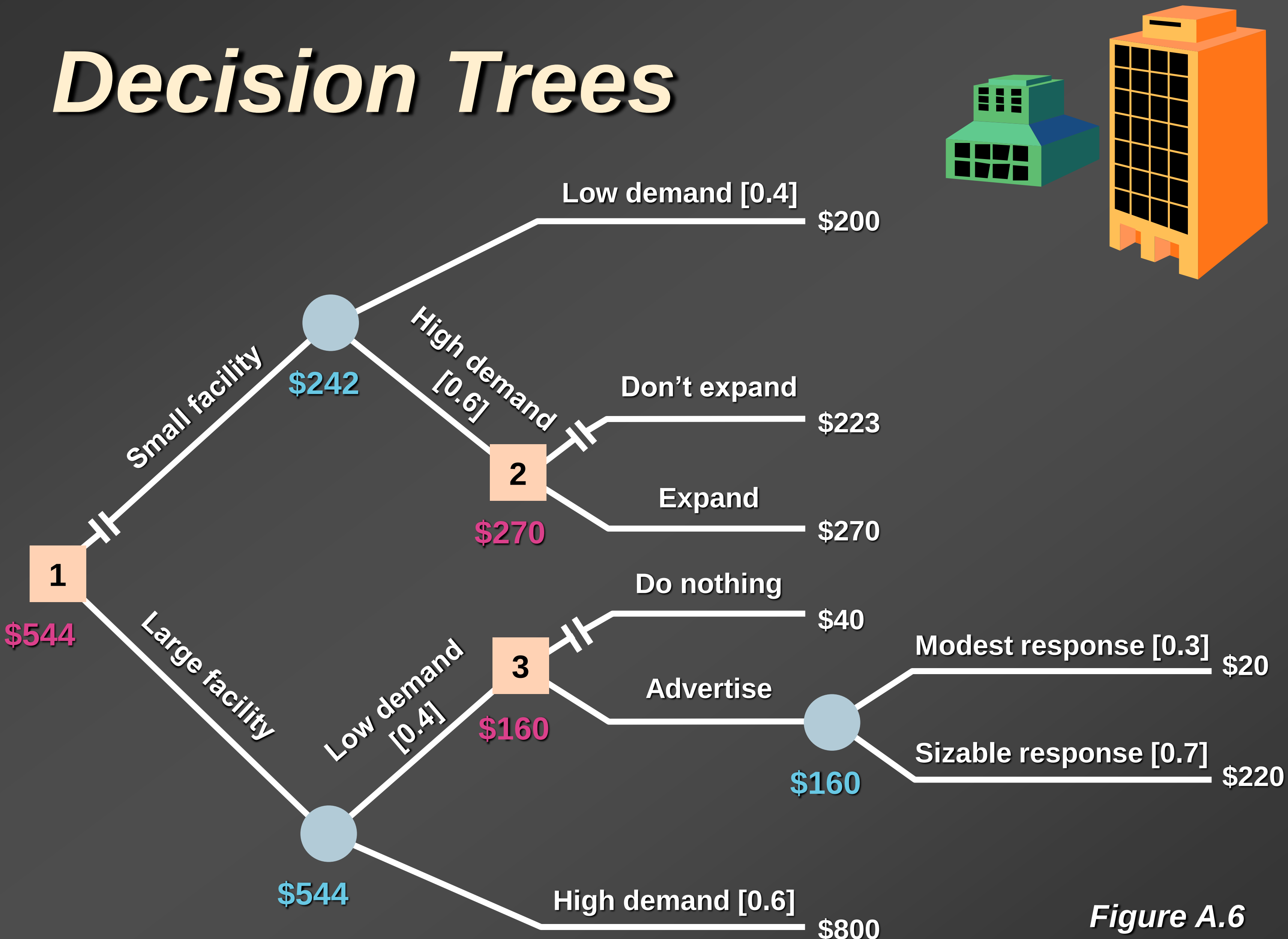


Figure A.6

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

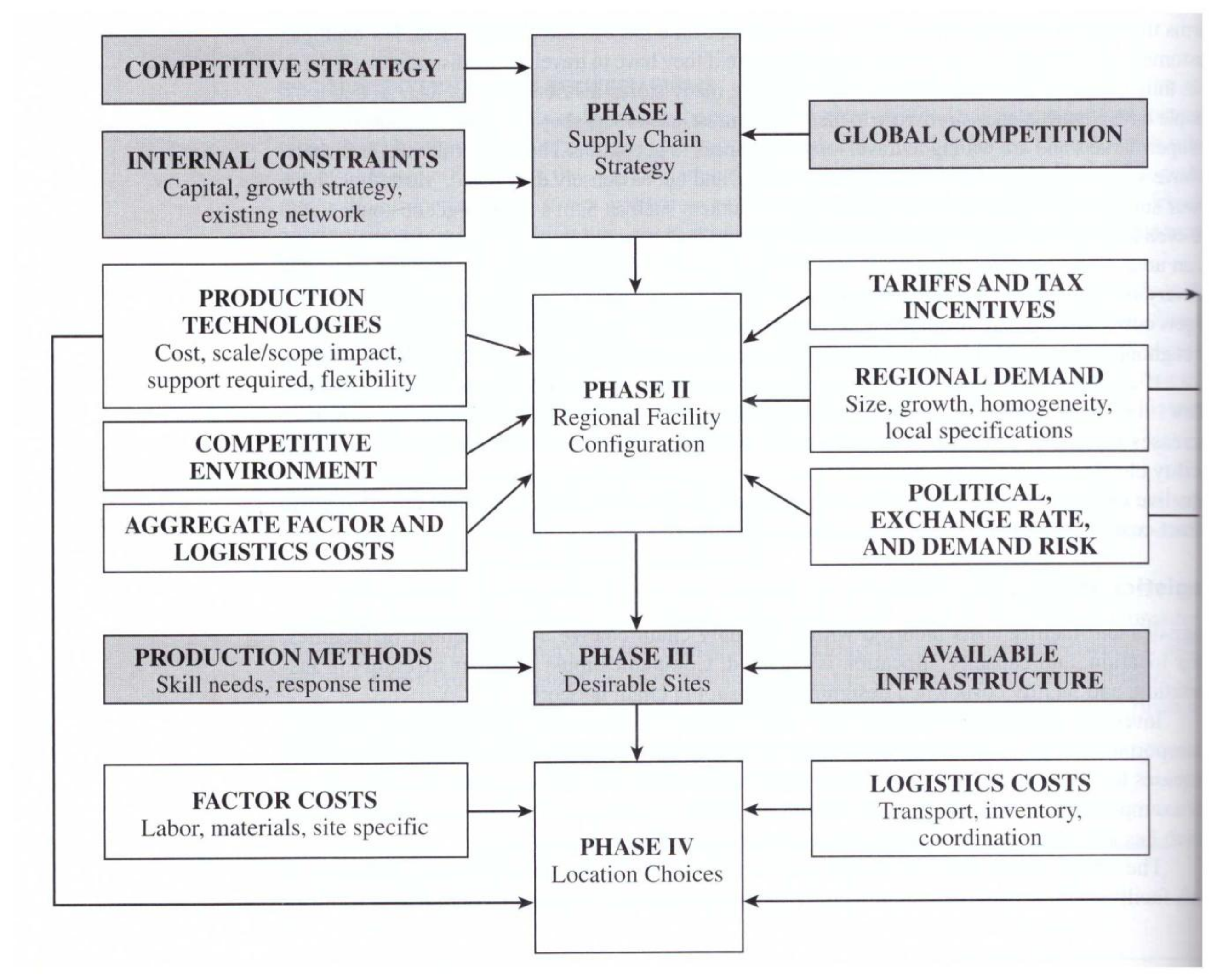
- ***Average of x becomes***

  sum of xi.Qi / sum Qi

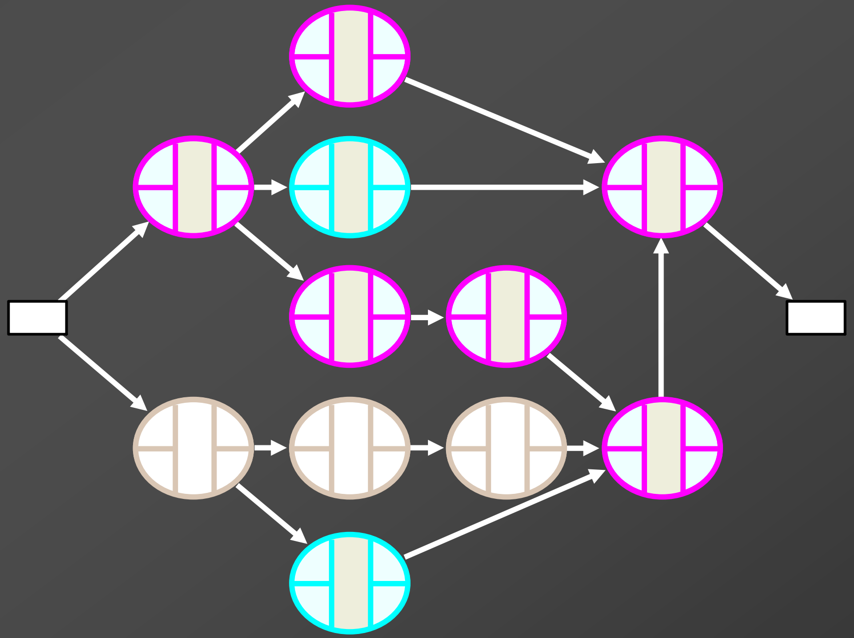
- ***Average of y becomes***

  sum of yi.Qi/sum Qi

NETWORK DESIGN DECISIONS



Planning and Managing Projects



Activity Relationships

Activity Relationship

AOA	AON

Activity on Arc

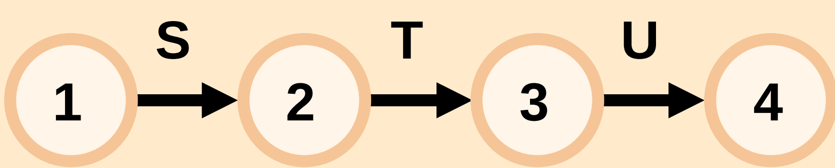
Activity on Network

Activity Relationships

Activity Relationship

S precedes T, which precedes U.

AOA



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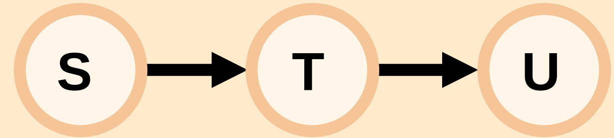

Activity on Arc

Activity on Network

Activity Relationships

Activity Relationship

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

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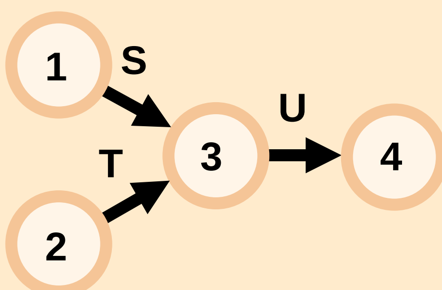
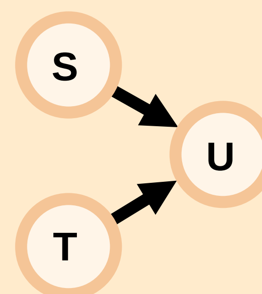
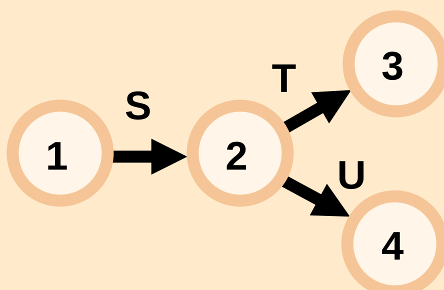
	

Activity Relationships

Activity Relationship

T and U cannot begin until S has been completed.

AOA



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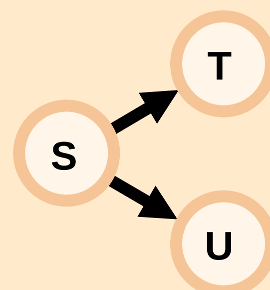

Activity Relationships

Activity Relationship

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

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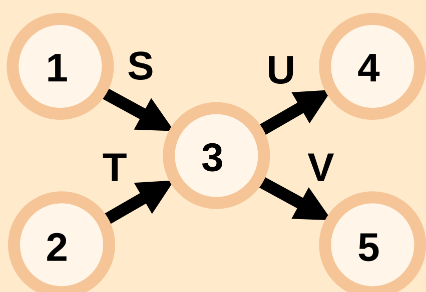	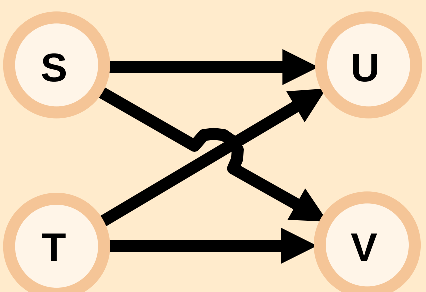

Activity Relationships

Activity Relationship

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

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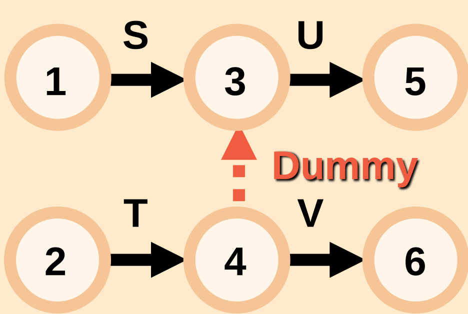
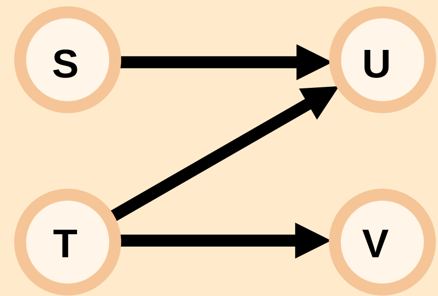
	

Activity Relationships

Activity Relationship

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

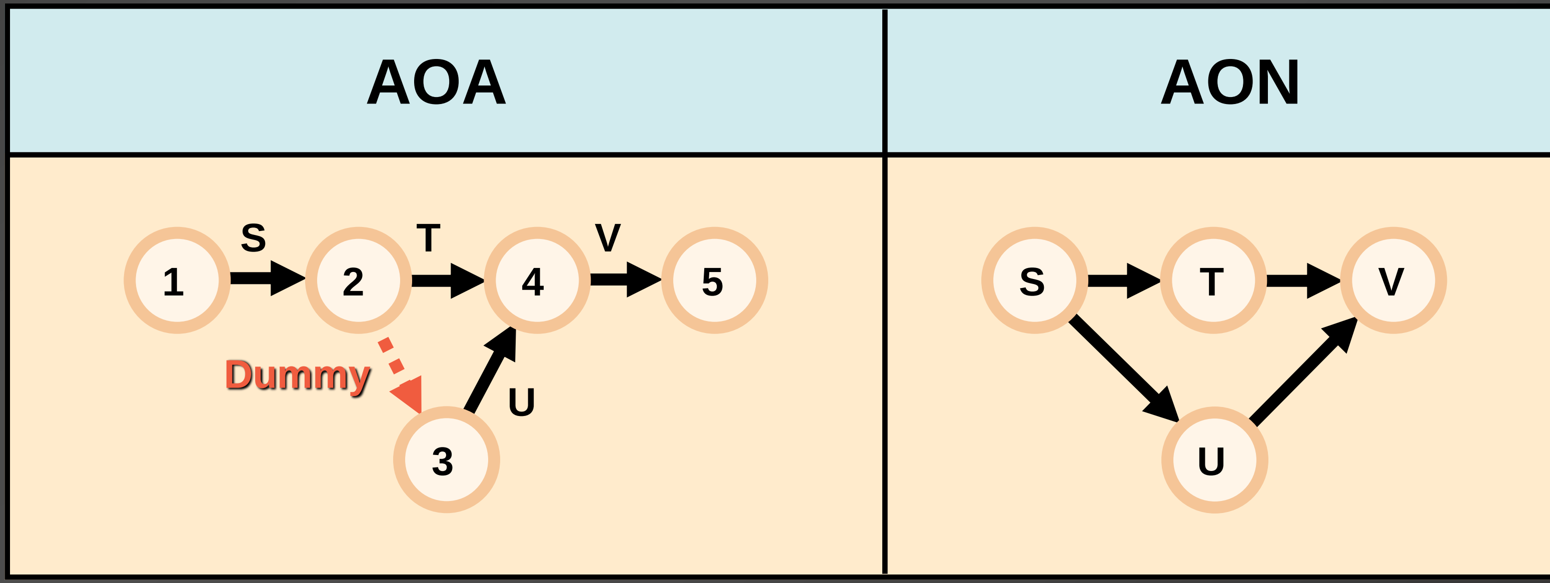
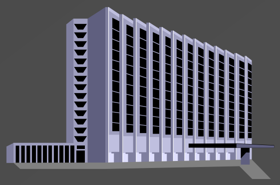
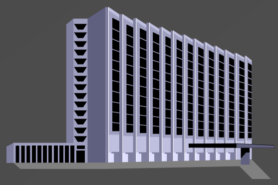


Figure 8.3

St. Adolf’s Hospital



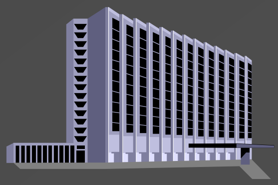
St. Adolf's Hospital



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.		

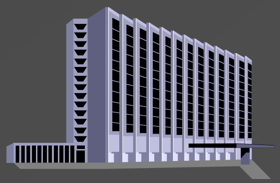
Example 8.1

St. Adolf's Hospital



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

St. Adolf’s Hospital



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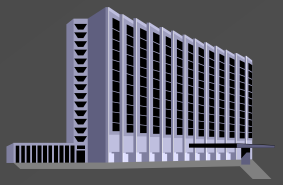

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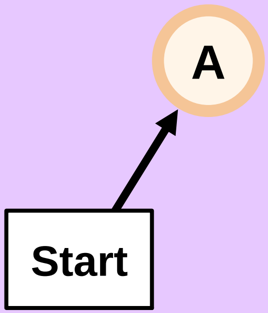

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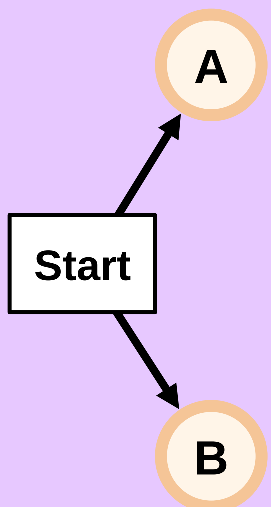

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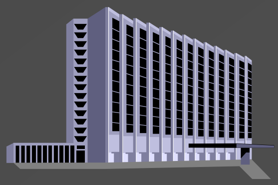

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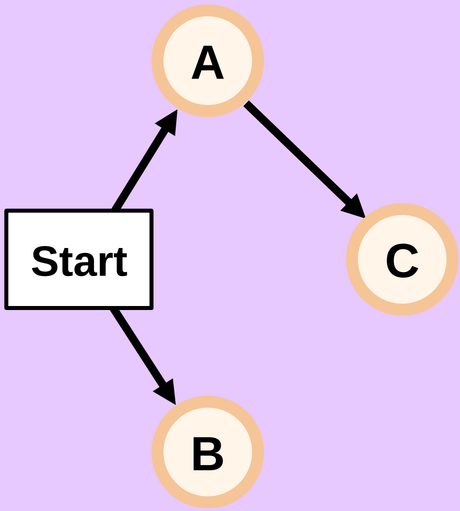

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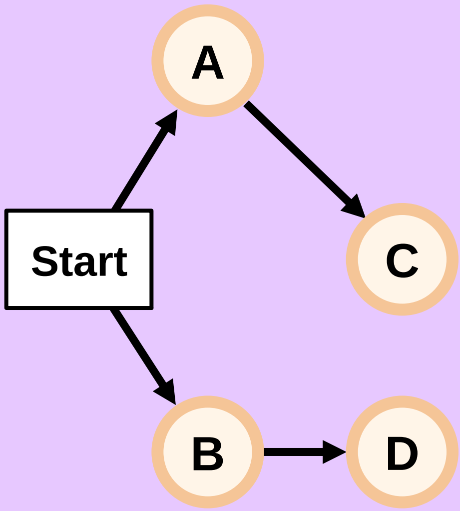

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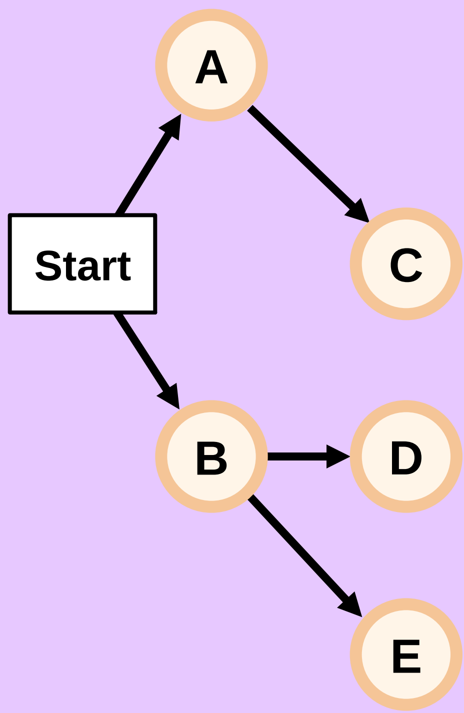

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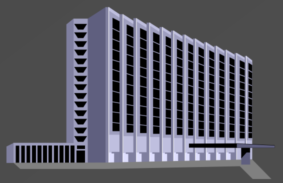

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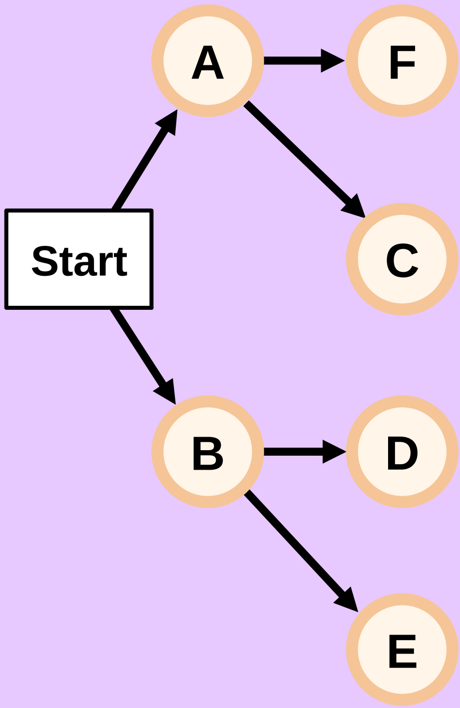

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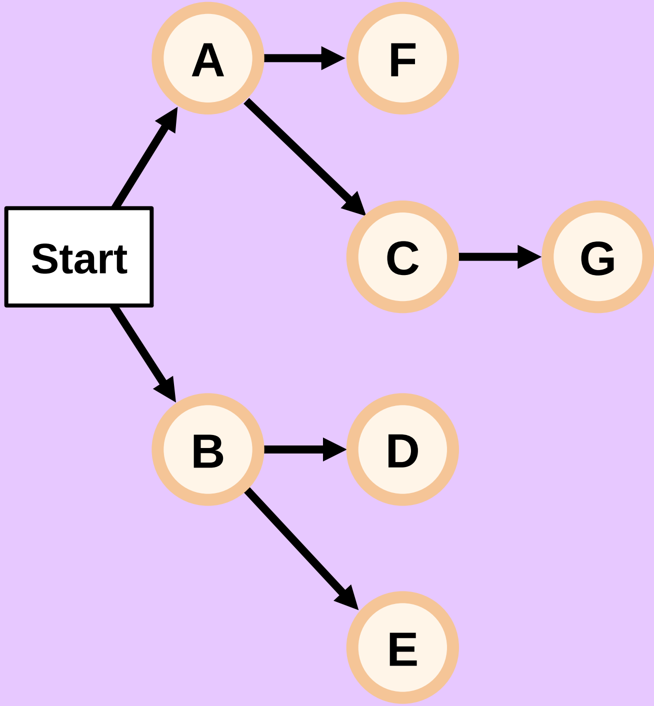

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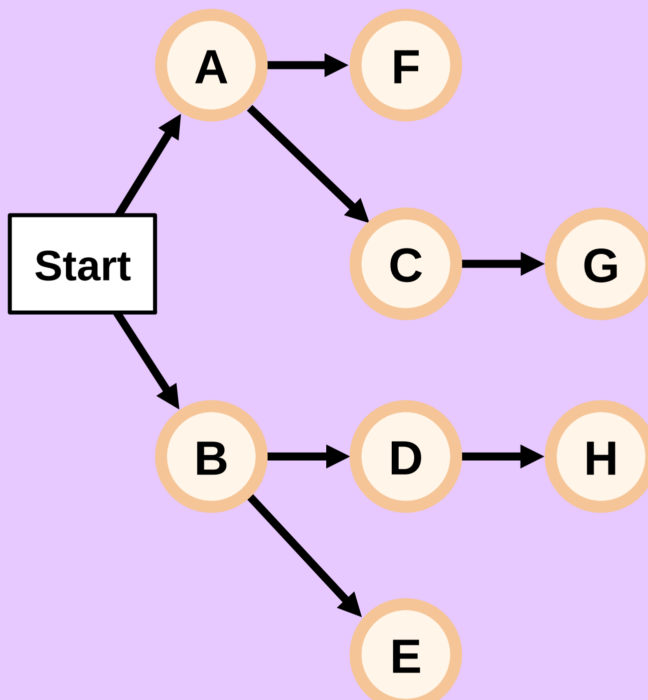

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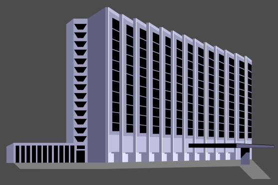

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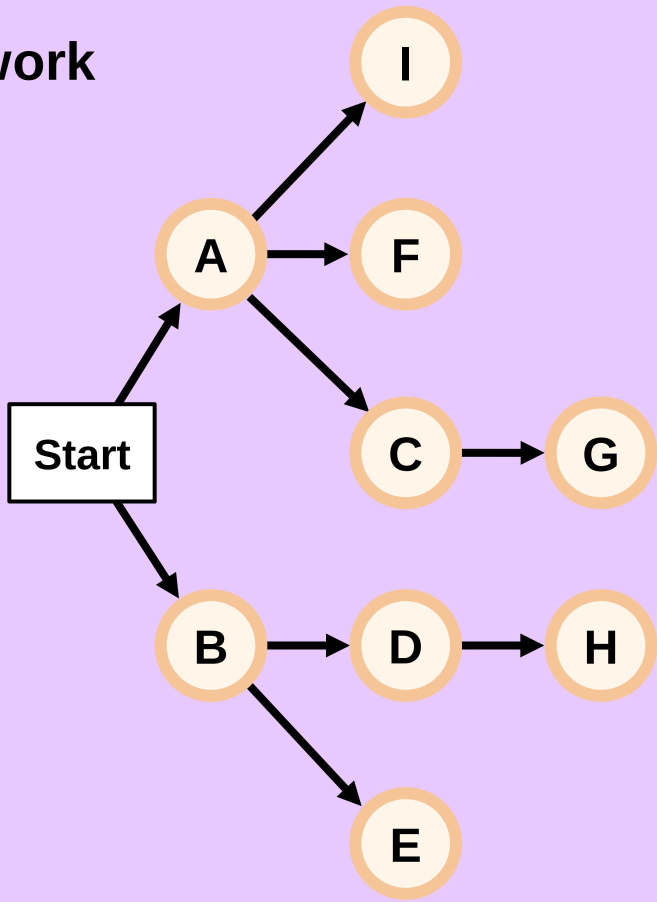

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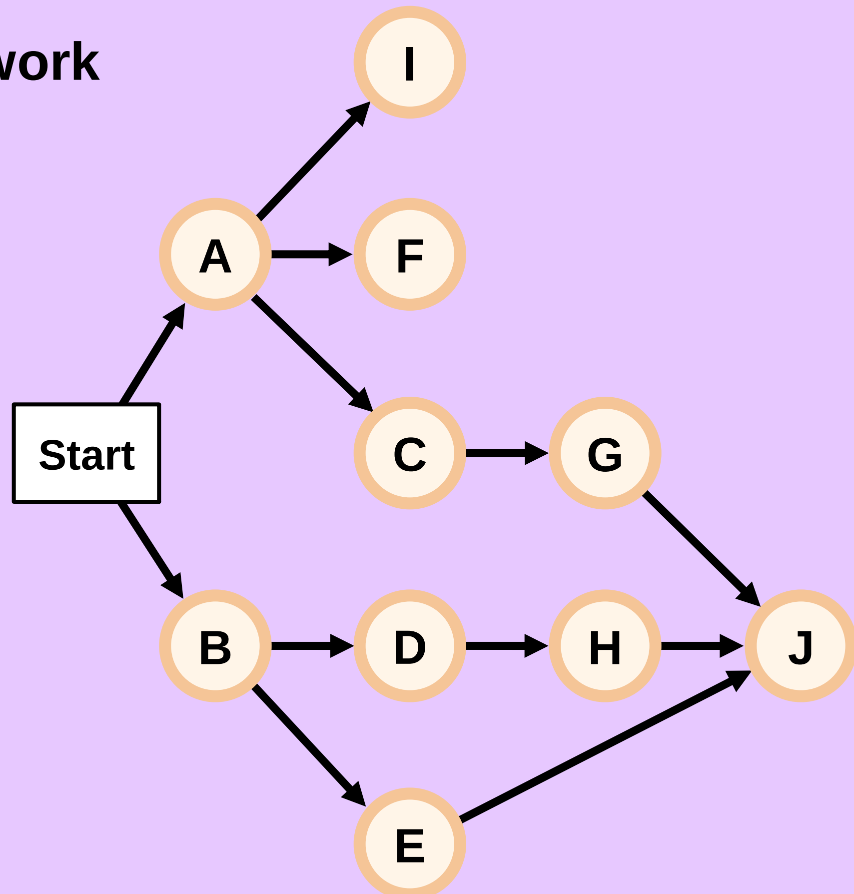

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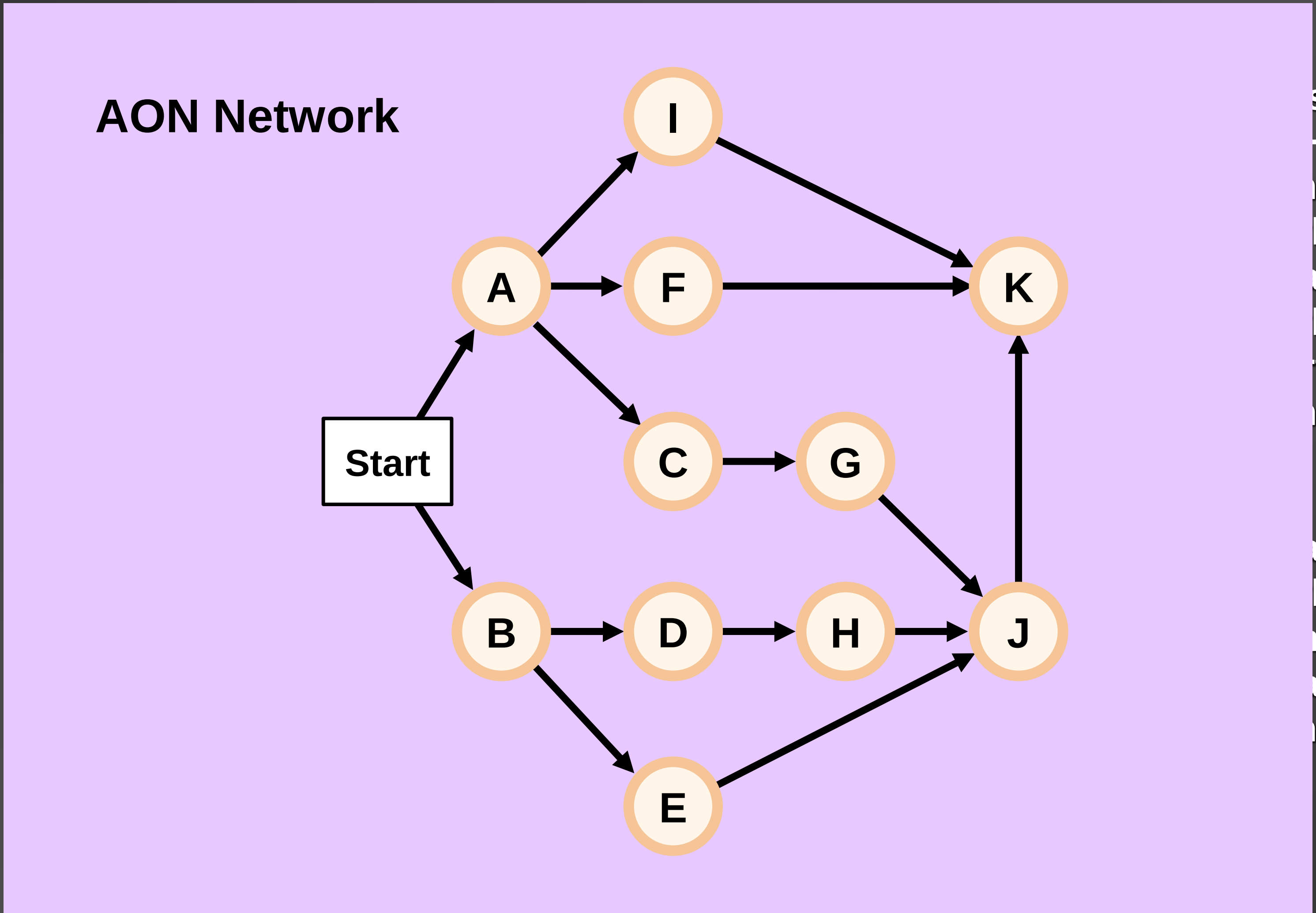

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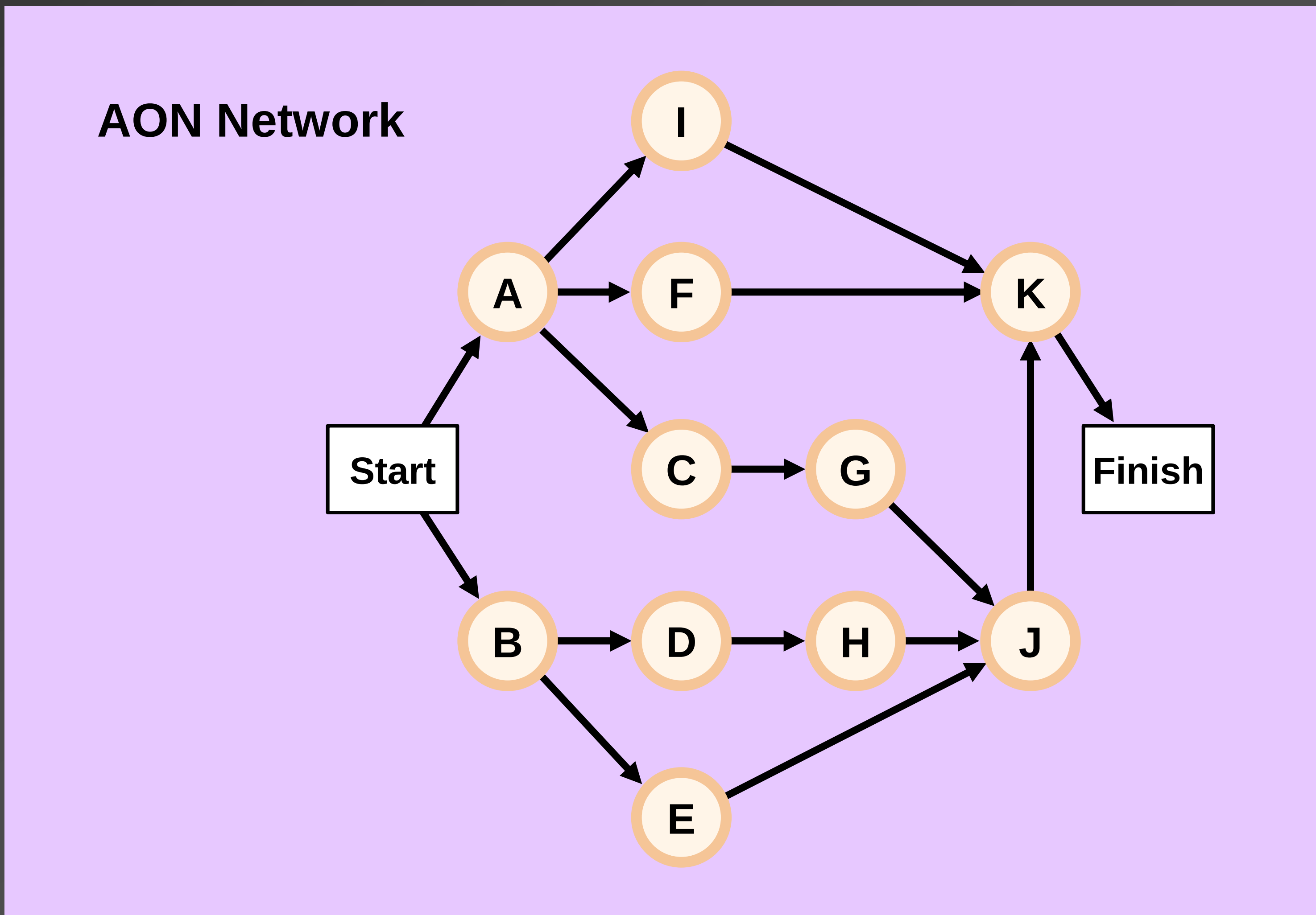

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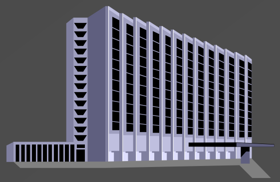

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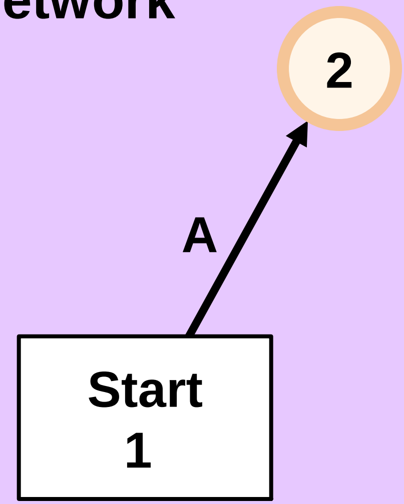

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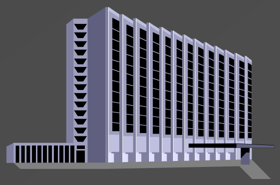

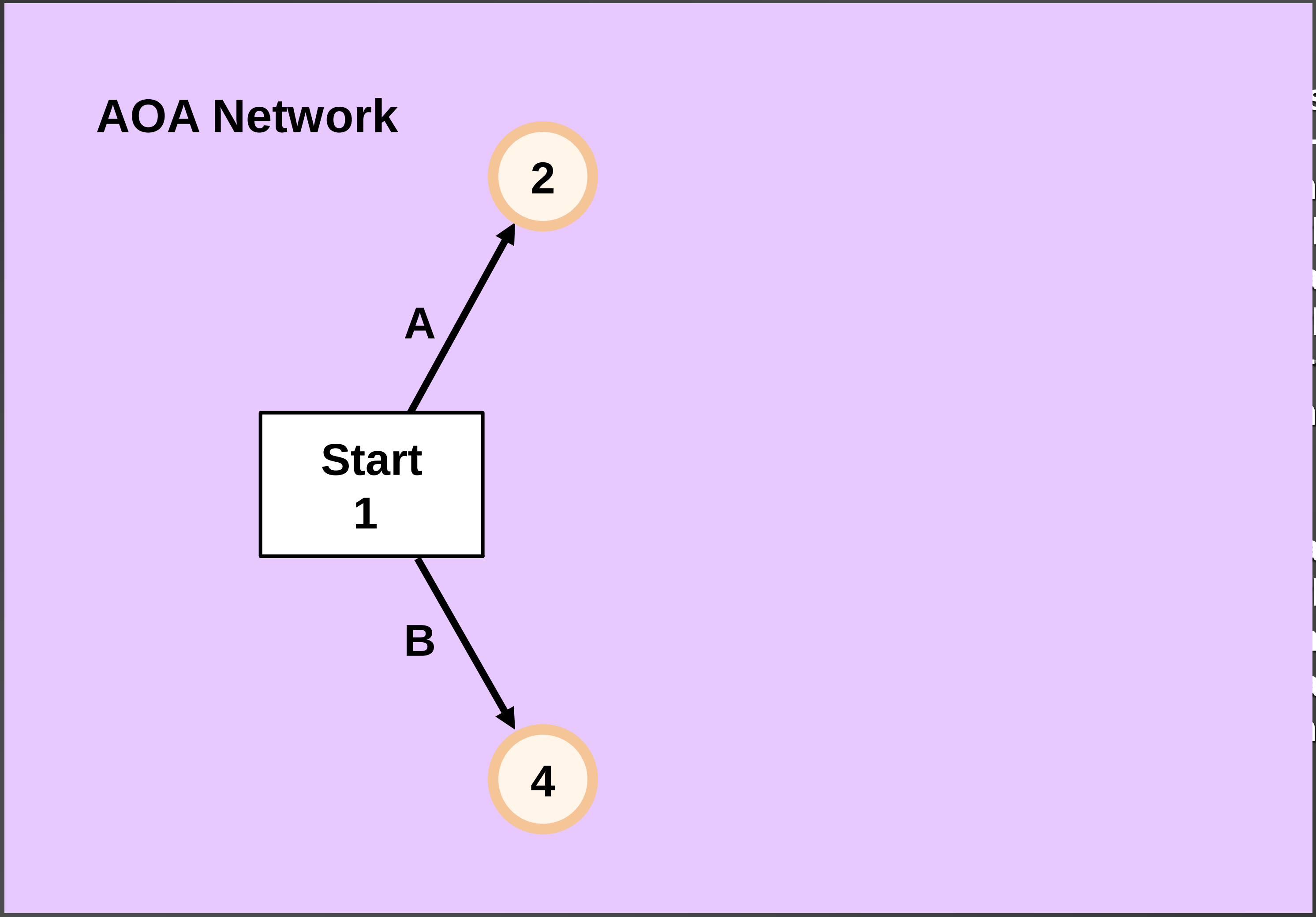

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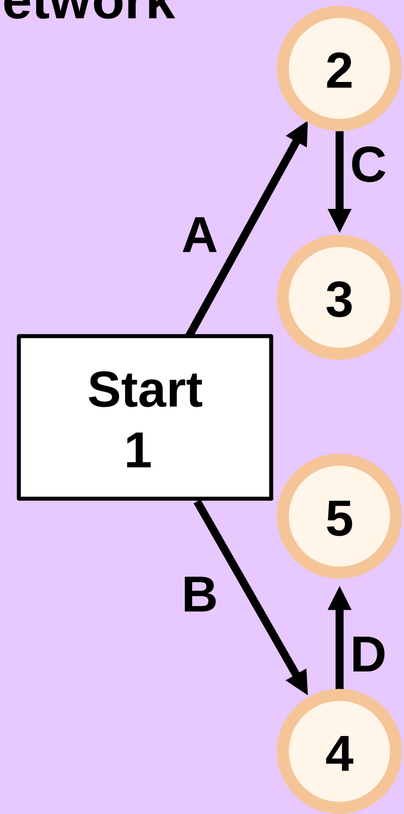

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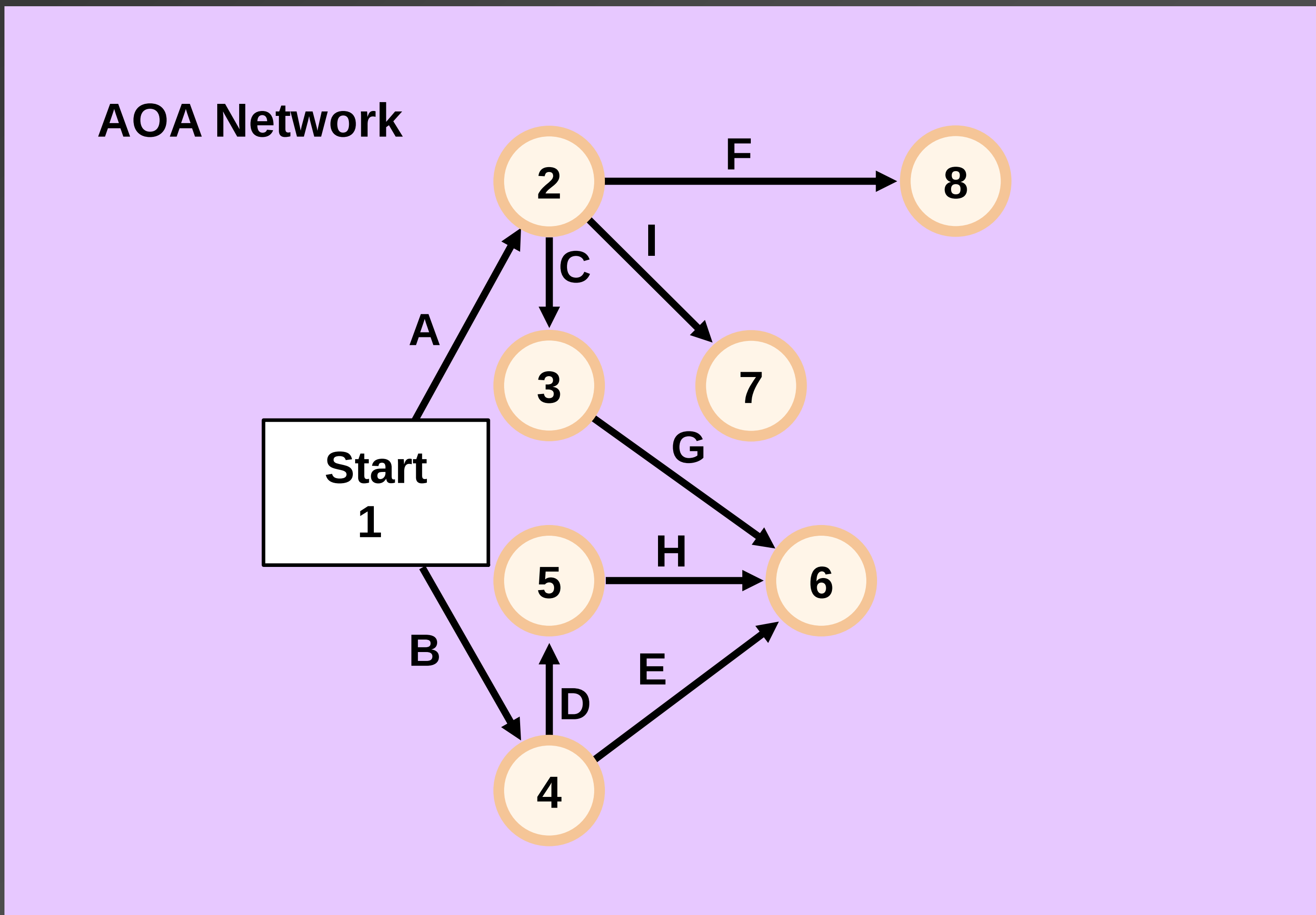

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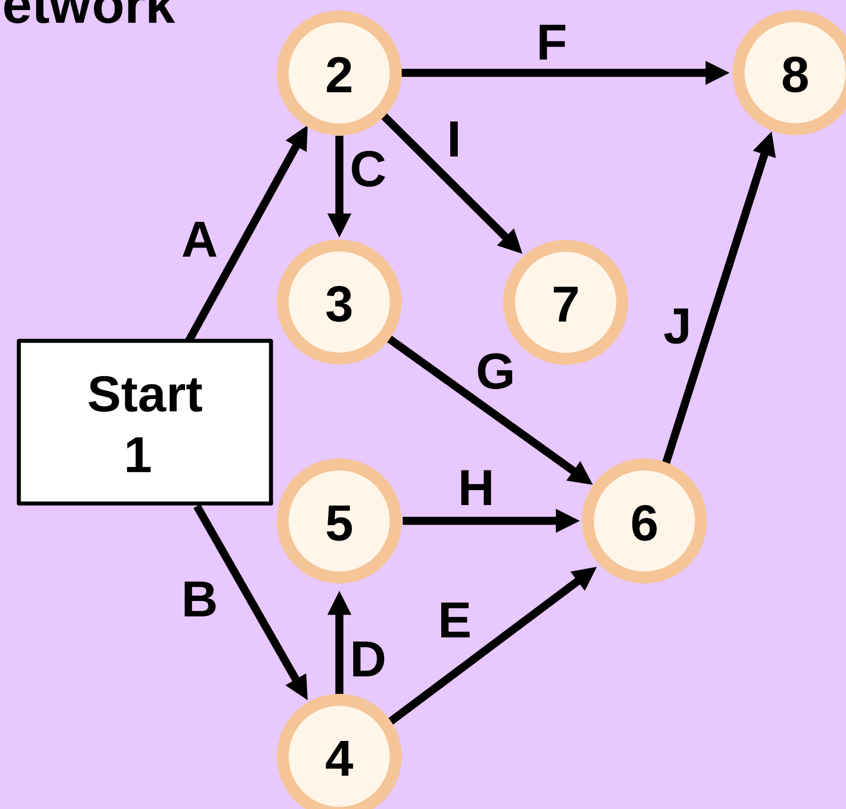

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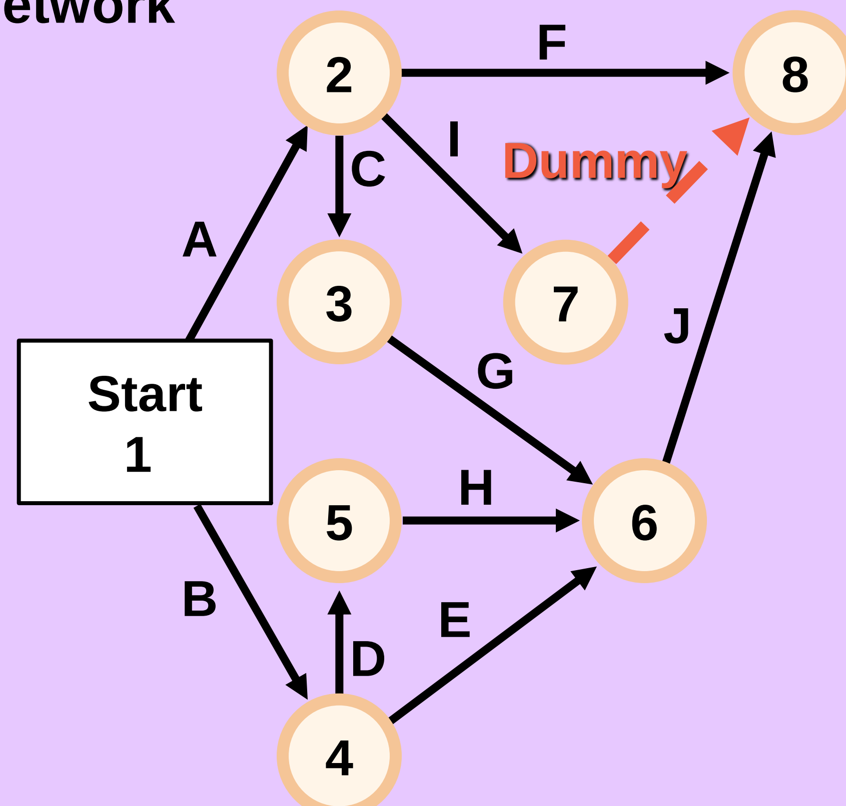
St. Adolf's Hospital

AOA Network



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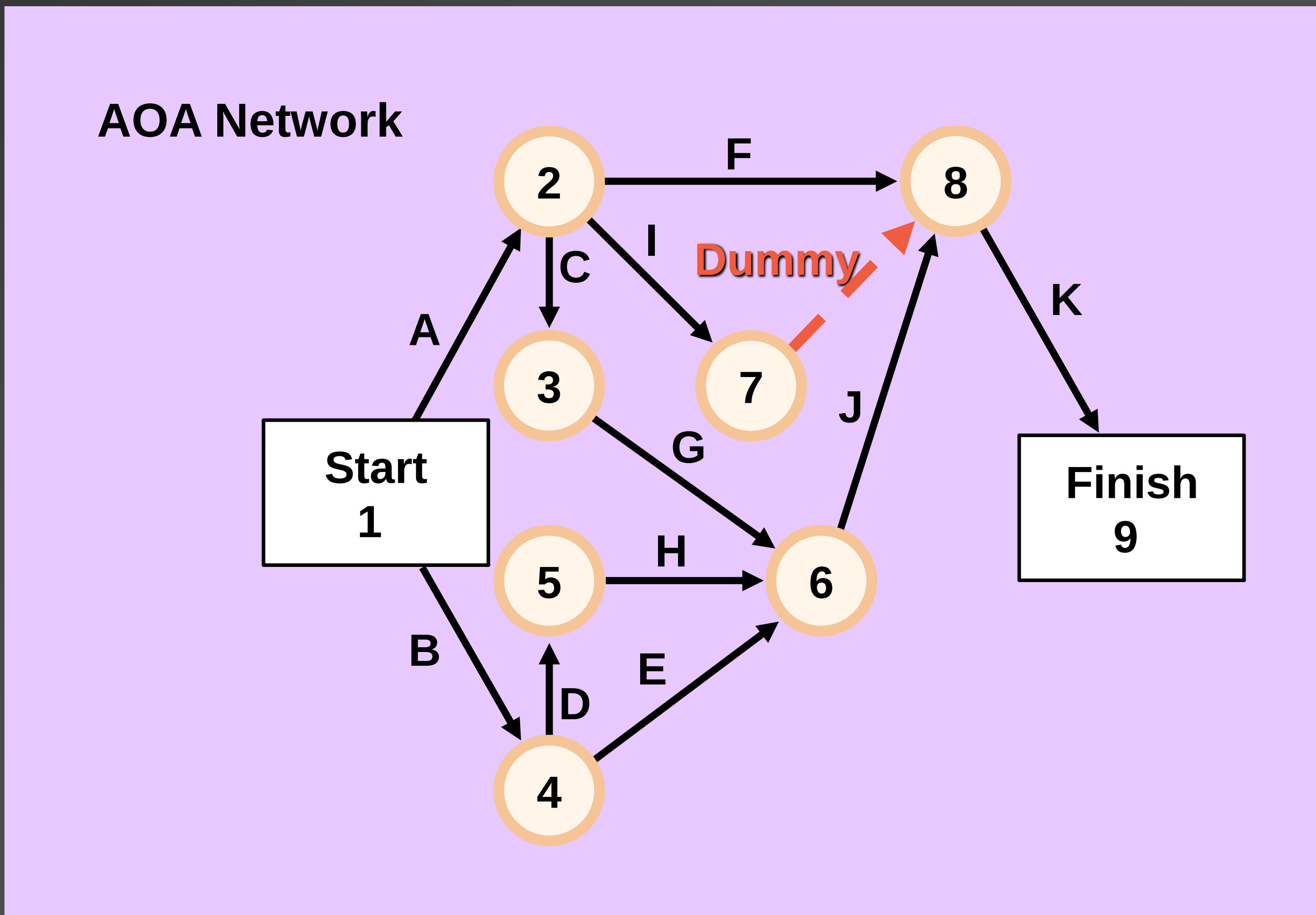

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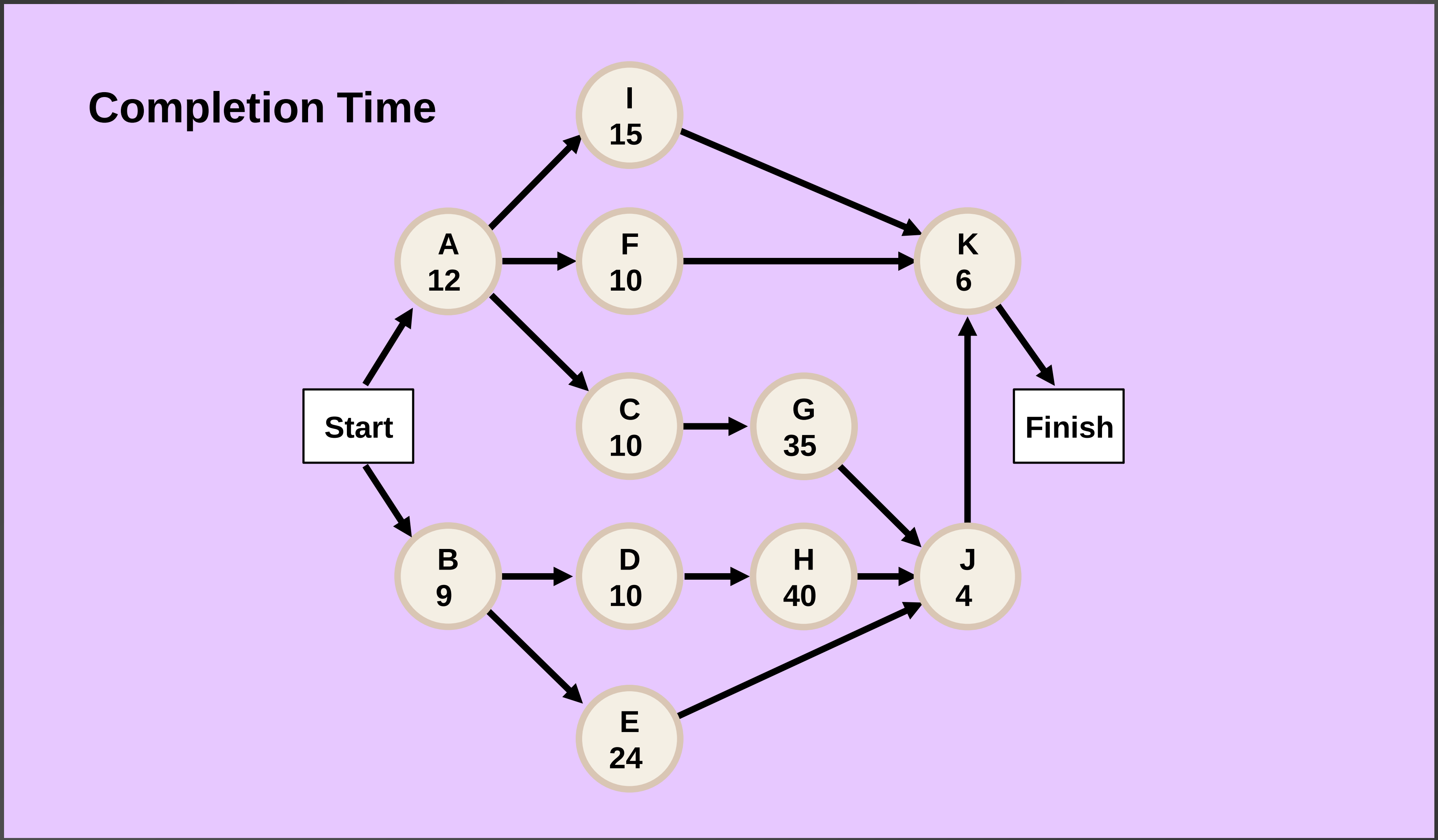
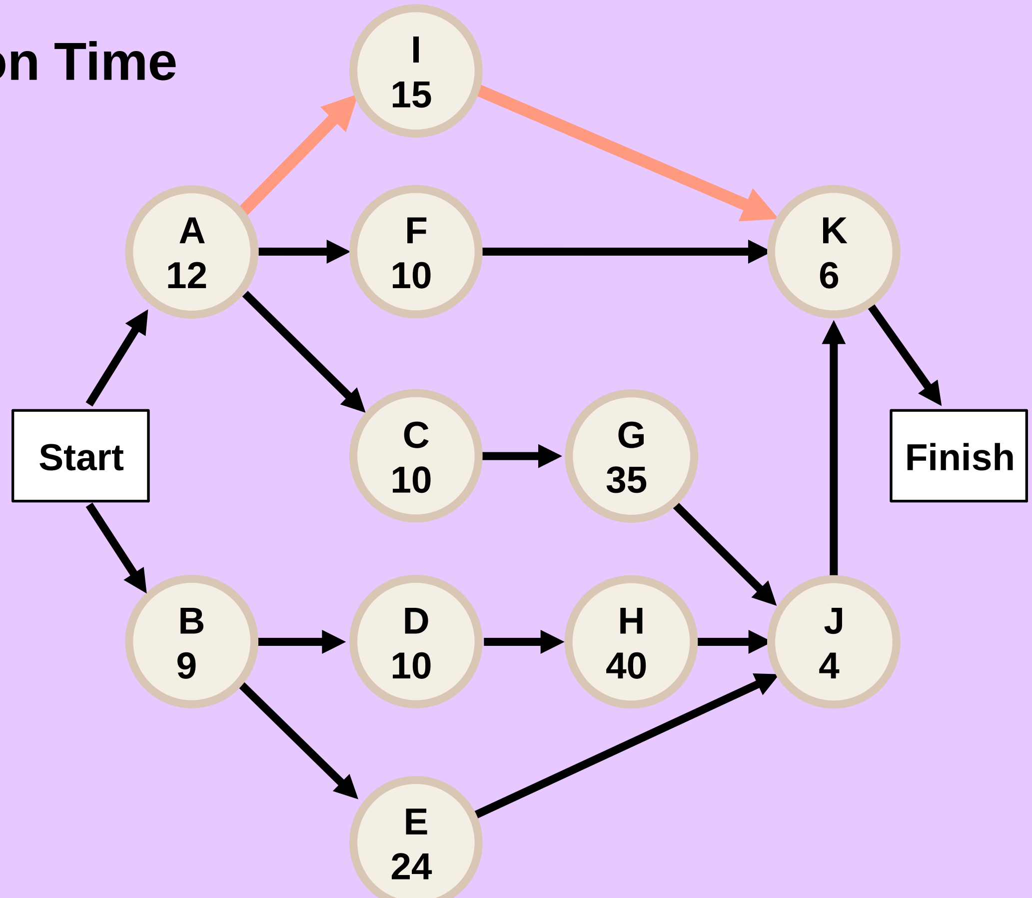
St. Adolf's Hospital



St. Adolf’s Hospital

Completion Time



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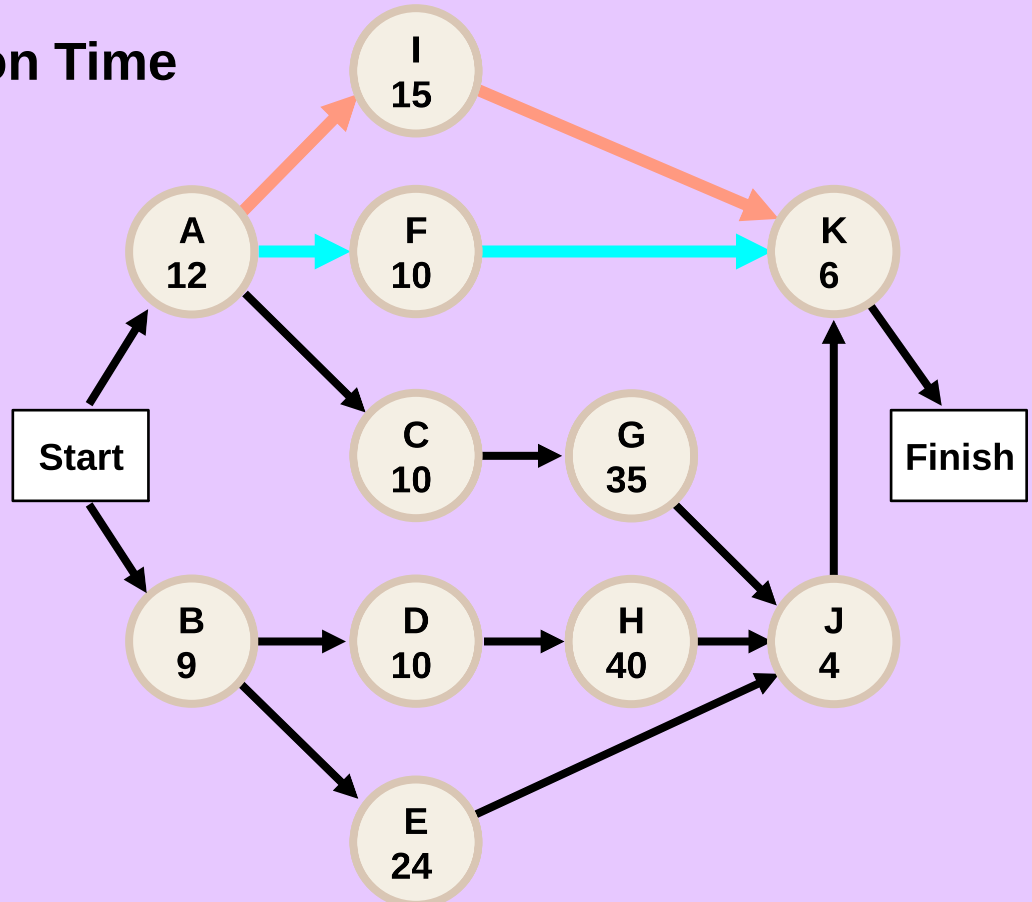
St. Adolf's Hospital

Completion Time



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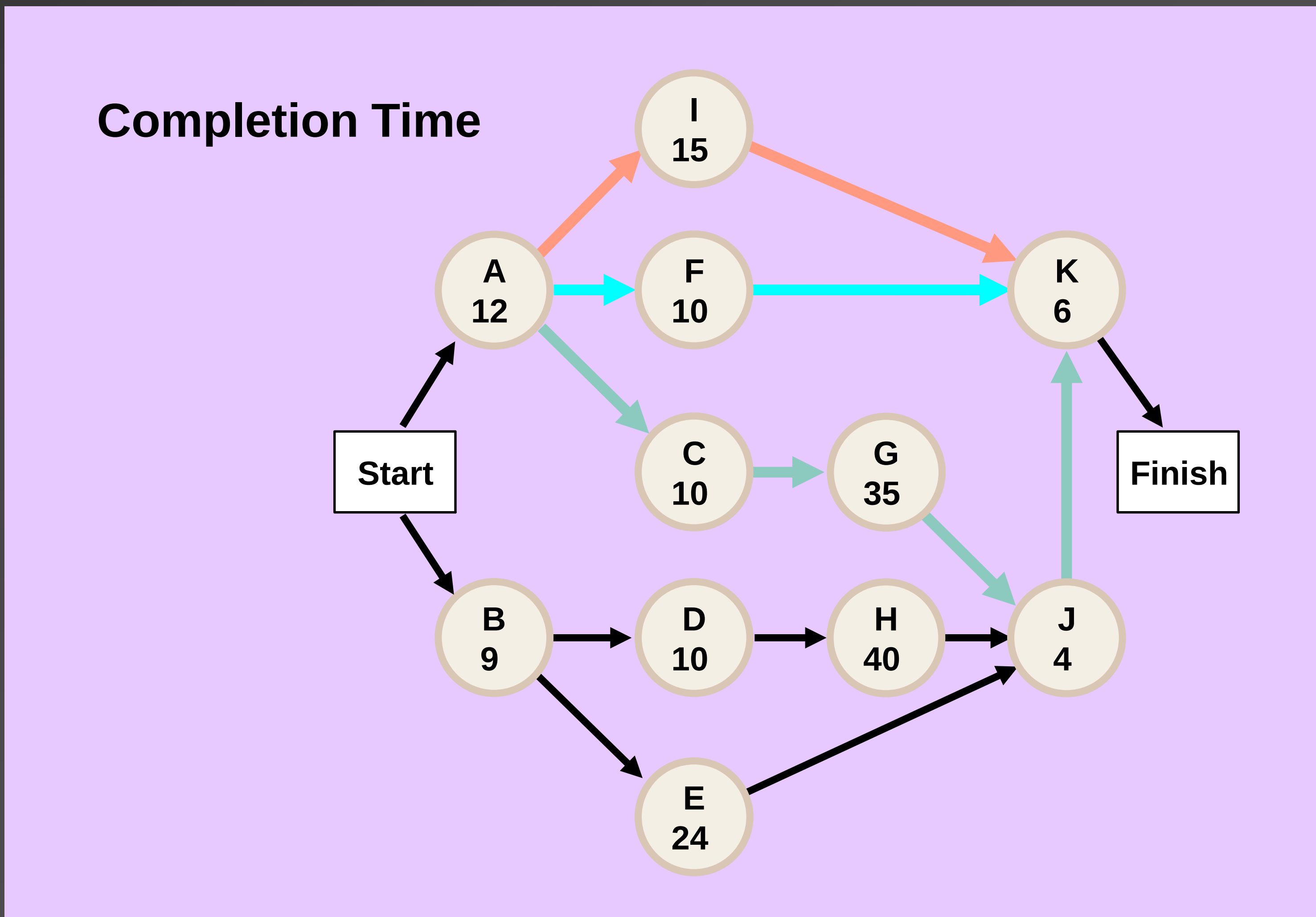

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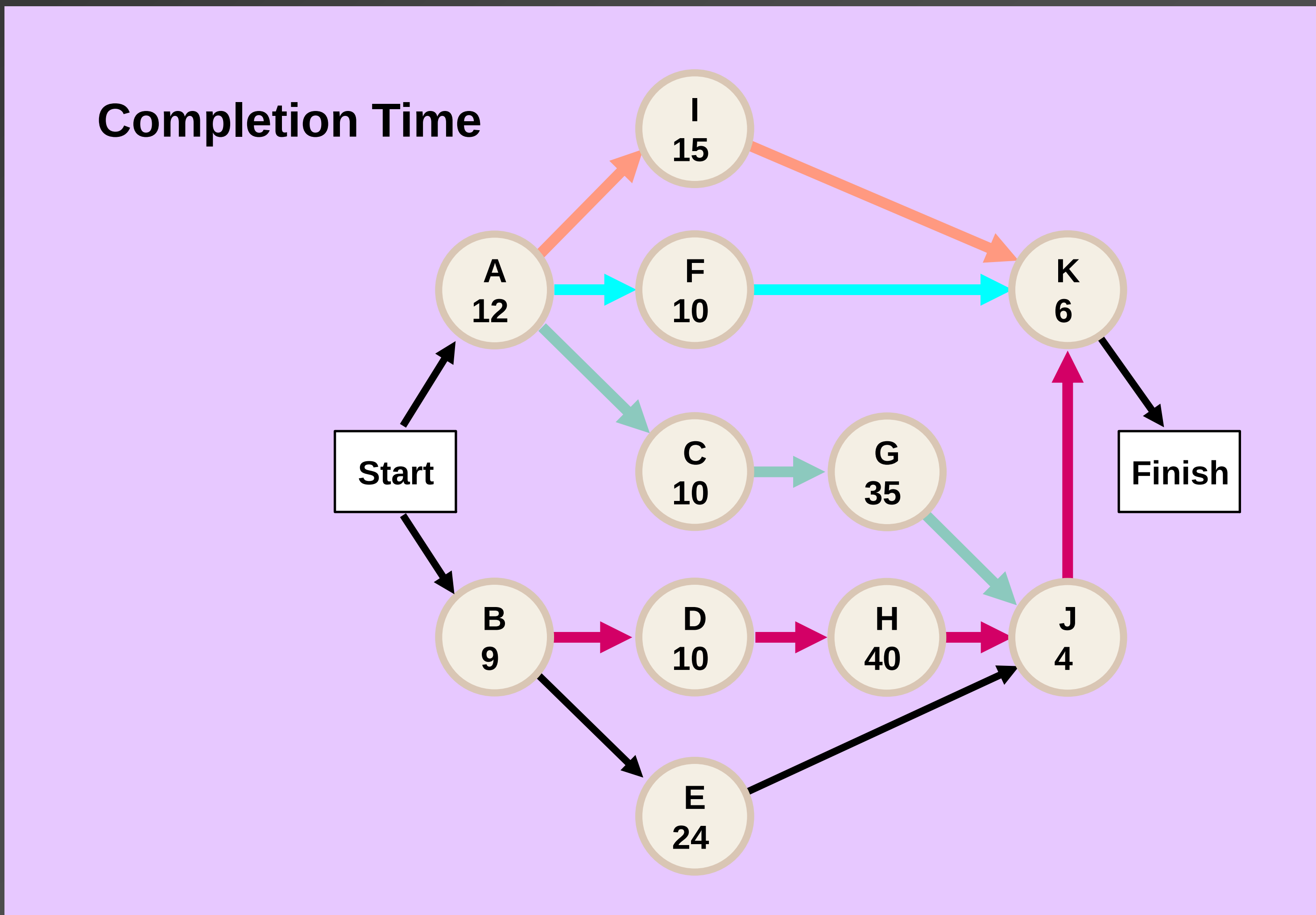

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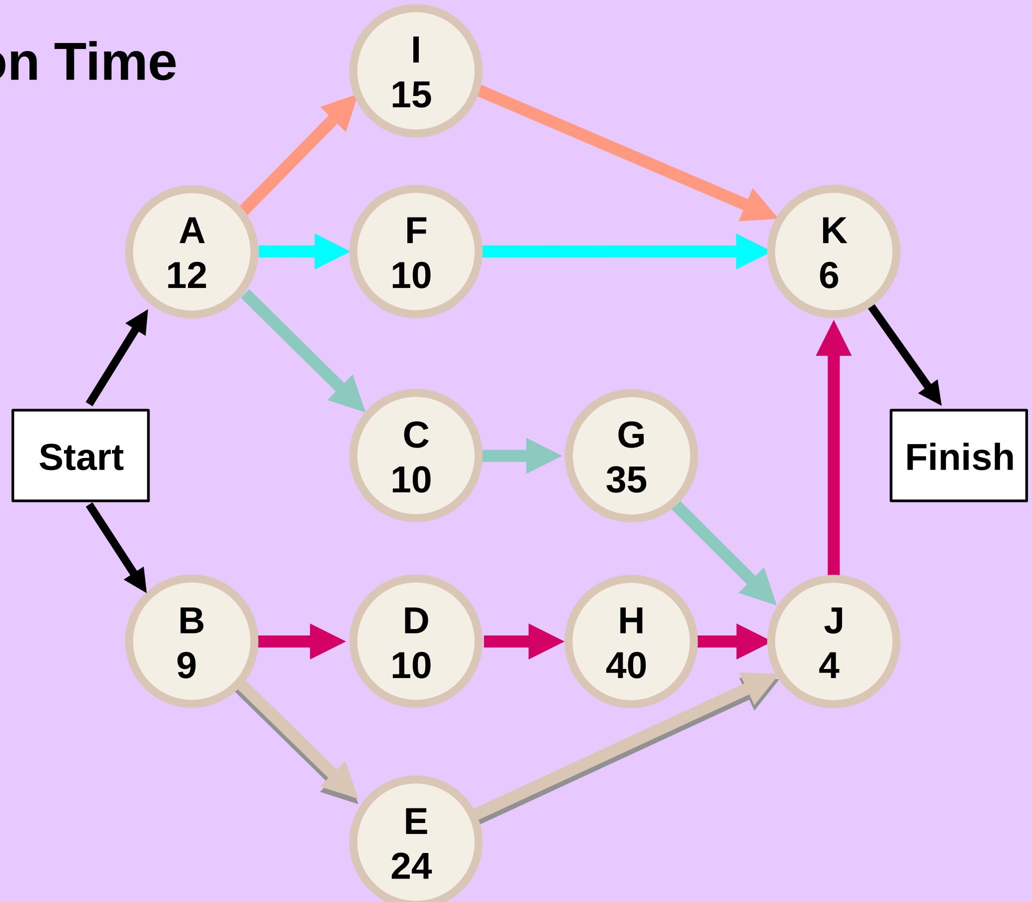
St. Adolf's Hospital

Completion Time



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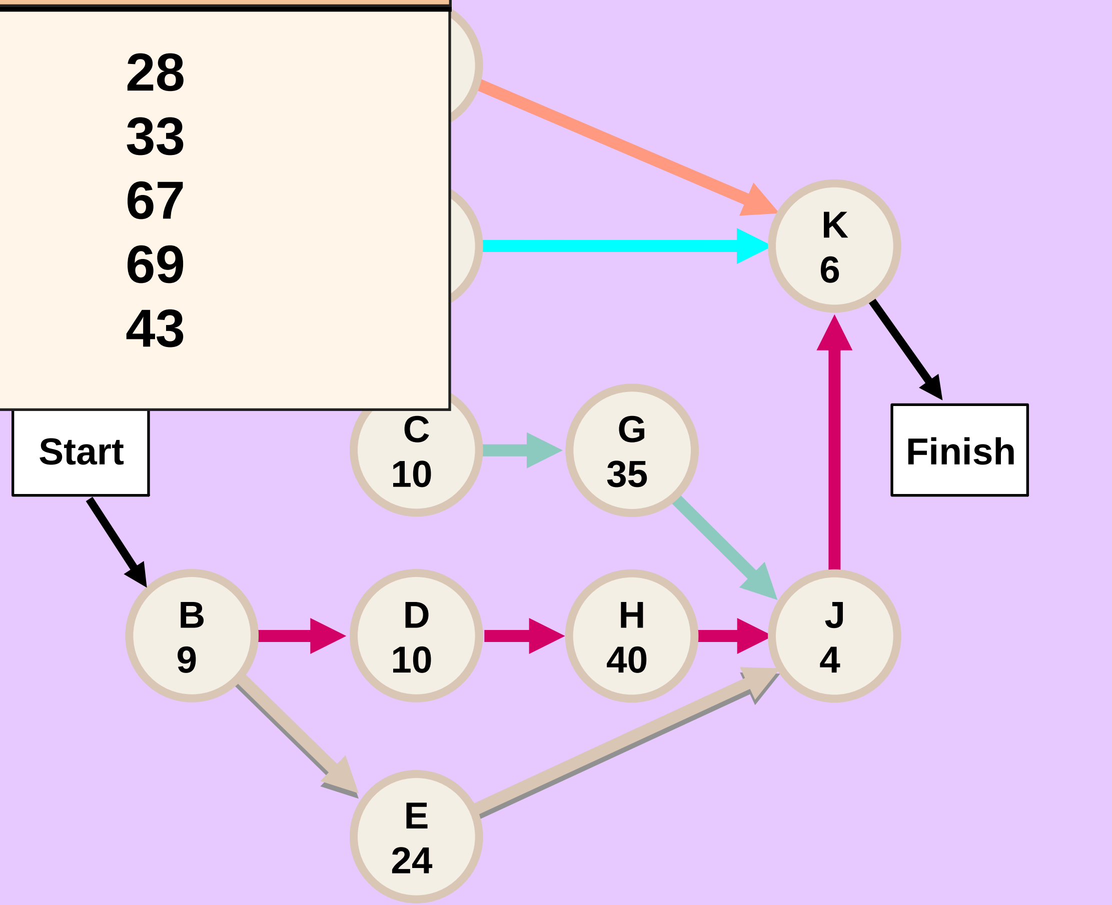
St. Adolf's Hospital

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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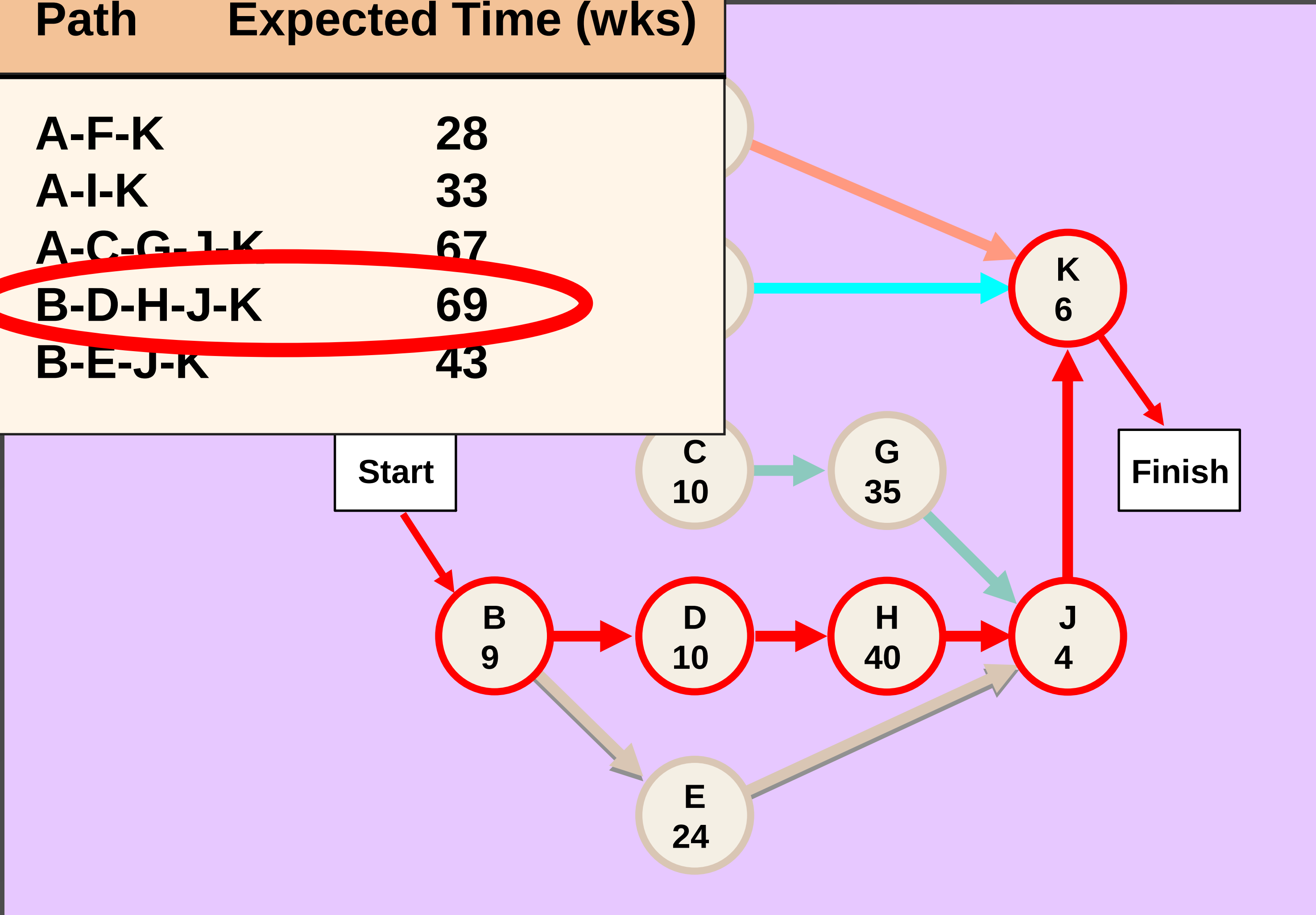
St. Adolf's Hospital

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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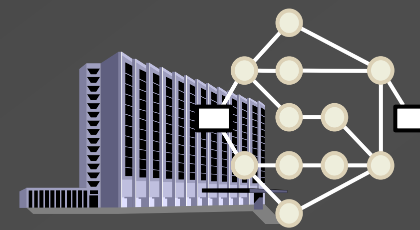
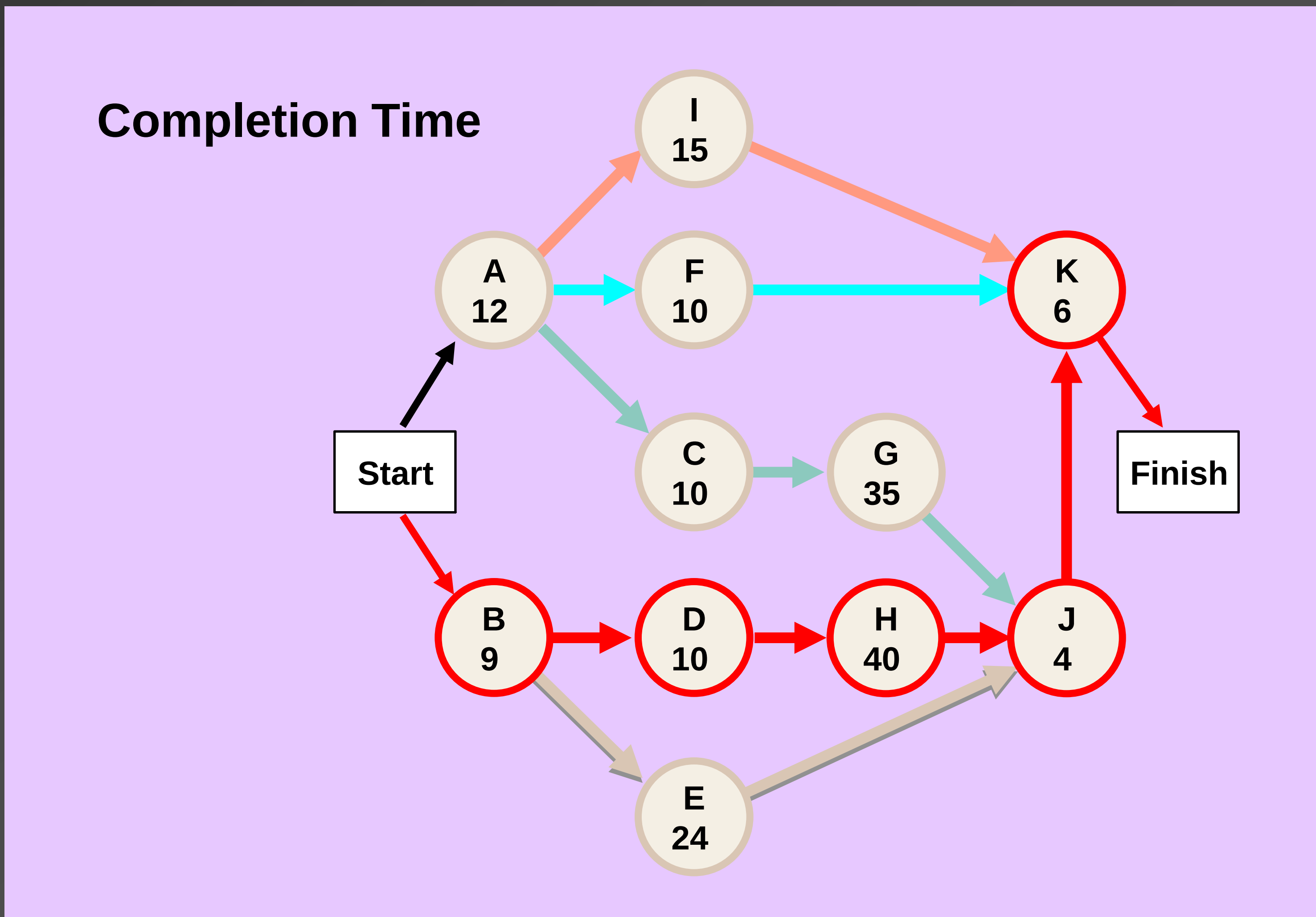
St. Adolf's Hospital





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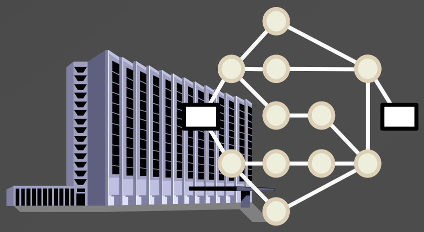
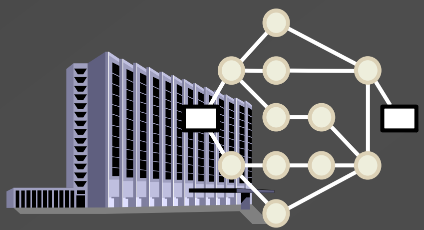
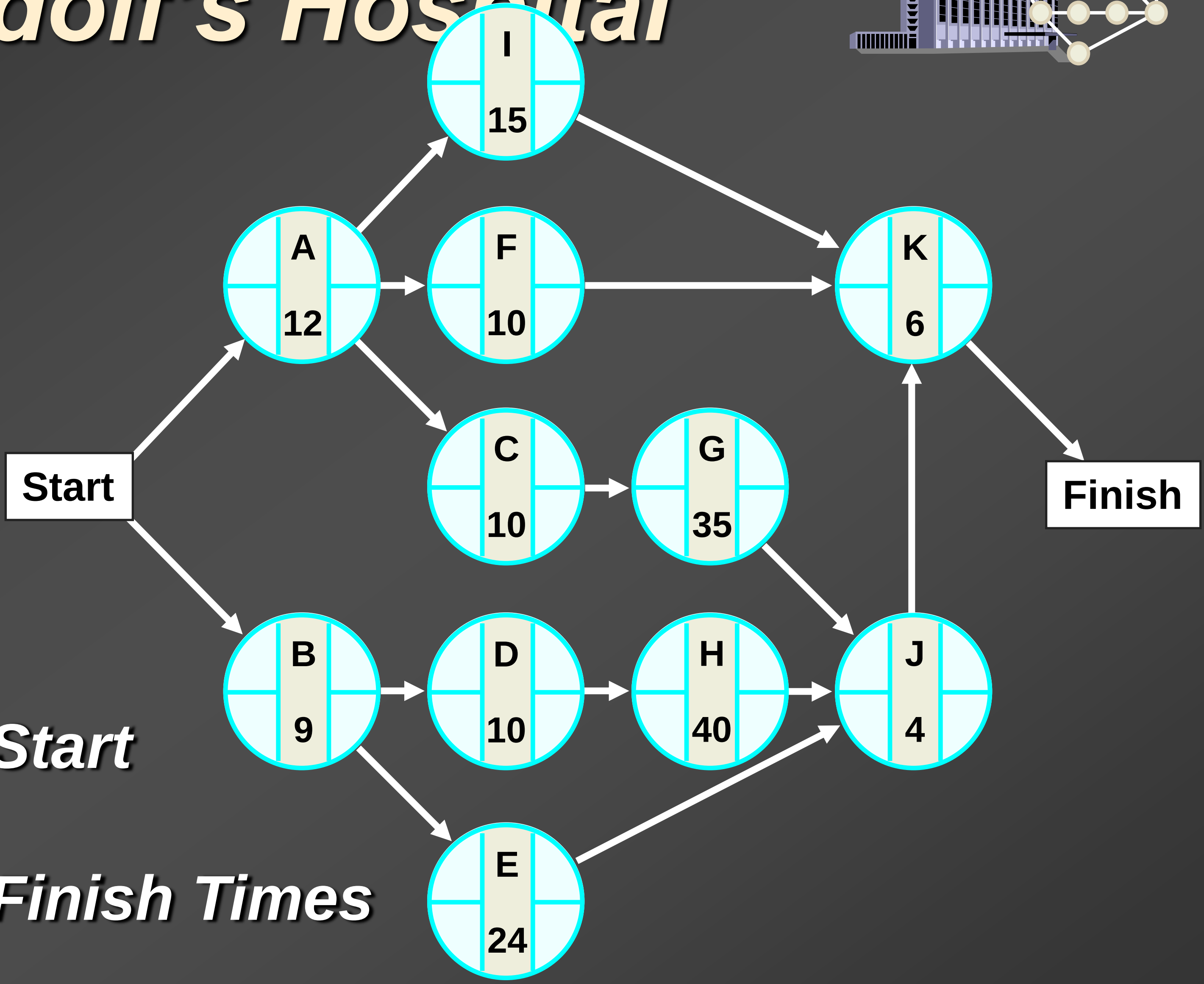
St. Adolf’s Hospital



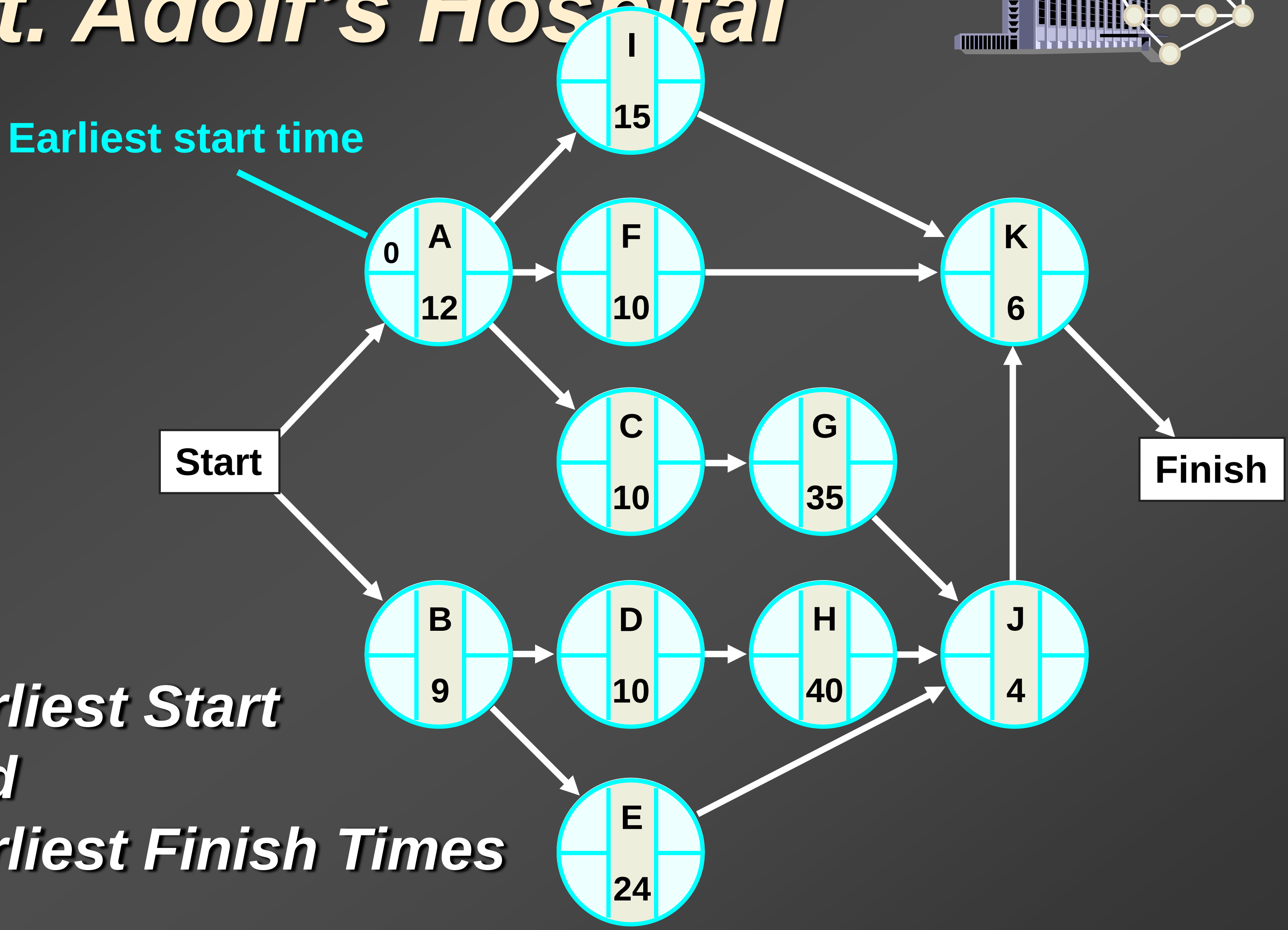
St. Adolf's Hospital





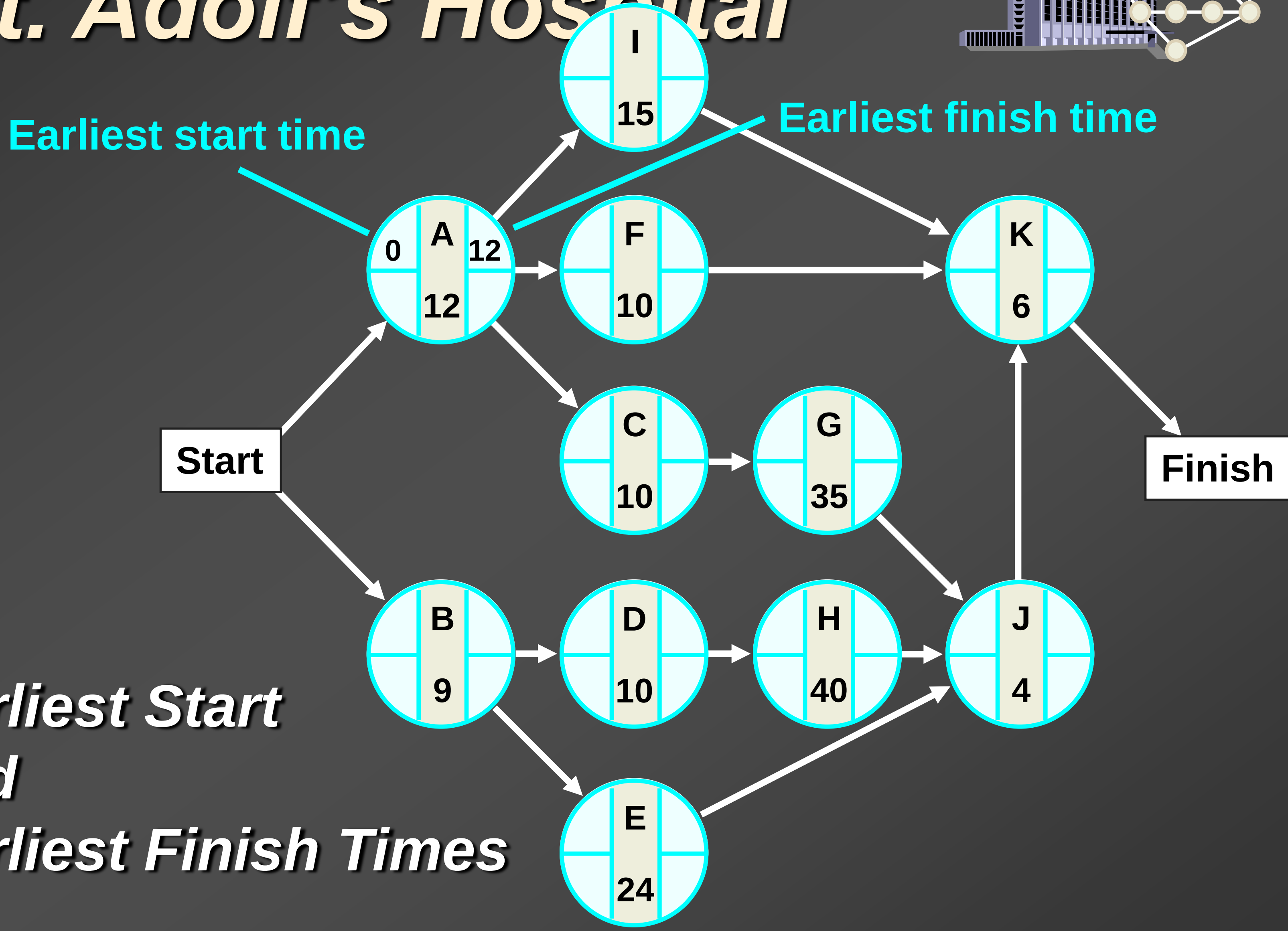
Earliest Start and Earliest Finish Times

St. Adolf's Hospital



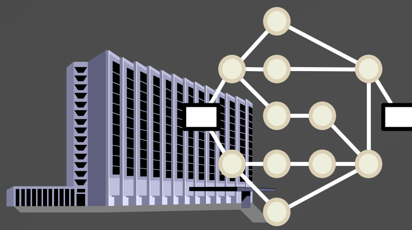
Earliest Start and Earliest Finish Times

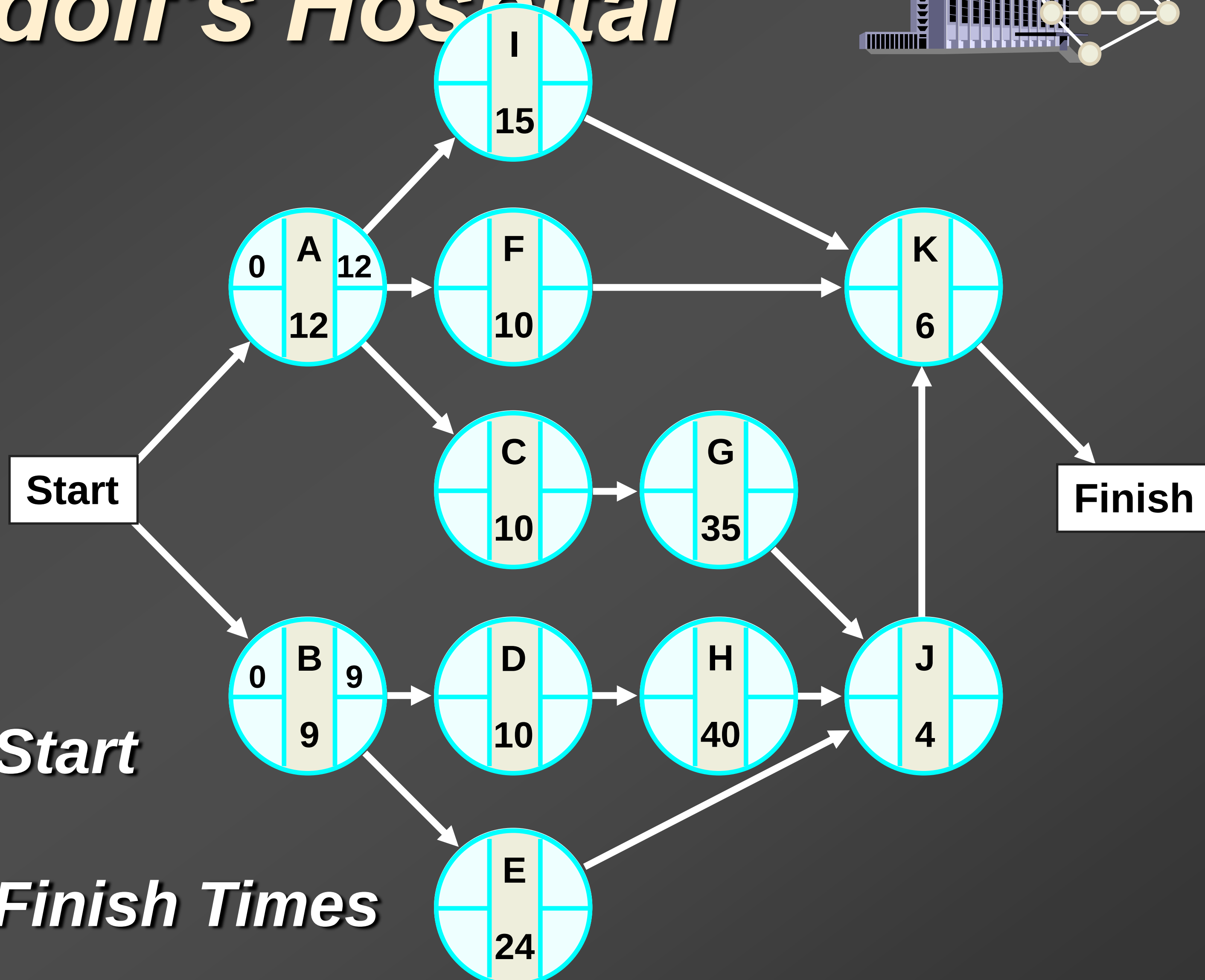
St. Adolf's Hospital



Earliest Start and Earliest Finish Times

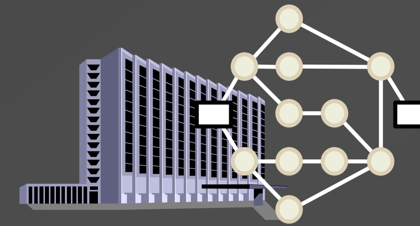
St. Adolf's Hospital

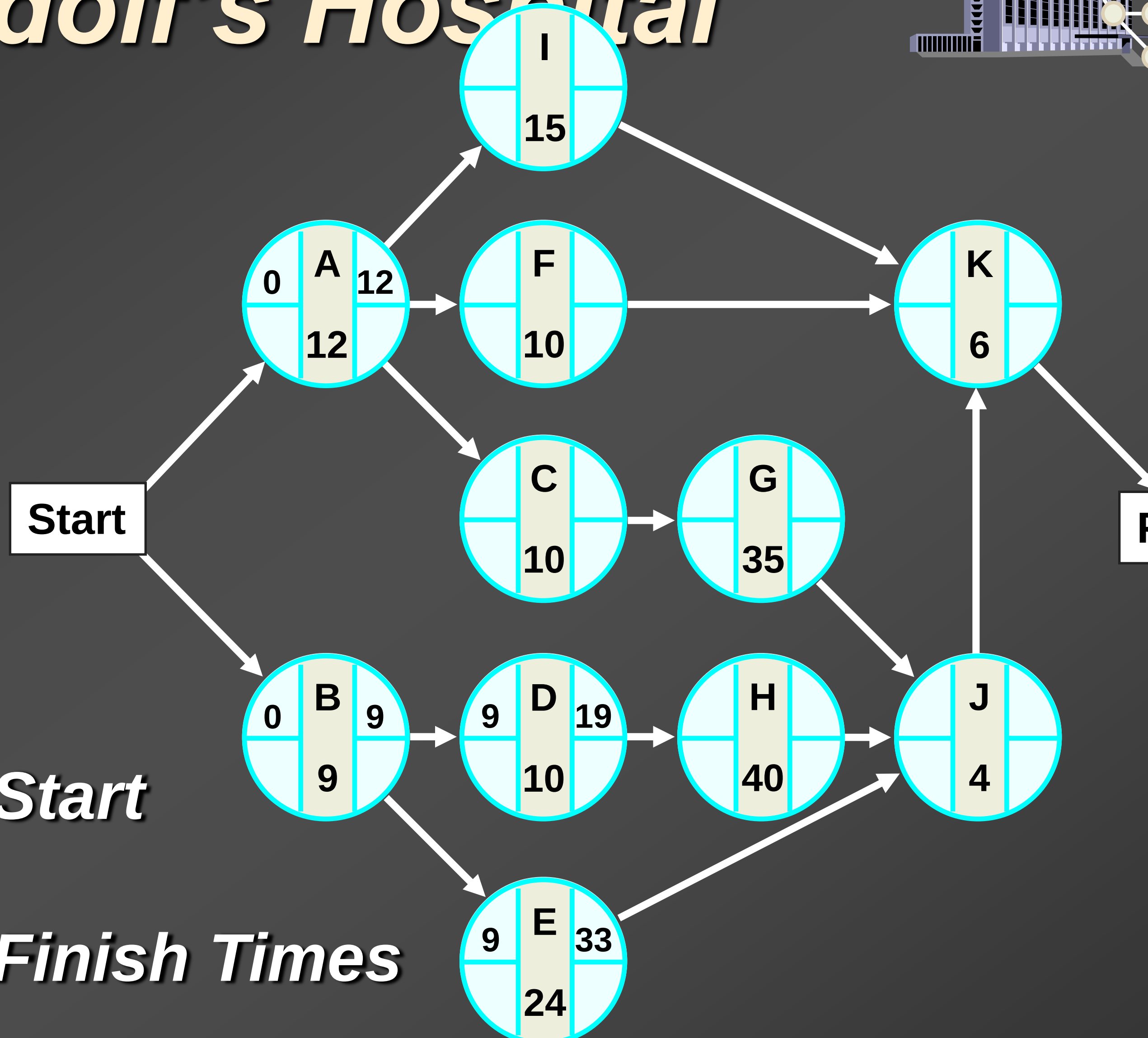




Earliest Start
and
Earliest Finish Times

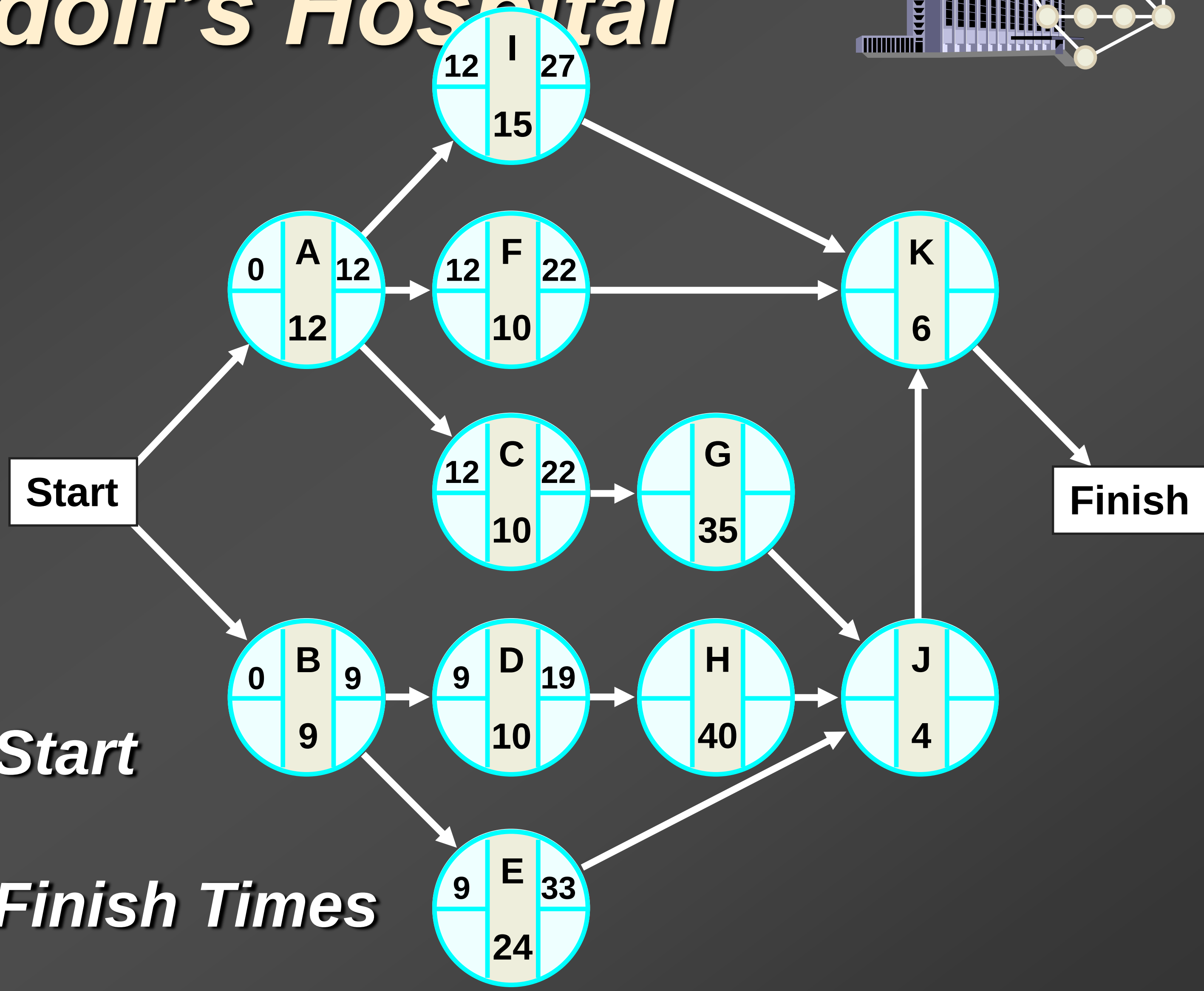
St. Adolf's Hospital





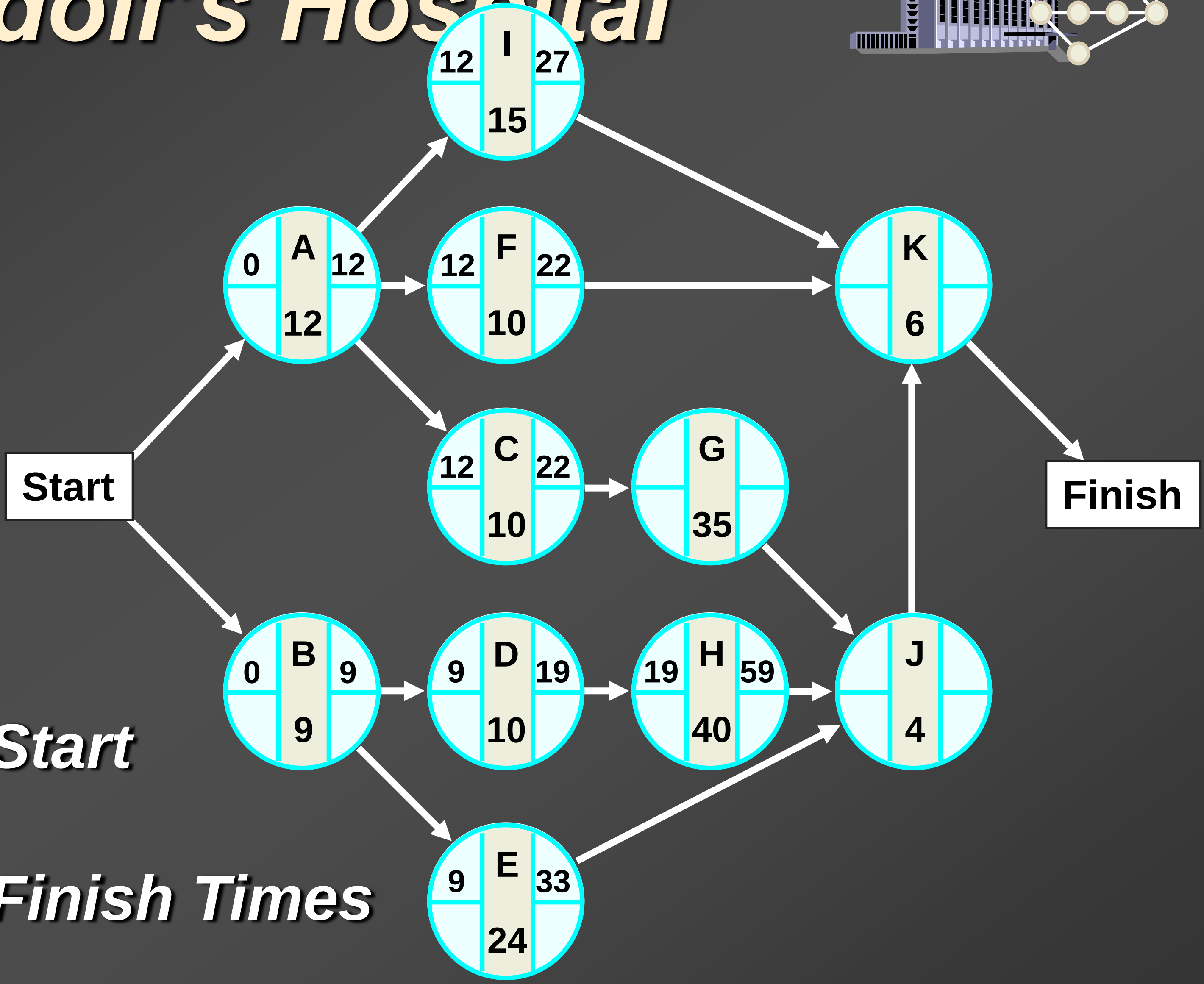
Earliest Start and Earliest Finish Times

St. Adolf's Hospital



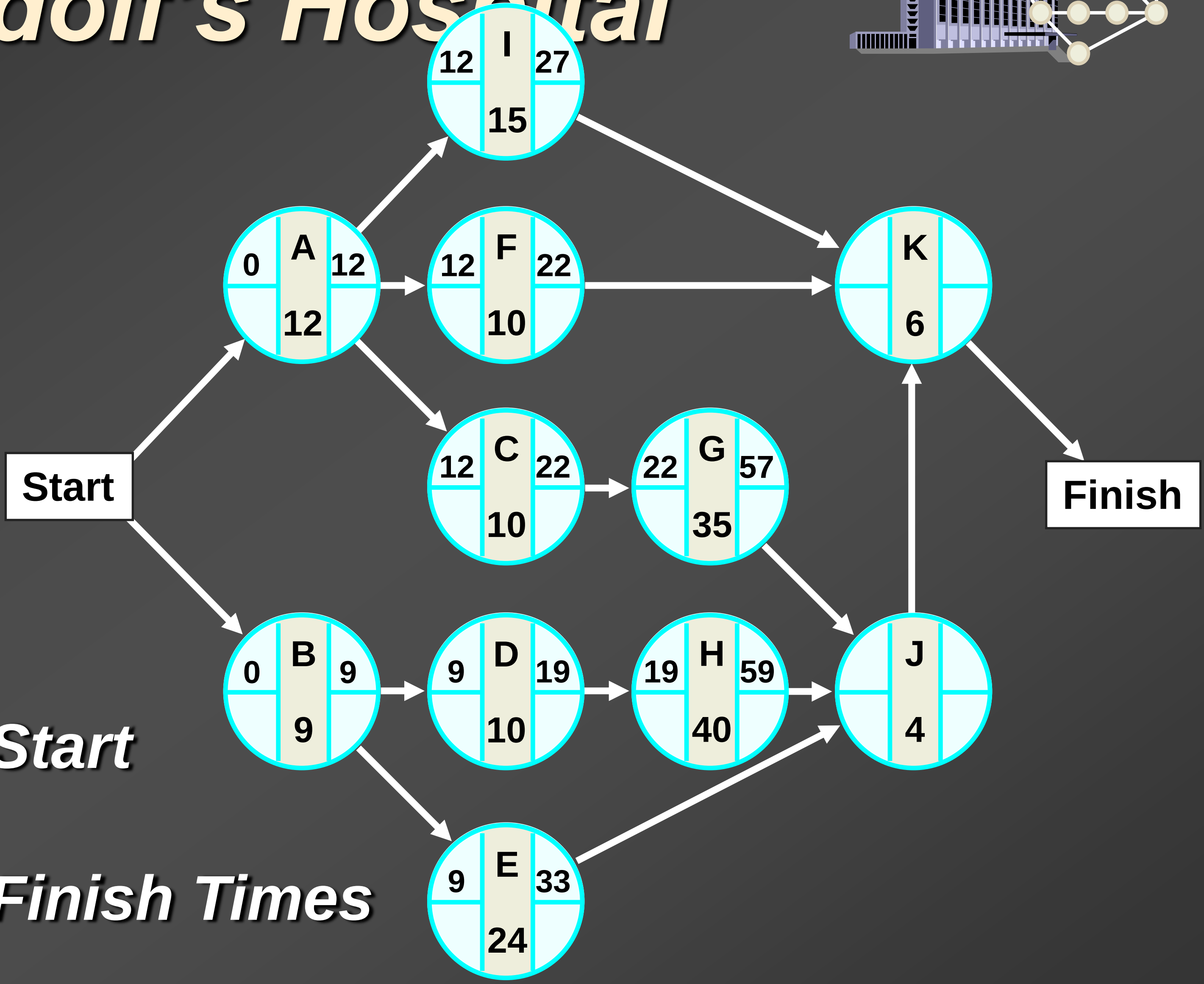
Earliest Start and Earliest Finish Times

St. Adolf's Hospital



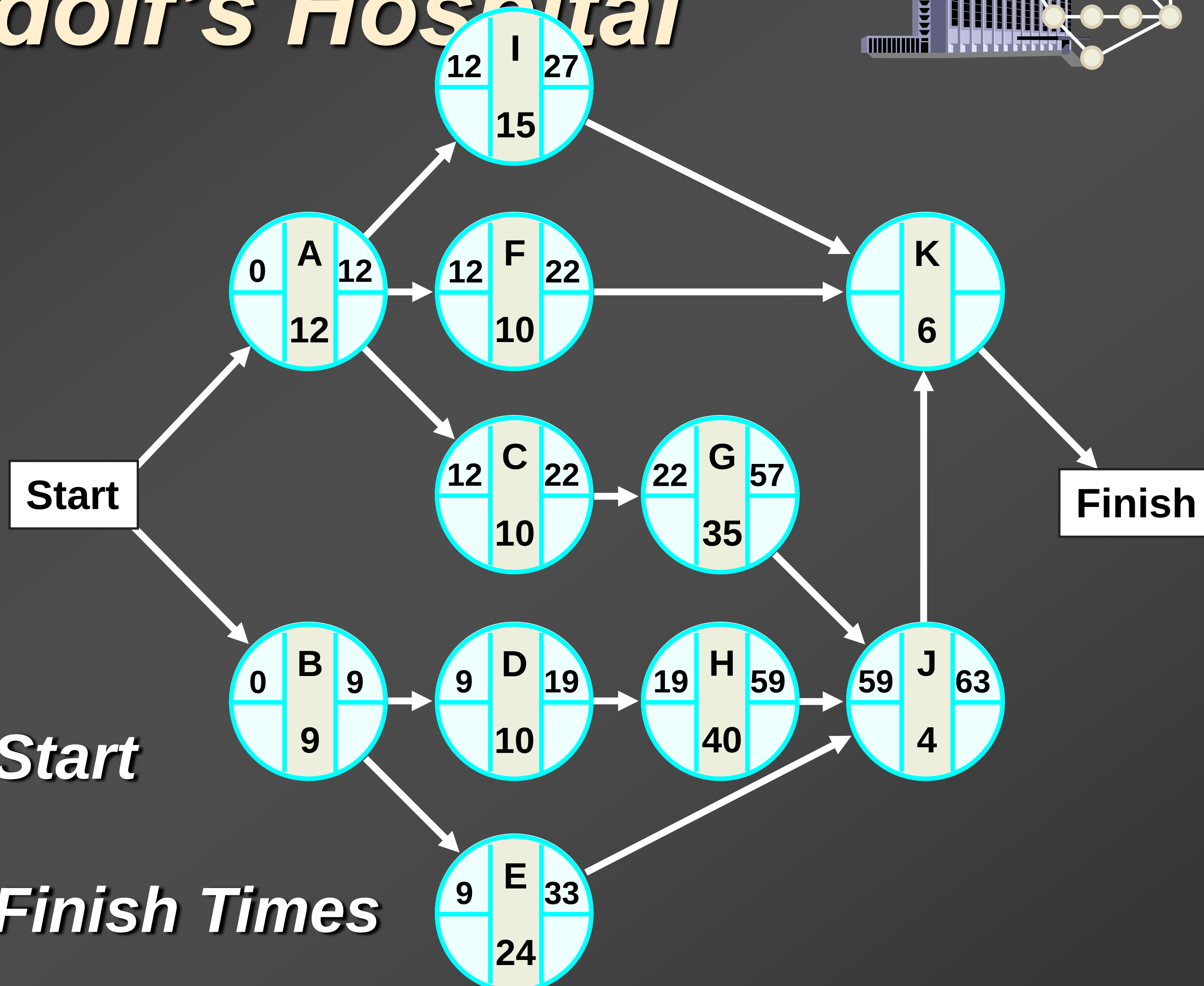
Earliest Start and Earliest Finish Times

St. Adolf's Hospital



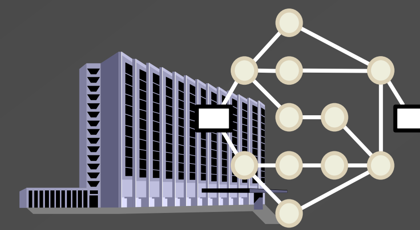
Earliest Start and Earliest Finish Times

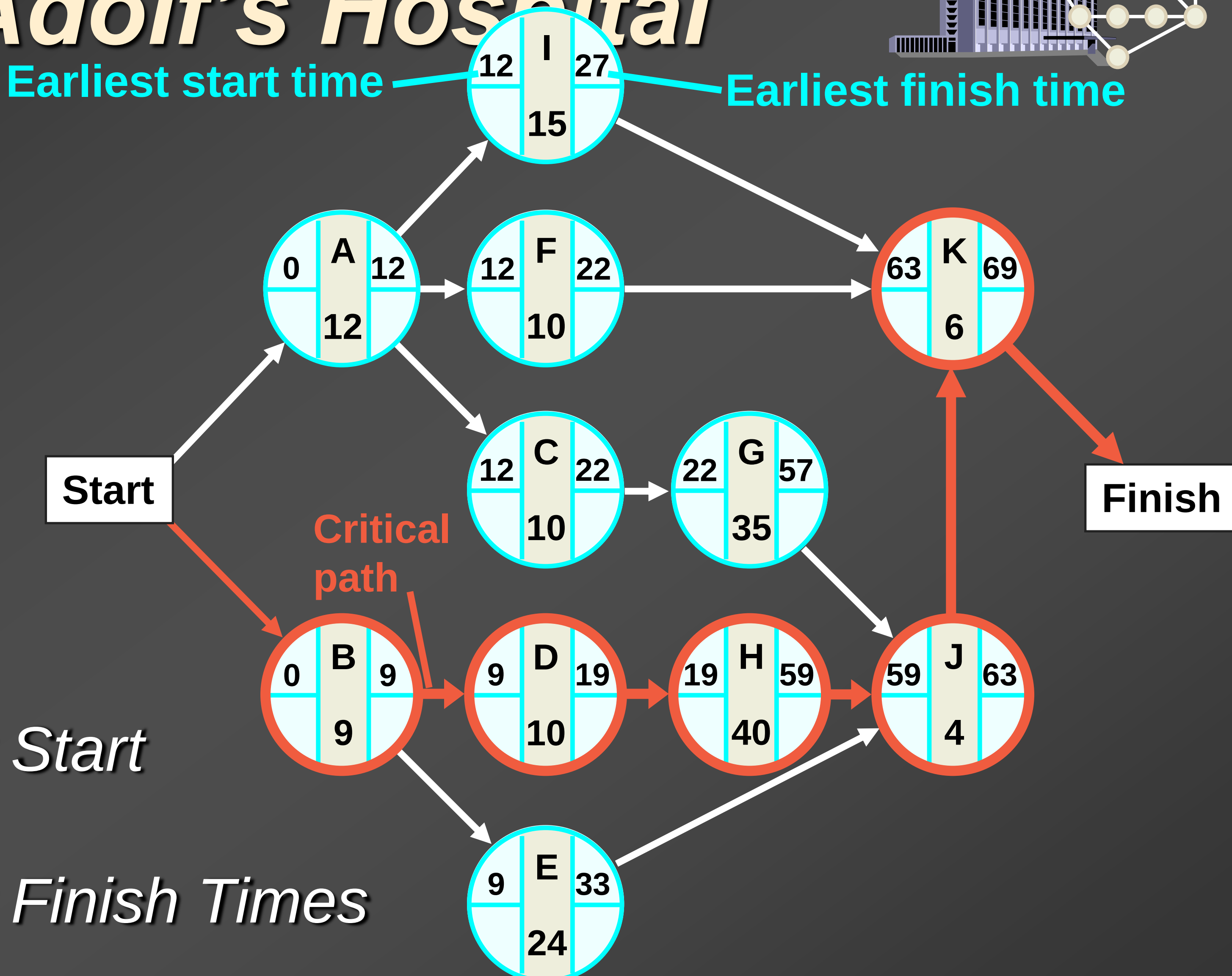
St. Adolf’s Hospital



Earliest Start and Earliest Finish Times

St. Adolf's Hospital





Earliest Start
and
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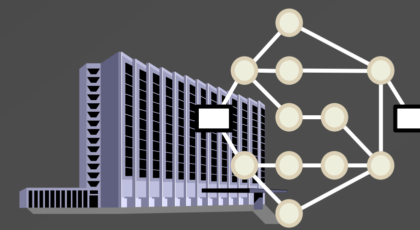
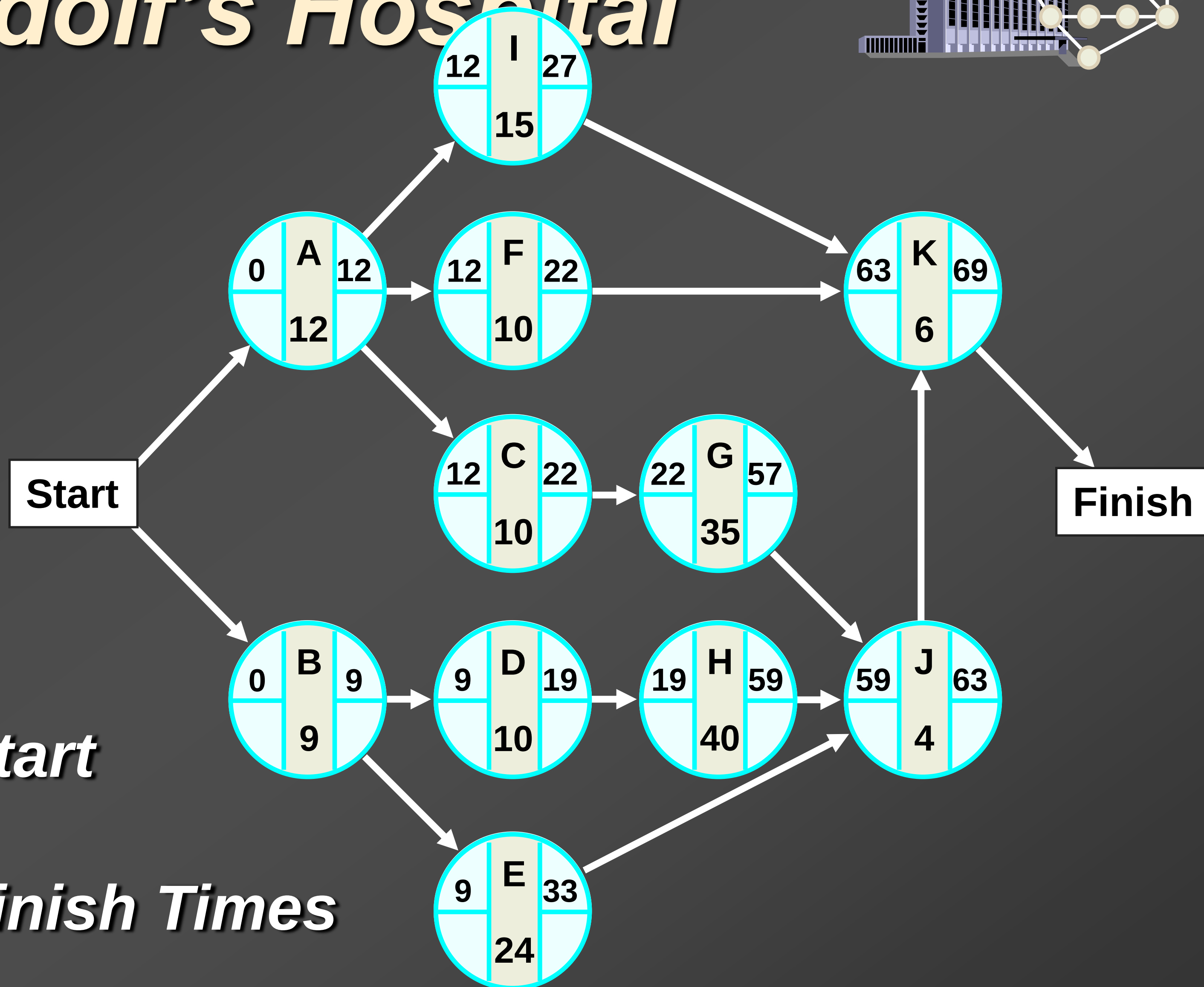
first

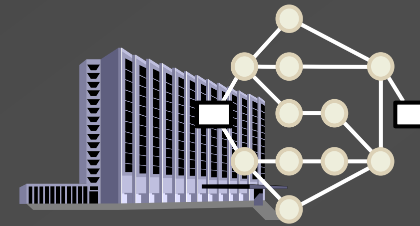
St. Adolf's Hospital

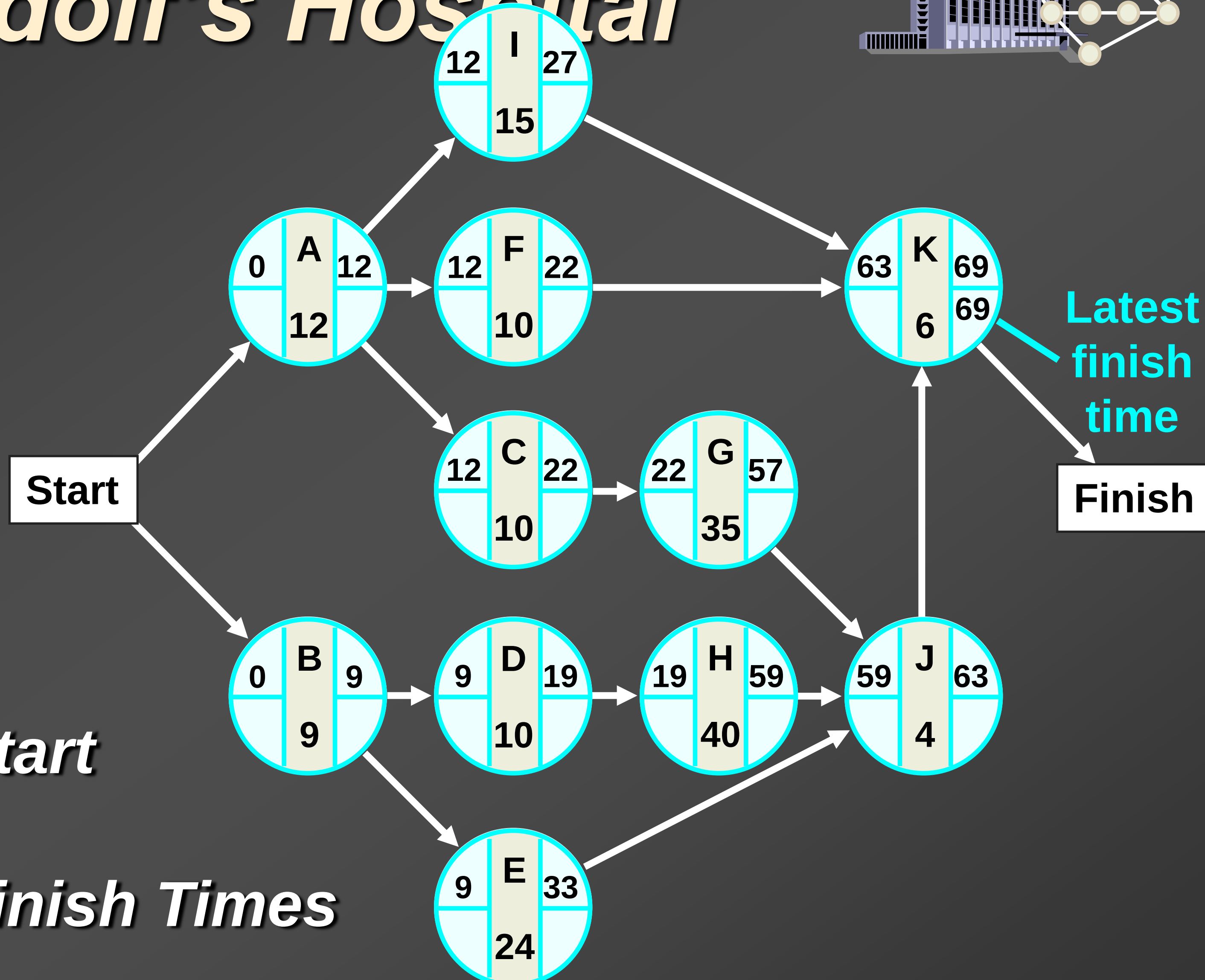




Latest Start
and
Latest Finish Times

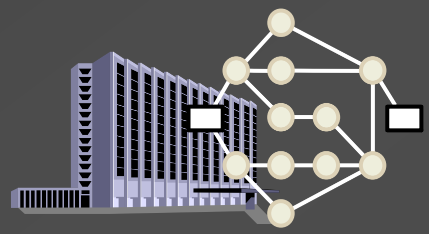
St. Adolf's Hospital

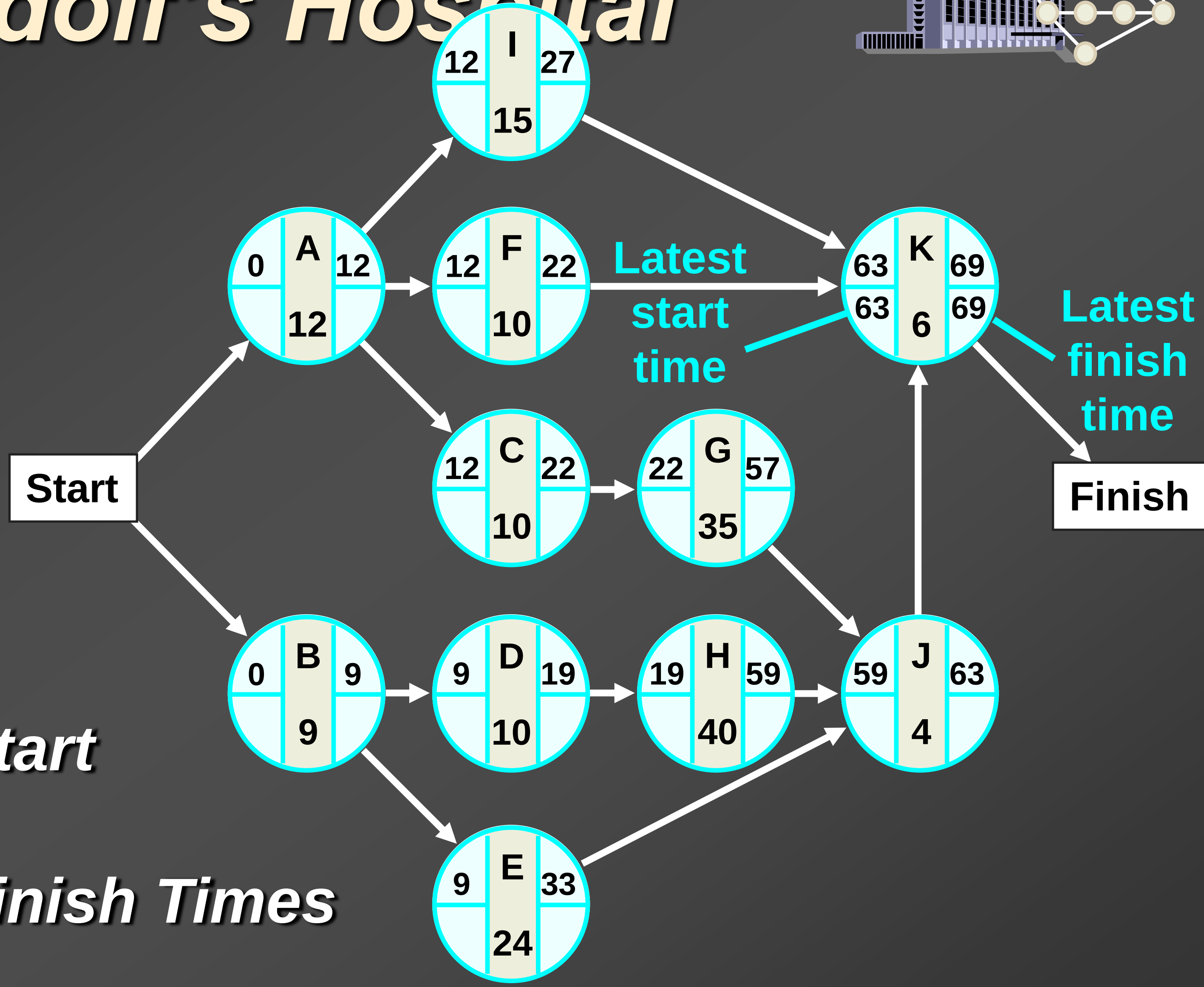




Latest Start and Latest Finish Times

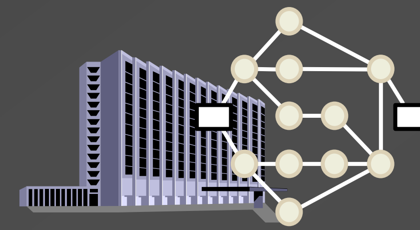
St. Adolf’s Hospital

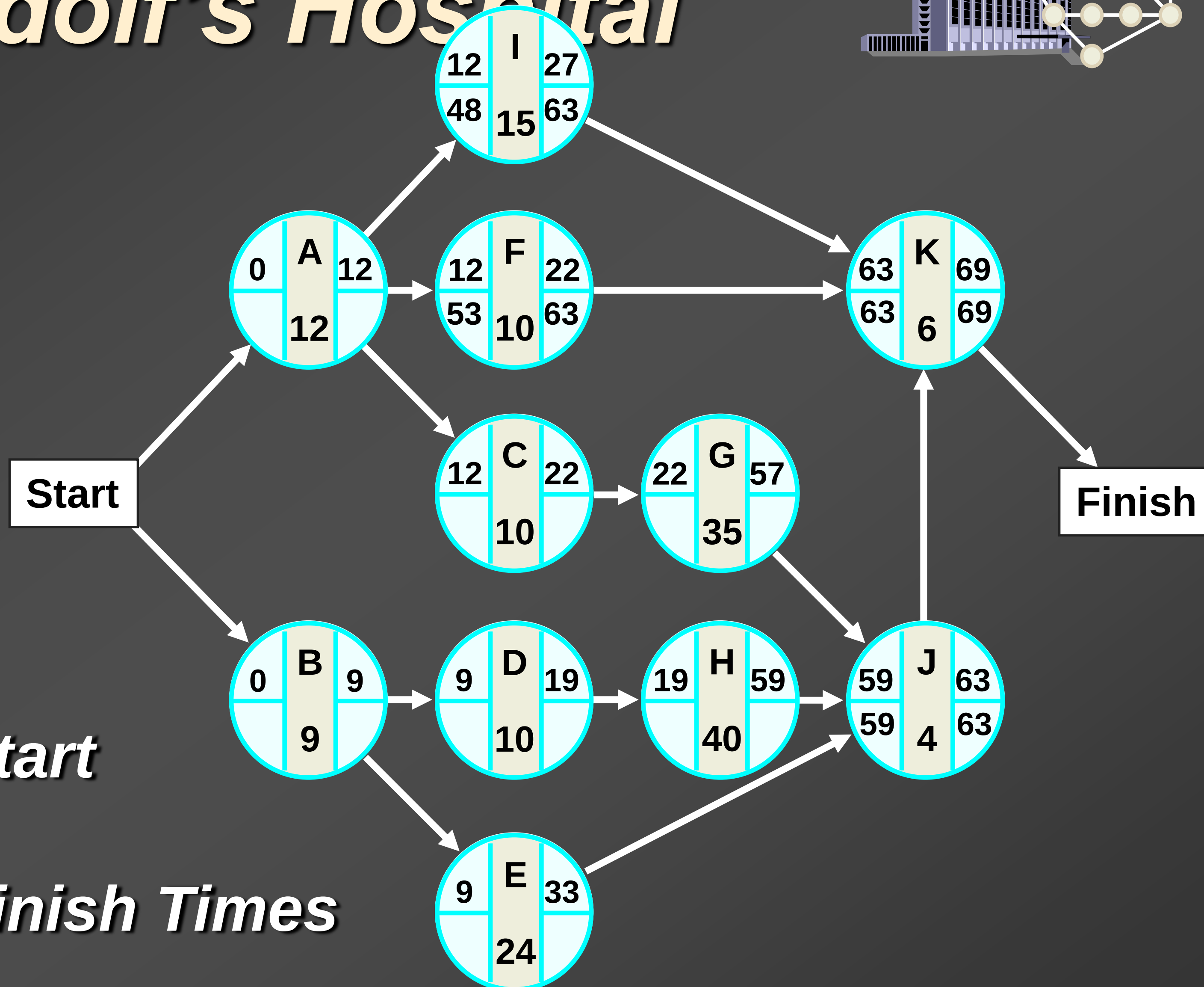




Latest Start and Latest Finish Times

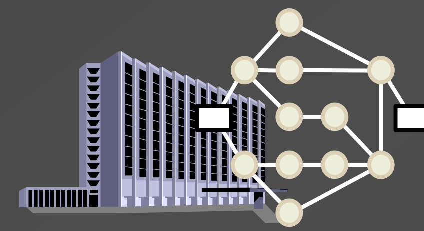
St. Adolf’s Hospital

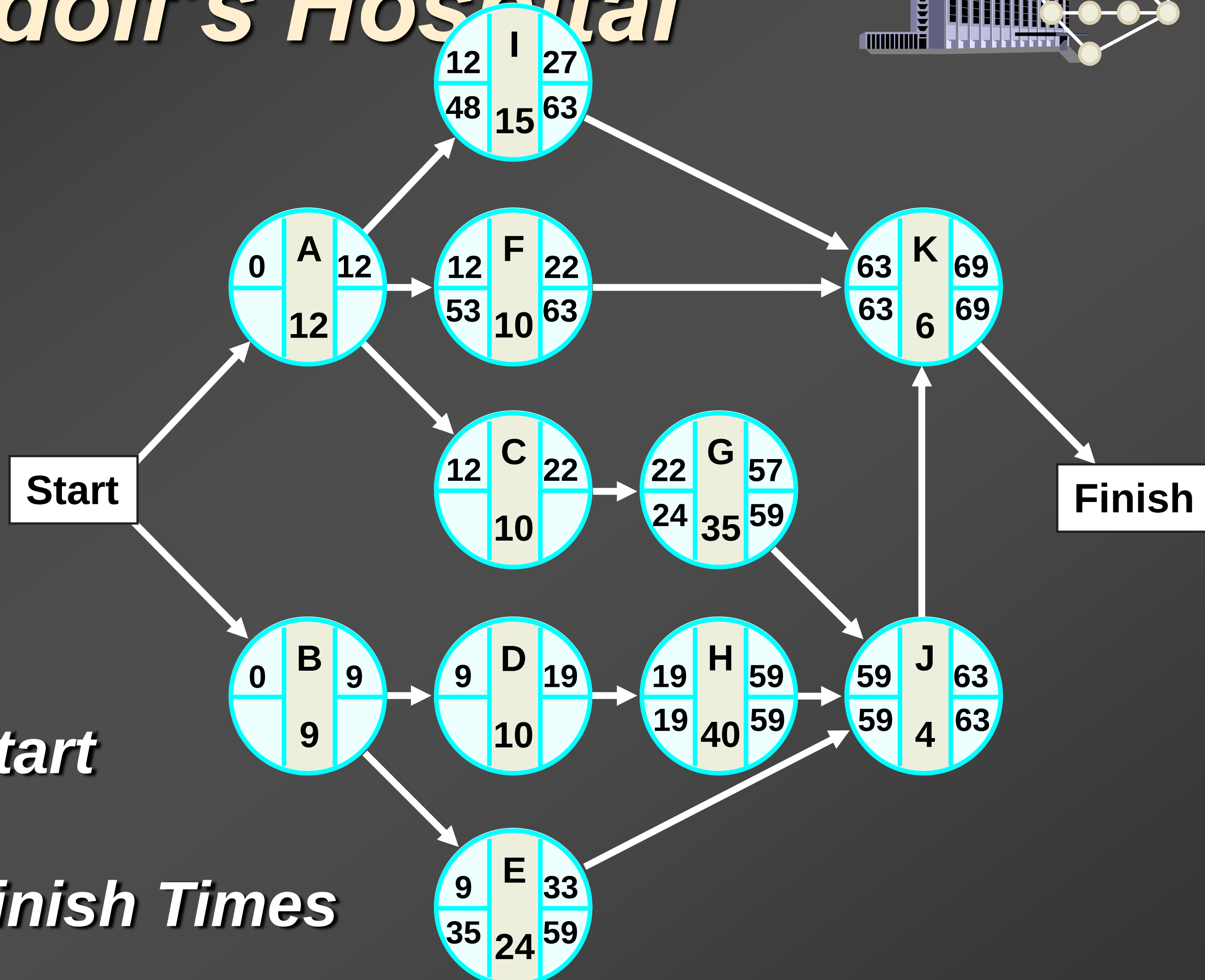




Latest Start and Latest Finish Times

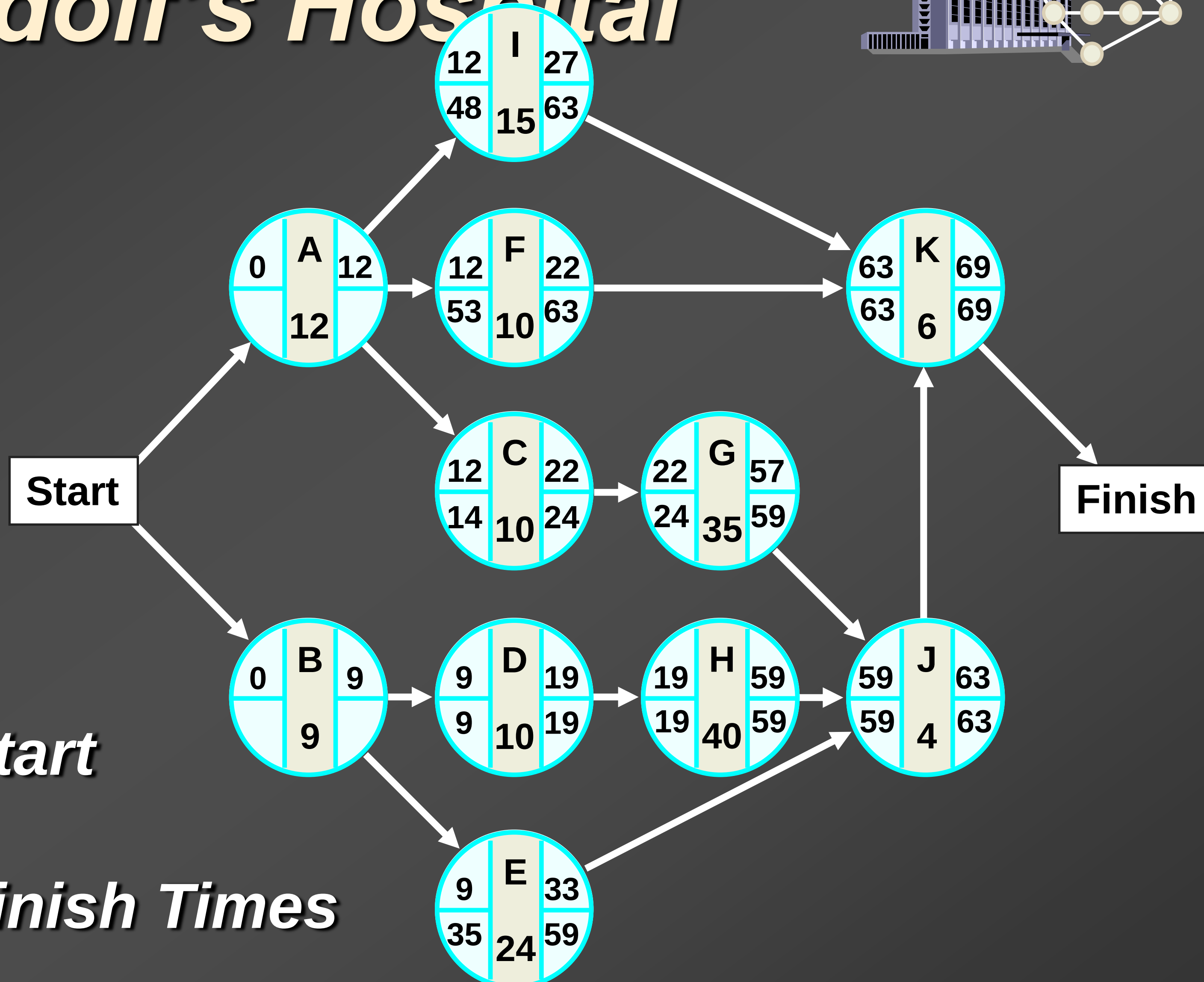
St. Adolf’s Hospital





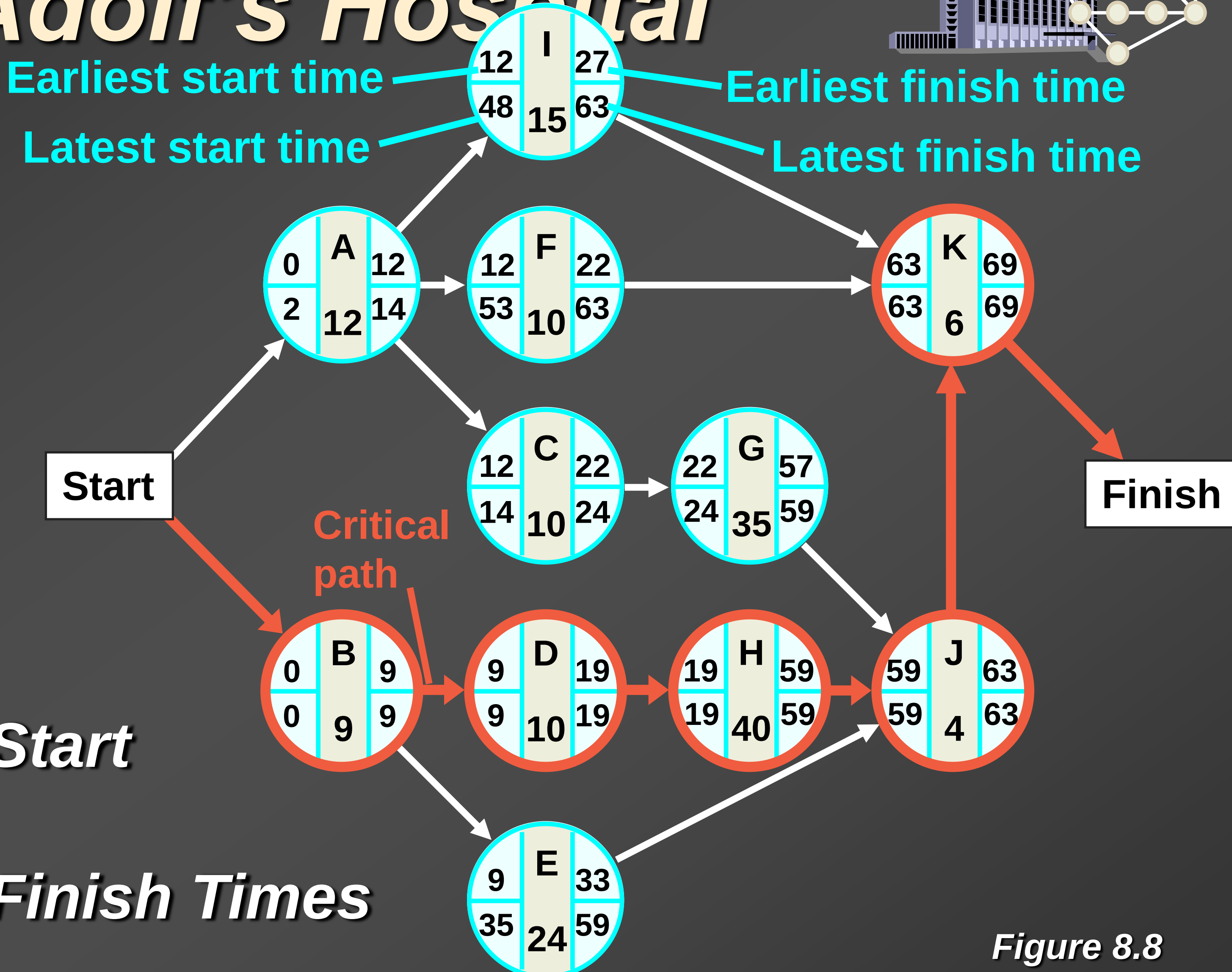
Latest Start
and
Latest Finish Times

St. Adolf's Hospital



Latest Start and Latest Finish Times

St. Adolf’s Hospital

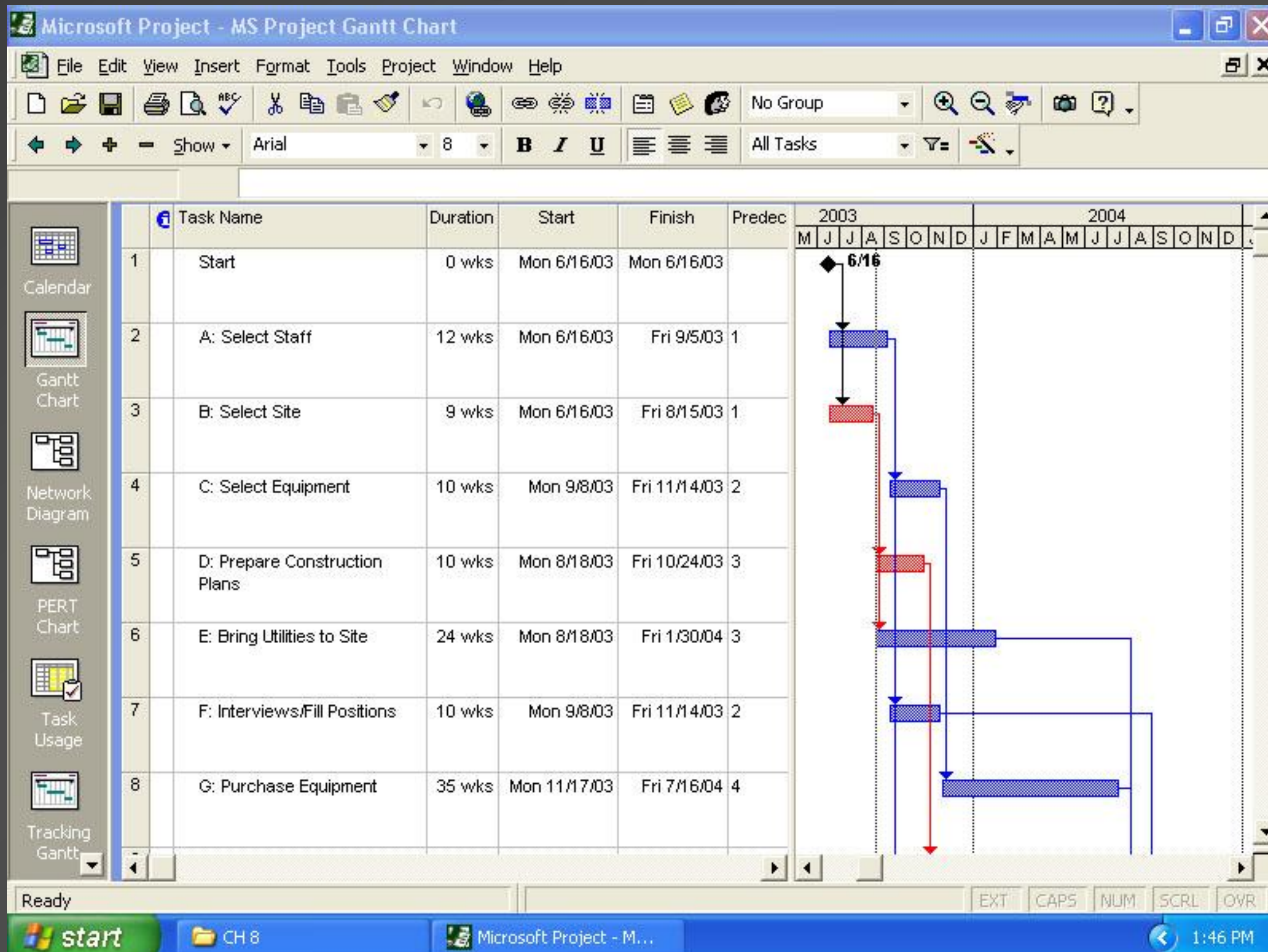


Latest Start and Latest Finish Times

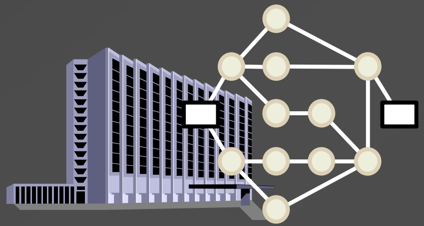
Figure 8.8

St. Adolf's Hospital

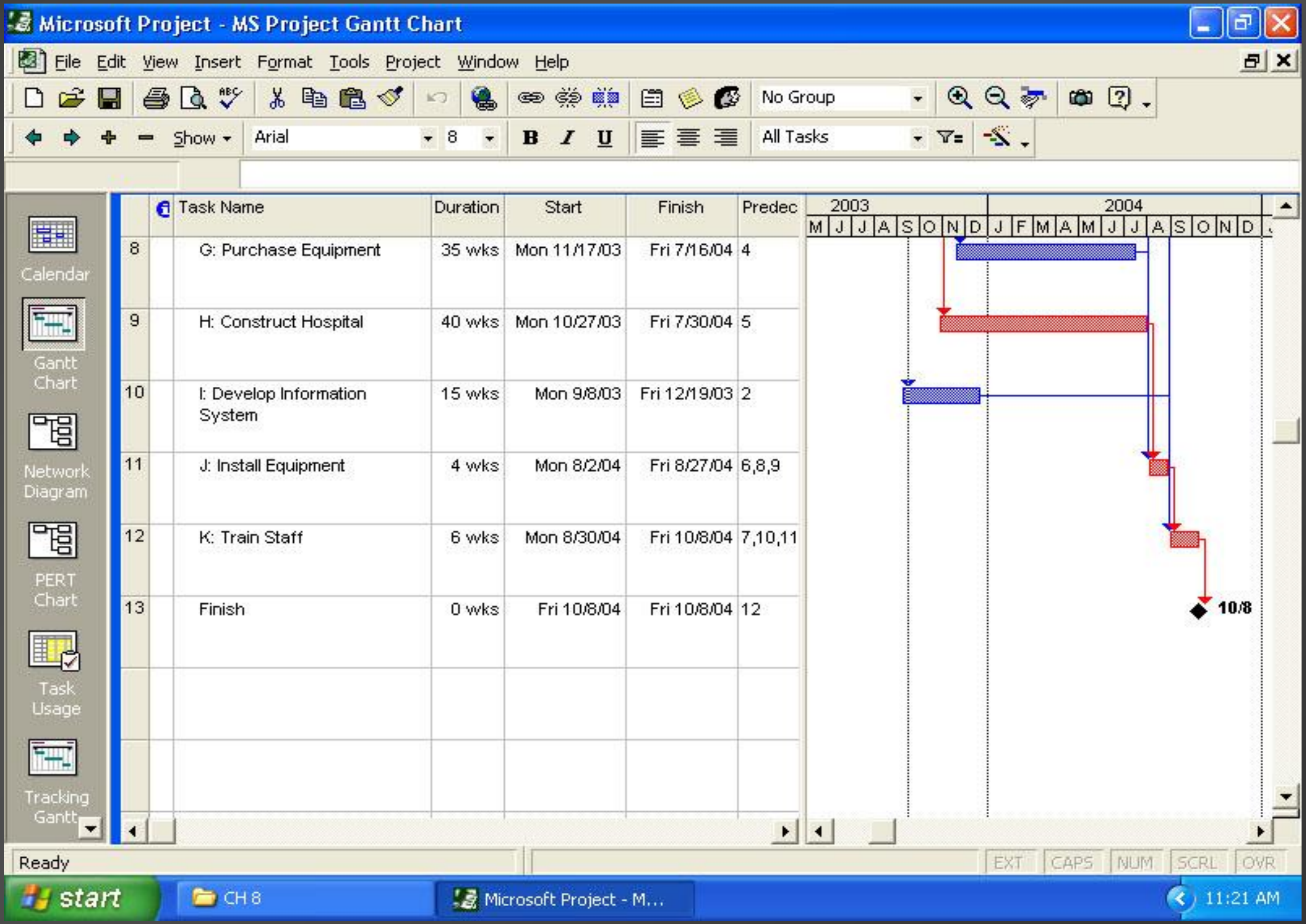
Gantt Charts



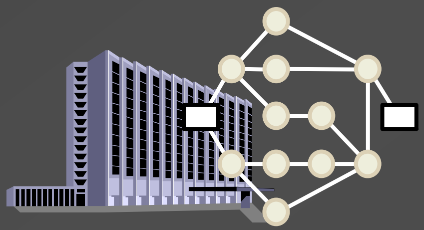
St. Adolf's Hospital



Gantt Charts



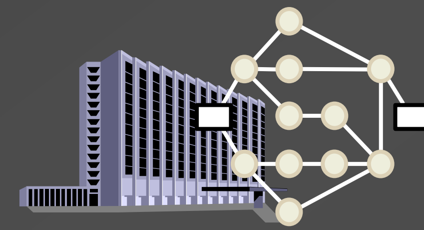
St. Adolf's Hospital

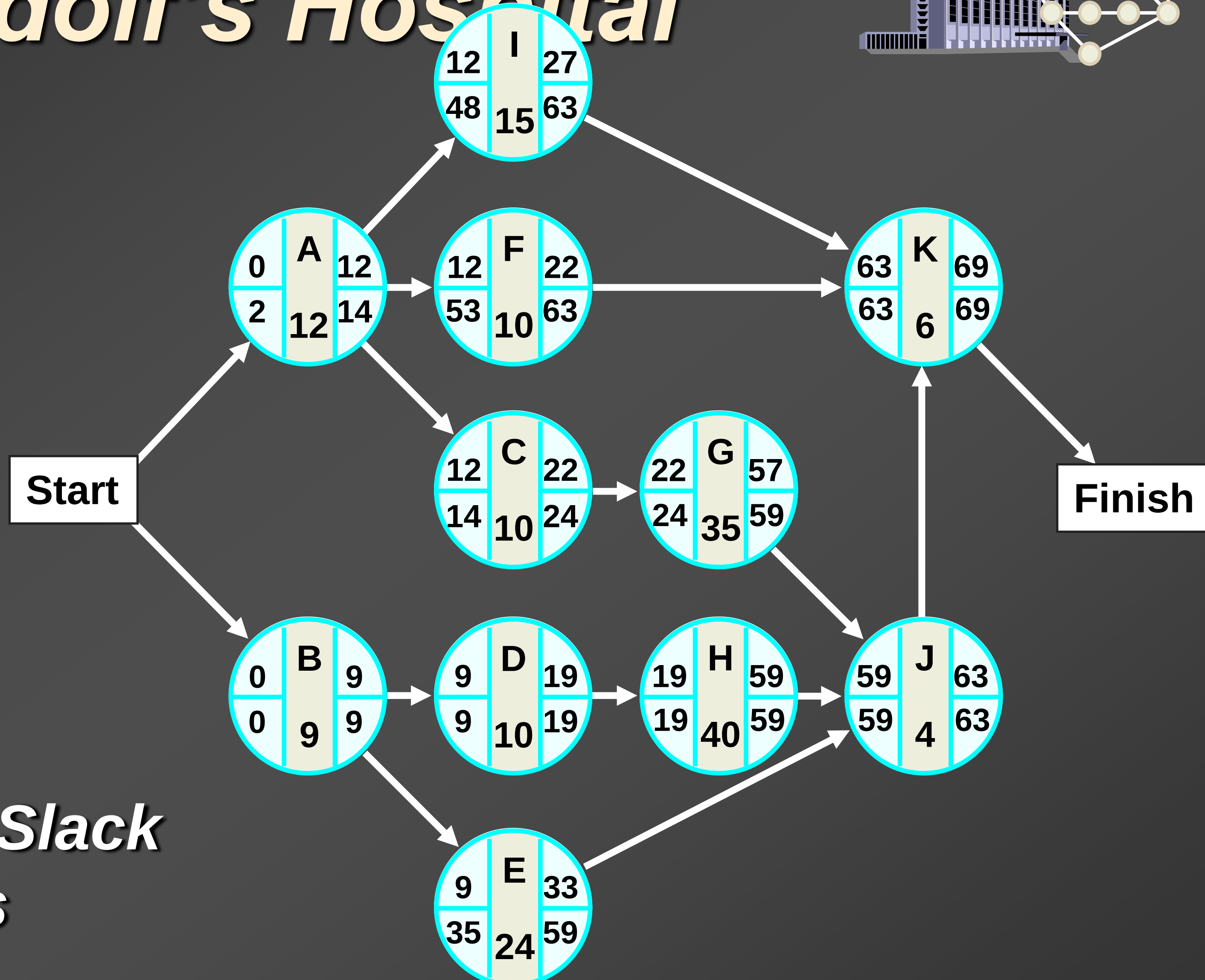


Activity Slack

	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

St. Adolf's Hospital

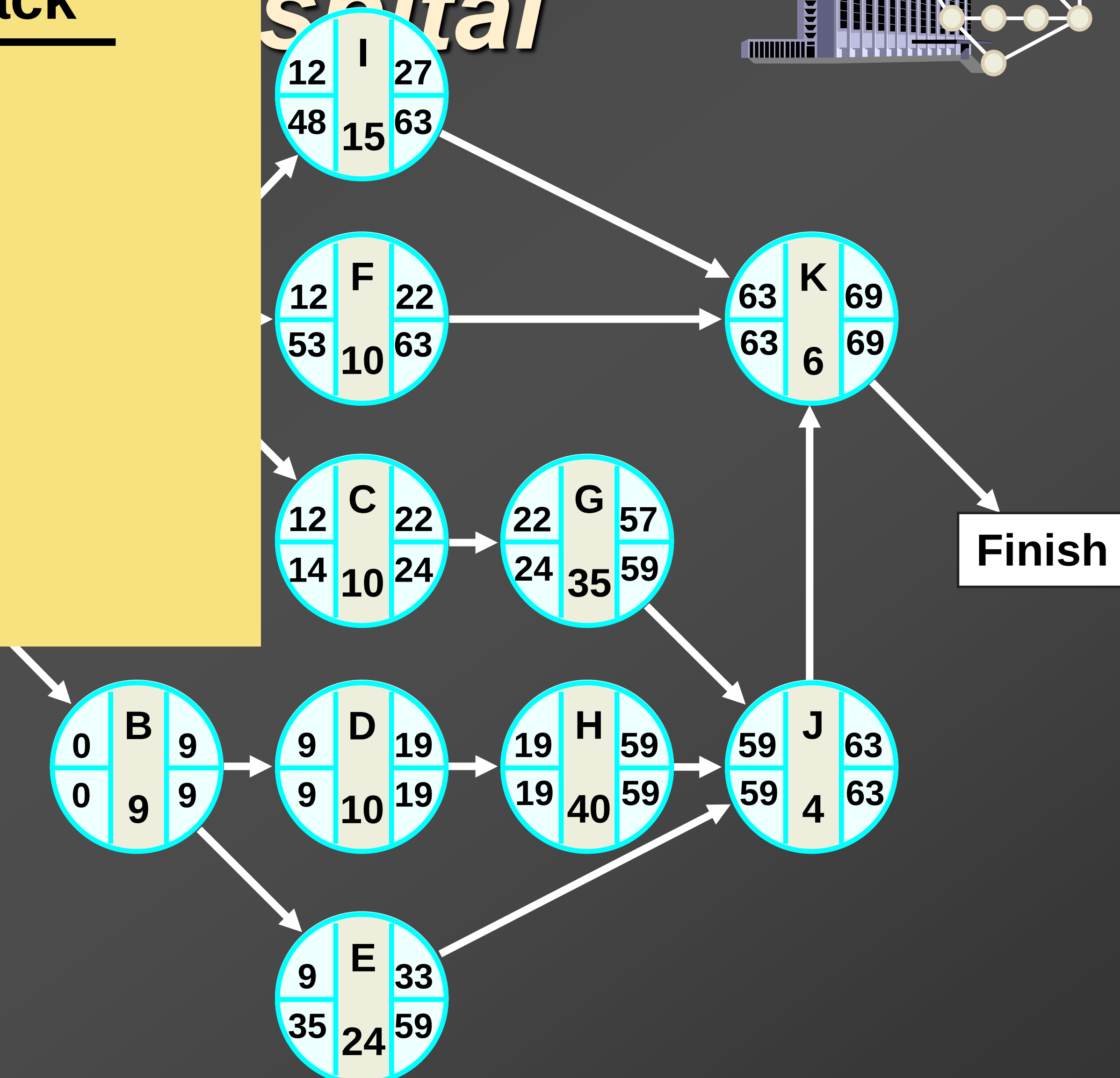




Activity Slack Analysis

Activity Slack

spital



Activity Slack Analysis

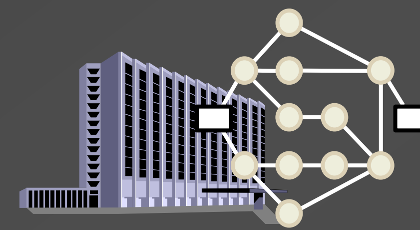
spital

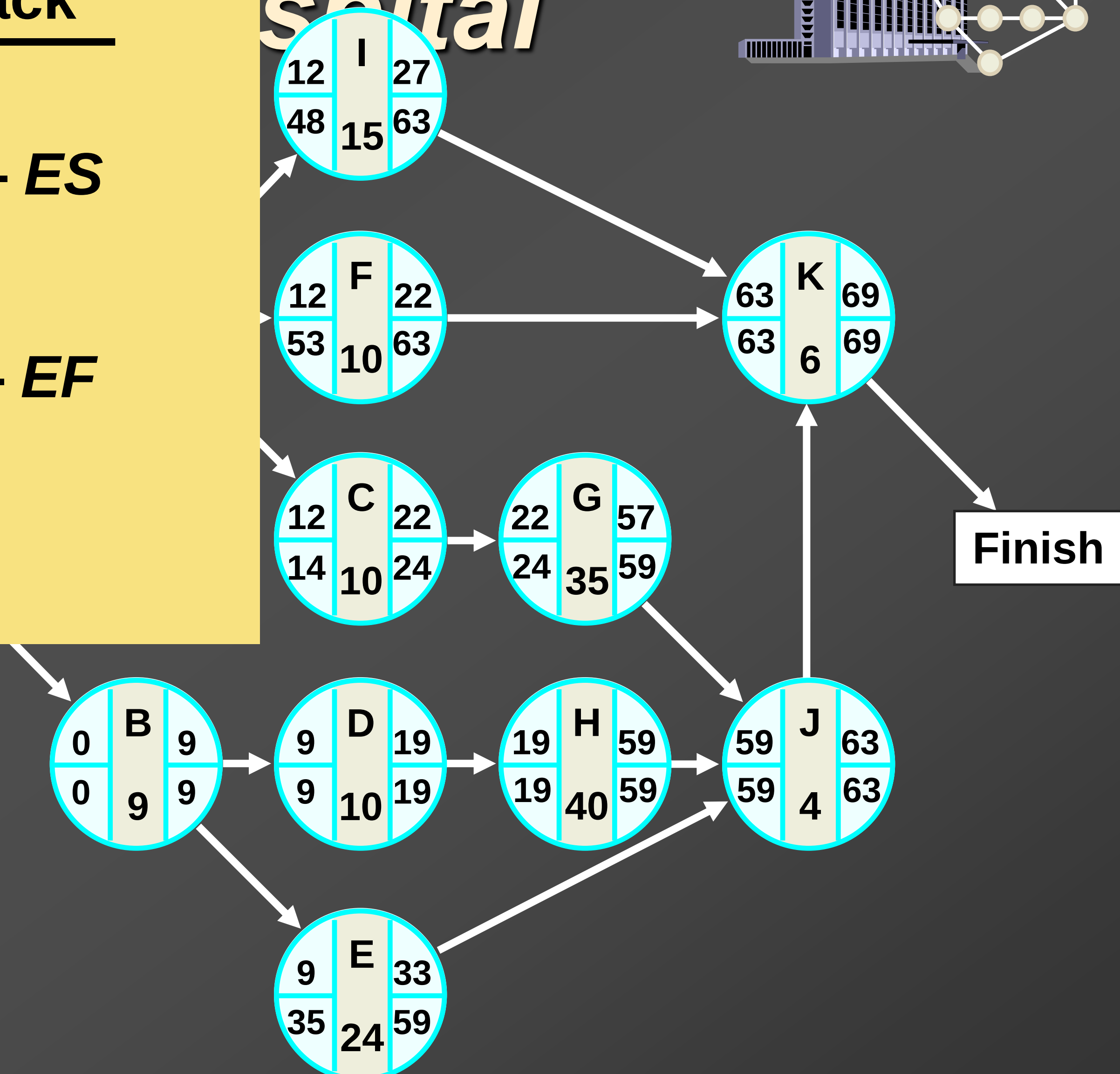
Activity Slack

Slack = *LS* – *ES*

or

Slack = *LF* – *EF*





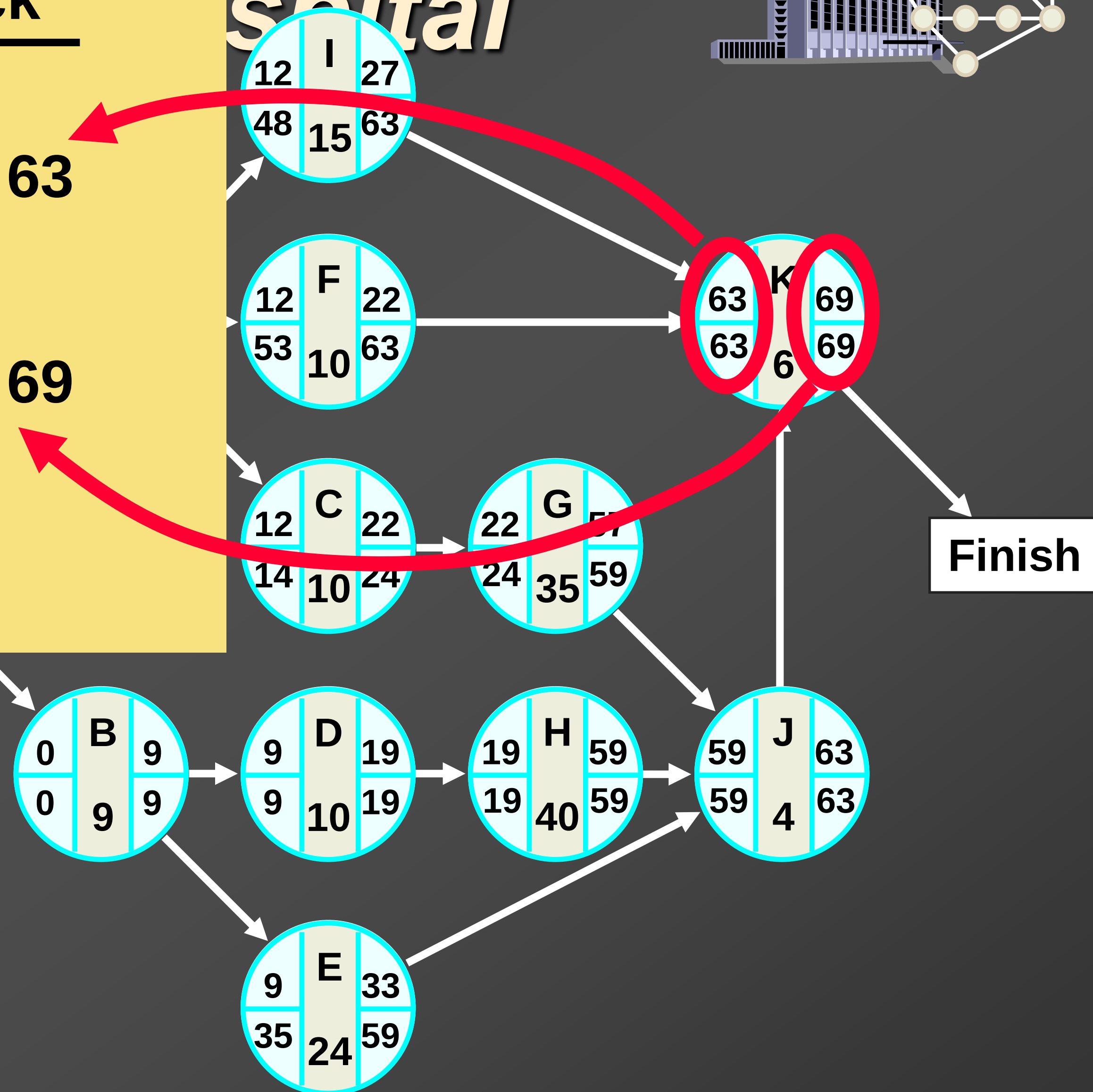
Activity Slack Analysis

Activity Slack

$$Slack_K = 63 - 63$$

or

$$Slack_K = 69 - 69$$



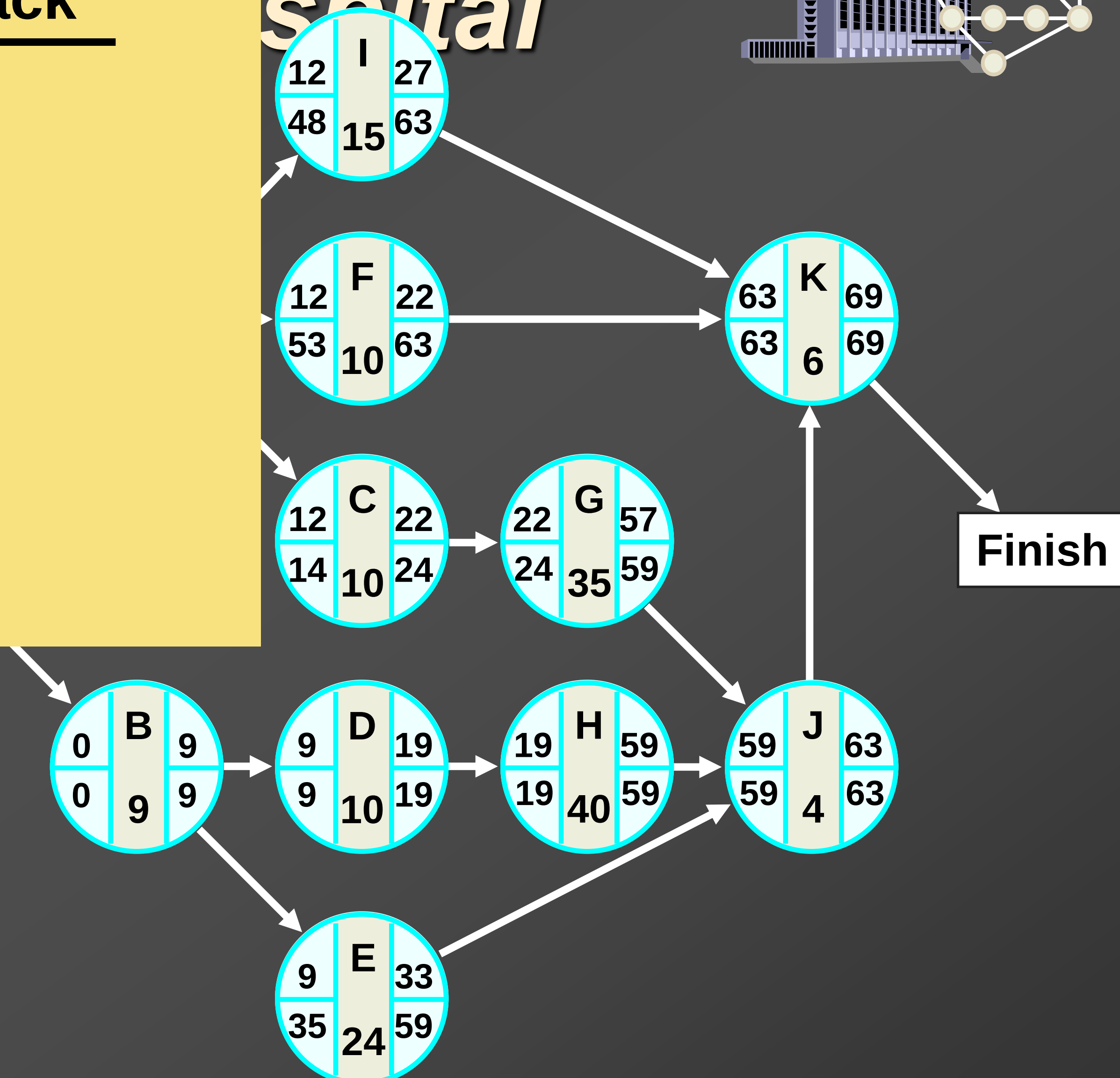
Activity Slack Analysis

Activity Slack

$Slack_K = 0$

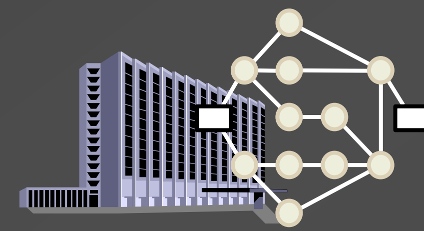
or

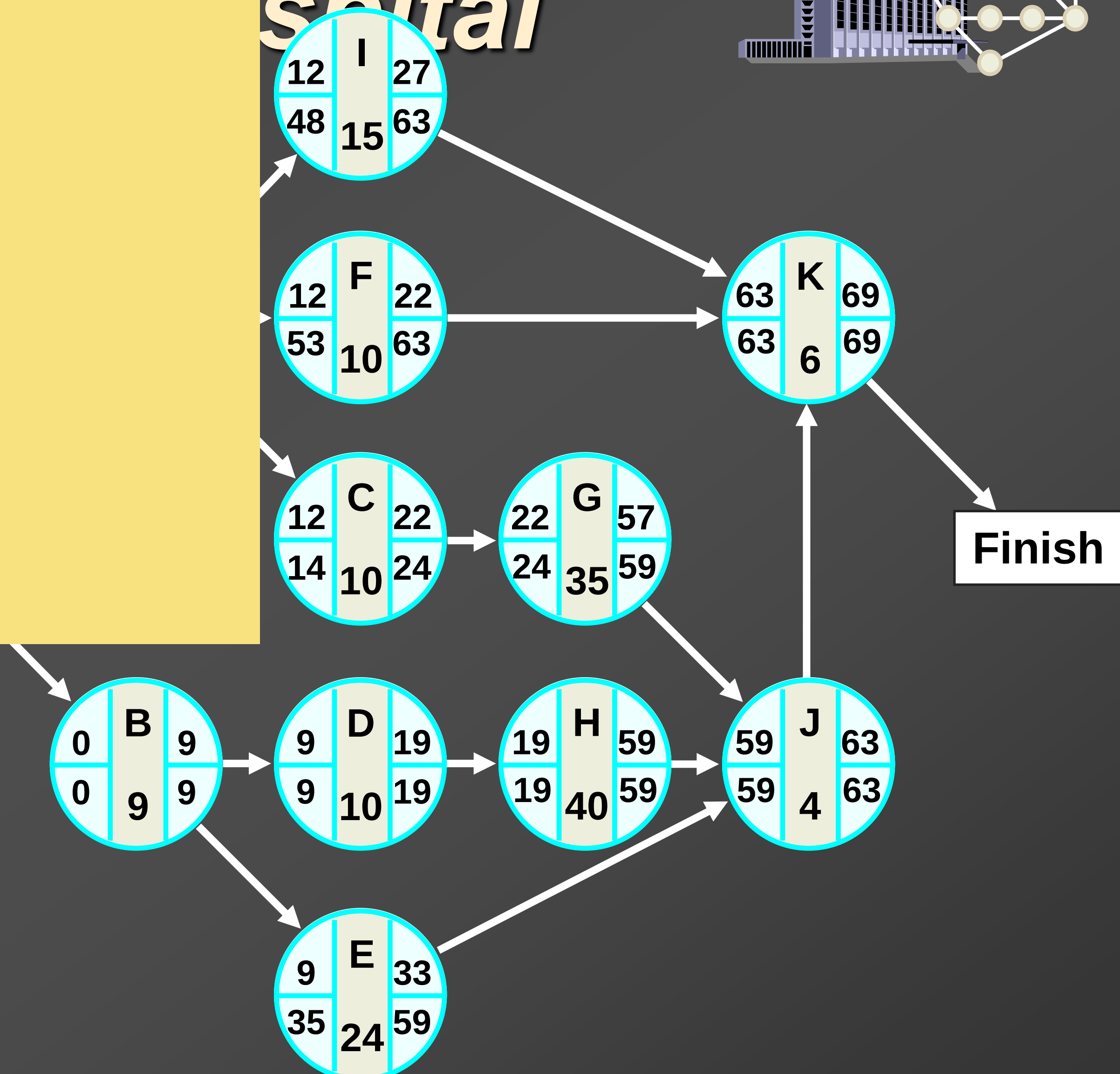
$Slack_K = 0$



Activity Slack Analysis

spital

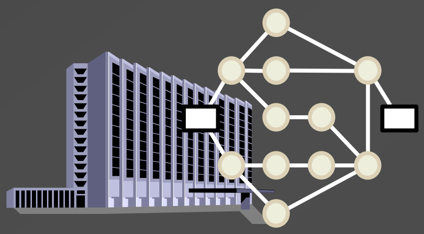


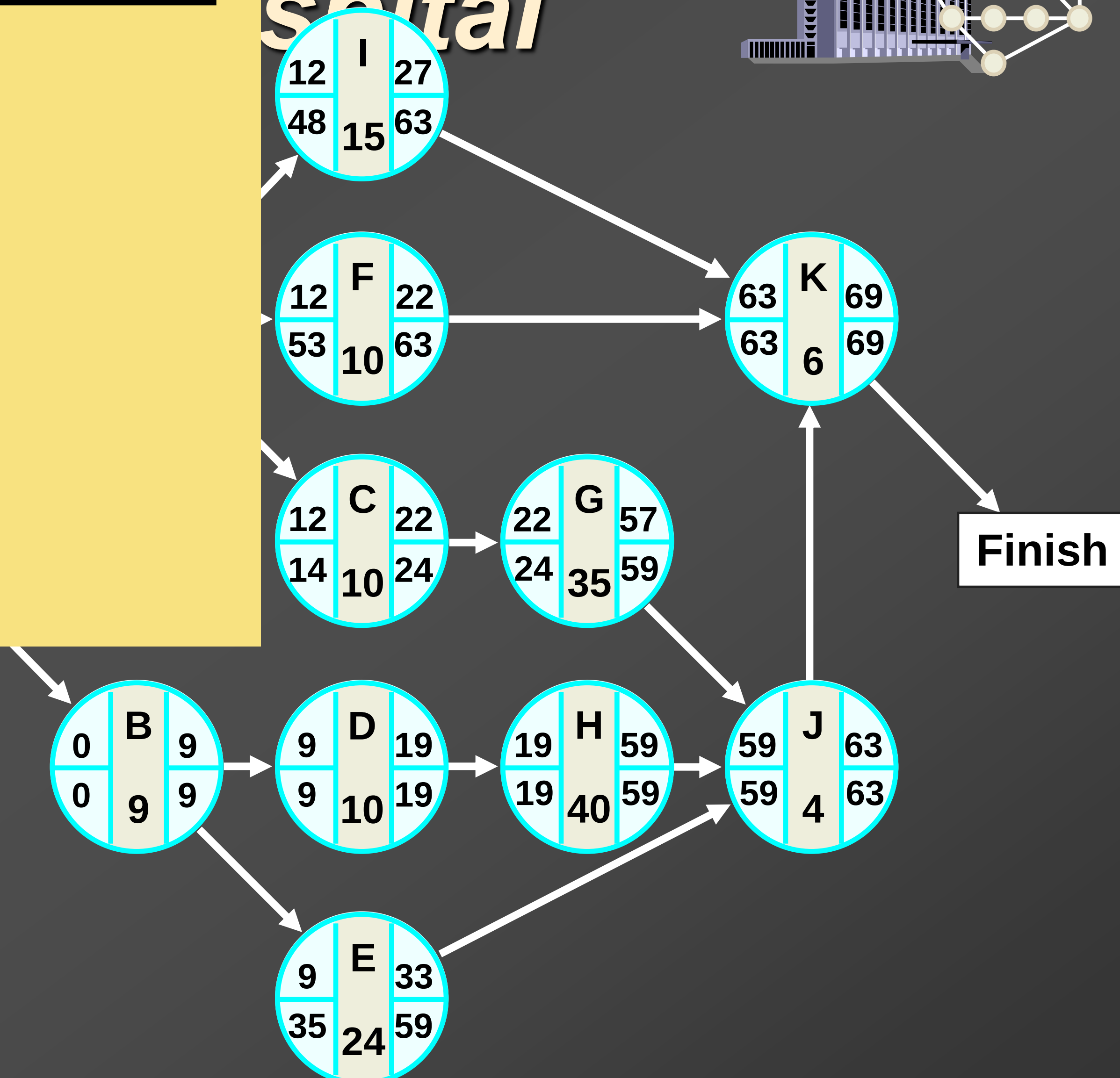


Activity Slack Analysis

Node	Duration	*ES*	*LS*	Slack

spital

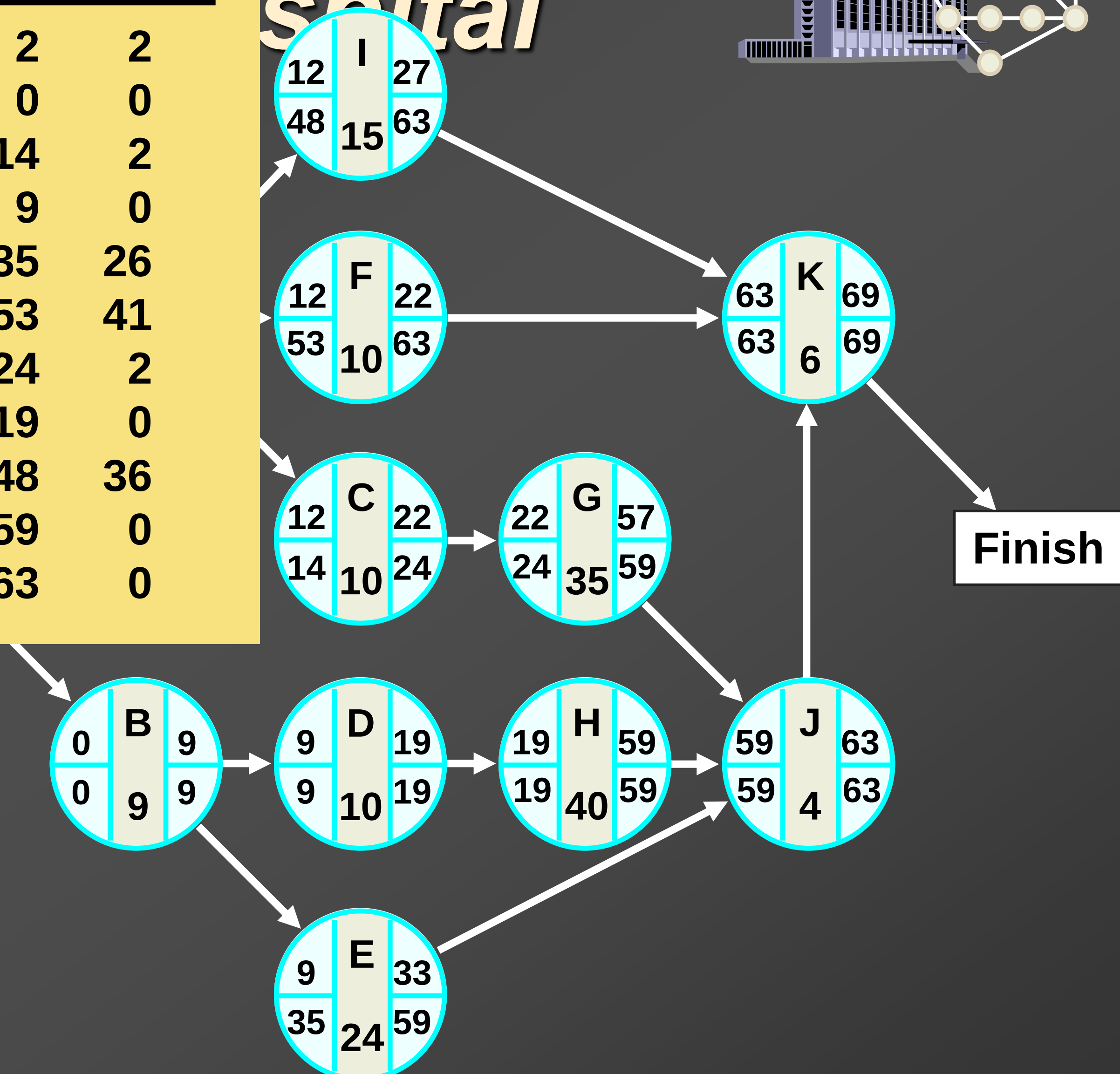




Activity Slack Analysis

spital

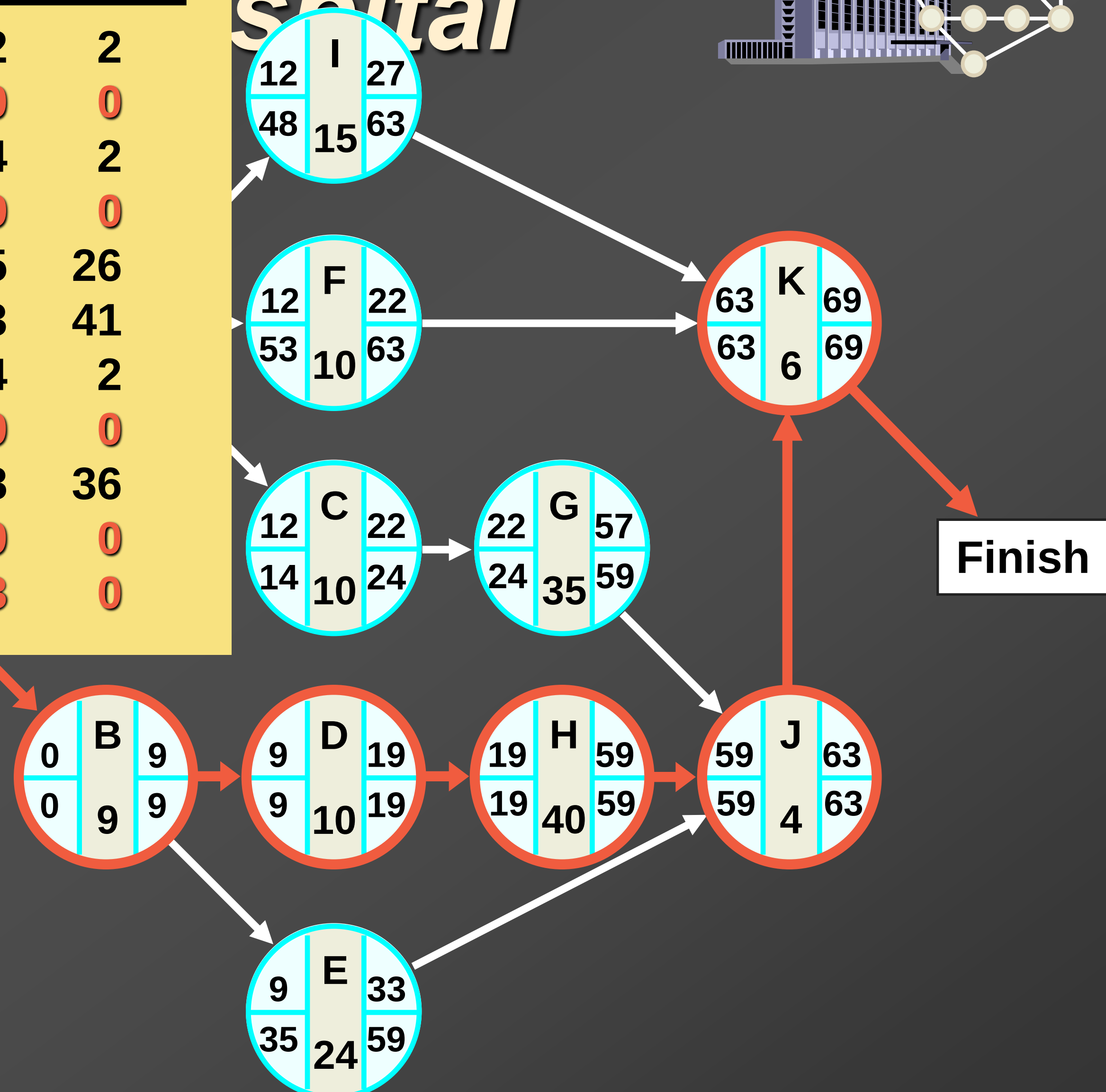
Node	Duration	*ES*	*LS*	Slack
A	12	0	2	2
B	9	0	0	0
C	10	12	14	2
D	10	9	9	0
E	24	9	35	26
F	10	12	53	41
G	35	22	24	2
H	40	19	19	0
I	15	12	48	36
J	4	59	59	0
K	6	63	63	0



Activity Slack Analysis

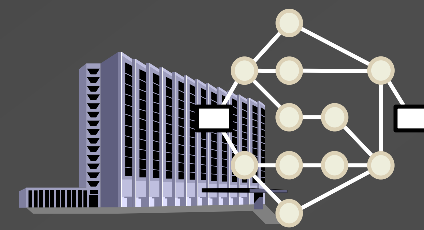
spital

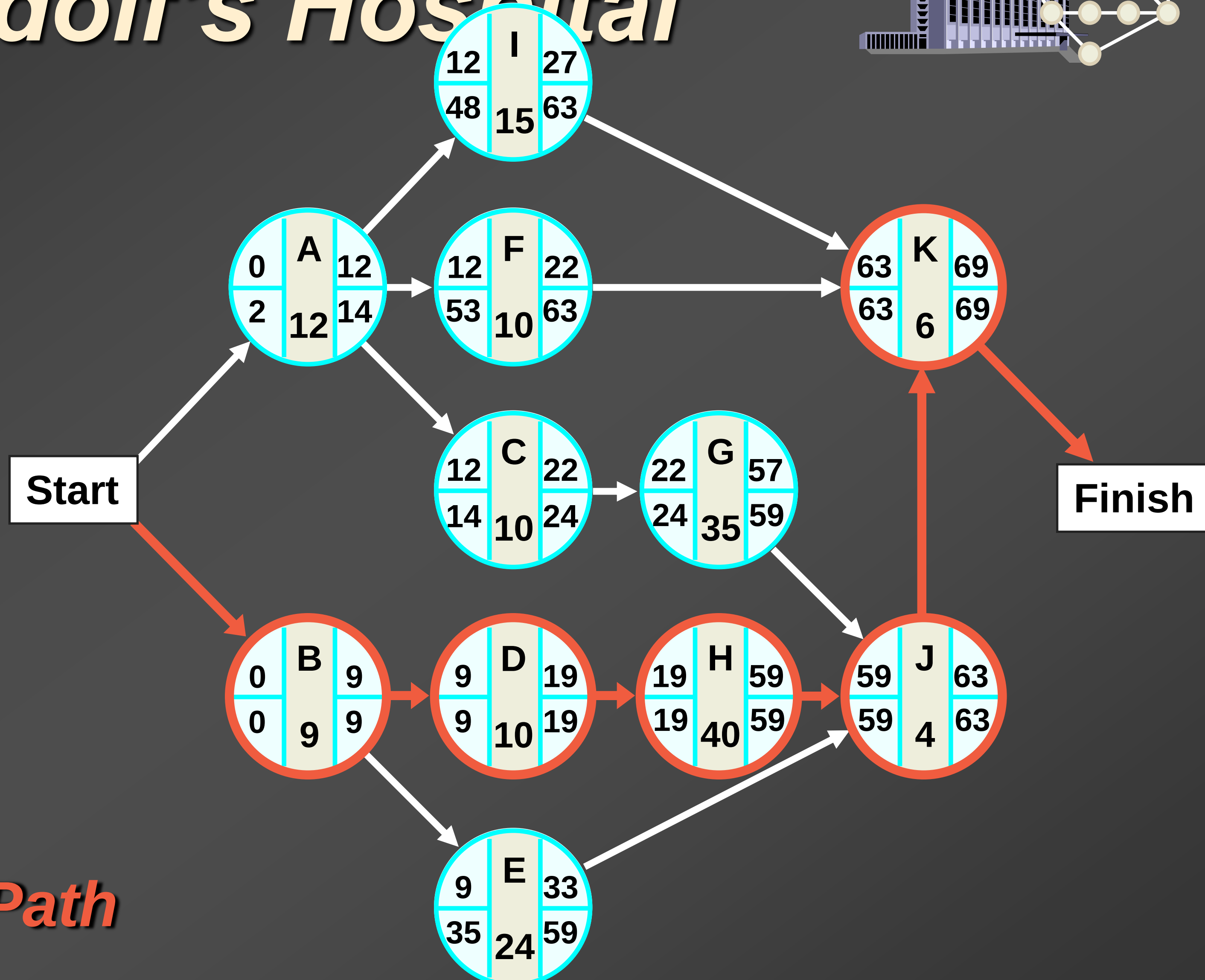
Node	Duration	*ES*	*LS*	Slack
A	12	0	2	2
B	9	0	0	0
C	10	12	14	2
D	10	9	9	0
E	24	9	35	26
F	10	12	53	41
G	35	22	24	2
H	40	19	19	0
I	15	12	48	36
J	4	59	59	0
K	6	63	63	0



Critical Path

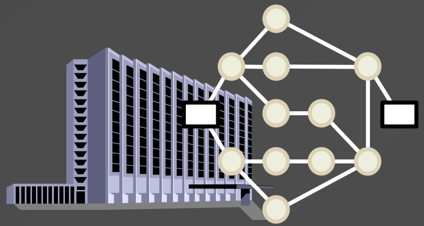
St. Adolf’s Hospital



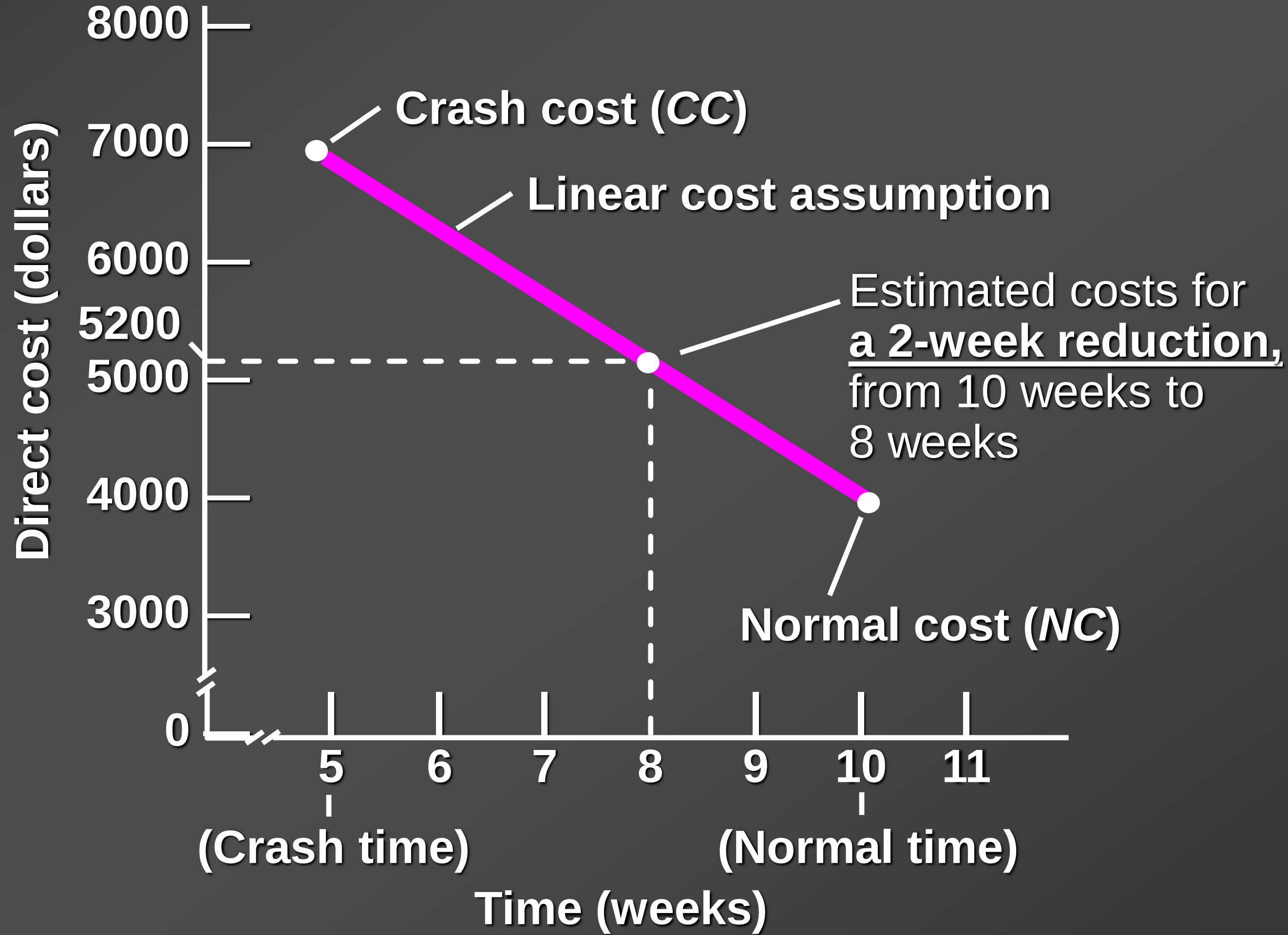


Critical Path

St. Adolf's Hospital



Cost-Time Relationships in Cost Analysis



St. Adolf's Hospital

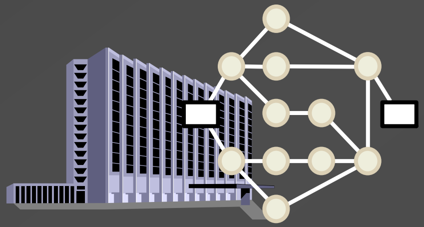
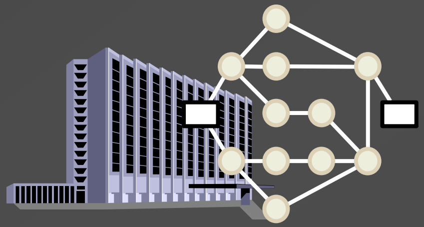


TABLE 8.1 DIRECT COST AND TIME DATA FOR THE ST. ADOLF'S HOSPITAL PROJECT

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		

St. Adolf’s Hospital



Minimum-Cost Schedule

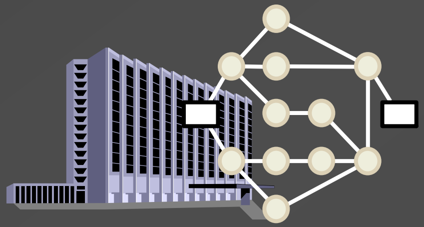
~~A-I-K:~~	33 weeks	B-D-H-J-K:	69 weeks
~~A-F-K:~~	28 weeks	~~B-E-J-K:~~	43 weeks
A-C-G-J-K:	67 weeks		

Total cost = $2,624,000
Indirect costs = $8,000/week
Penalty cost = $20,000/week after week 65

Critical Path B-D-H-J-K: 69 weeks

Crash Activity J by 3 weeks @ $1,000/week

St. Adolf's Hospital



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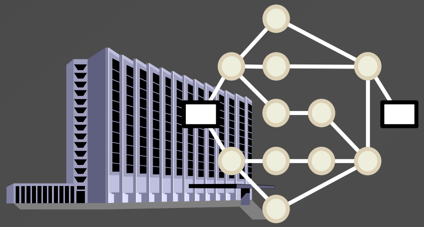
Total cost = $2,624,000
Indirect costs = $8,000/week
Penalty cost = $20,000/week after week 65

Critical Path B-D-H-J-K: 69 weeks

Crash Activity J by 3 weeks @ $1,000/week

3($28,000) – 3($1,000) = $81,000

St. Adolf's Hospital



Minimum-Cost Schedule

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~~A-F-K:~~	28 weeks	~~B-E-J-K:~~	43 weeks
A-C-G-J-K:	67 weeks		

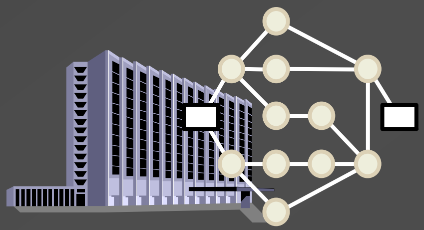
Total cost = $2,624,000
Indirect costs = $8,000/week
Penalty cost = $20,000/week after week 65

Critical Path B-D-H-J-K: 66 weeks

Crash Activity J by 3 weeks @ $1,000/week

3($28,000) – 3($1,000) = $81,000
$2,624,000 – $81,000 = $2,543,000

St. Adolf's Hospital



Minimum-Cost Schedule

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St. Adolf's Hospital

Minimum

A-I-K:
A-F-K:
A-C-G-J-K

Total c
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Critical P

Crash Ac

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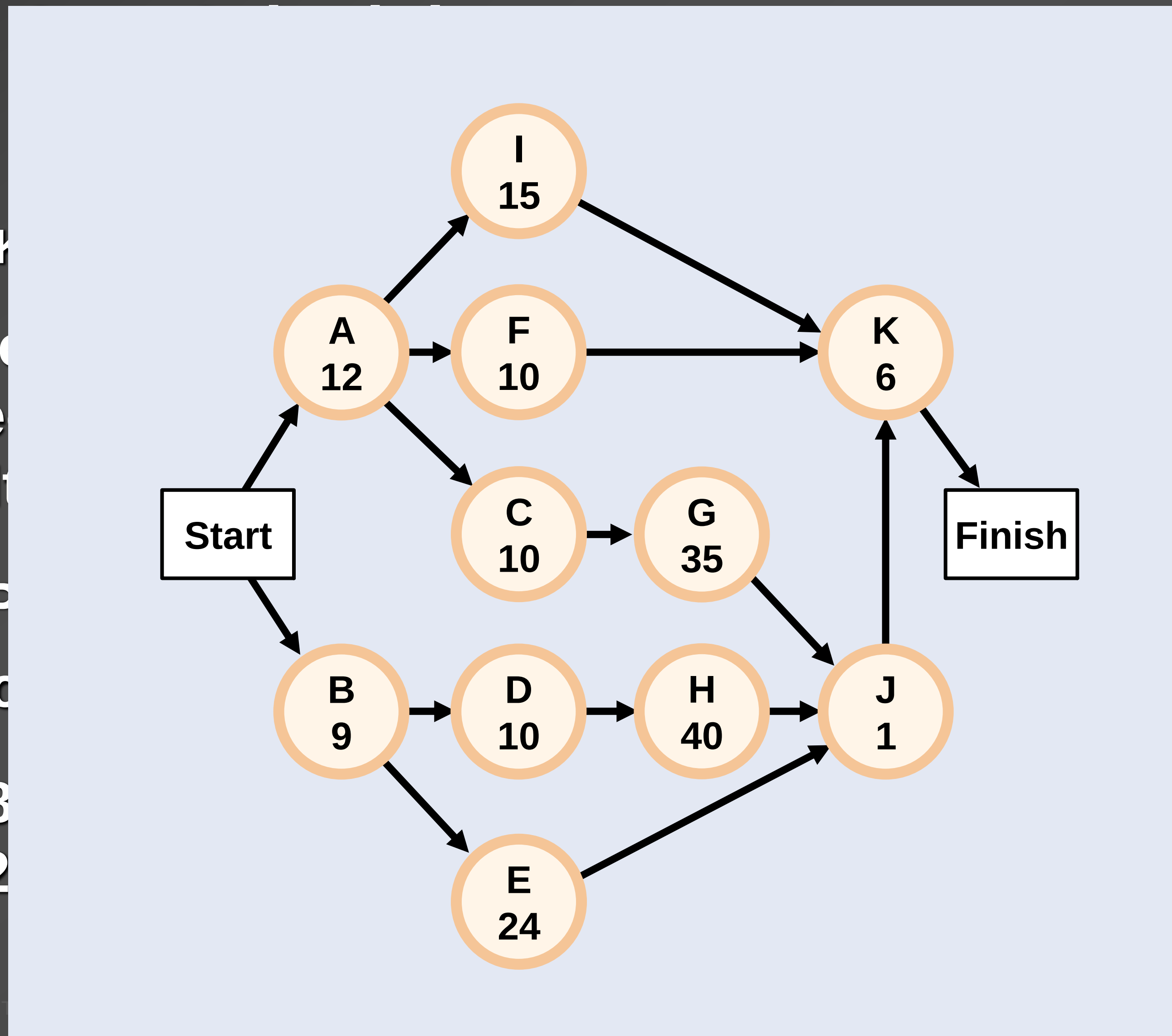
$2,62



St. Ado

Minimum C

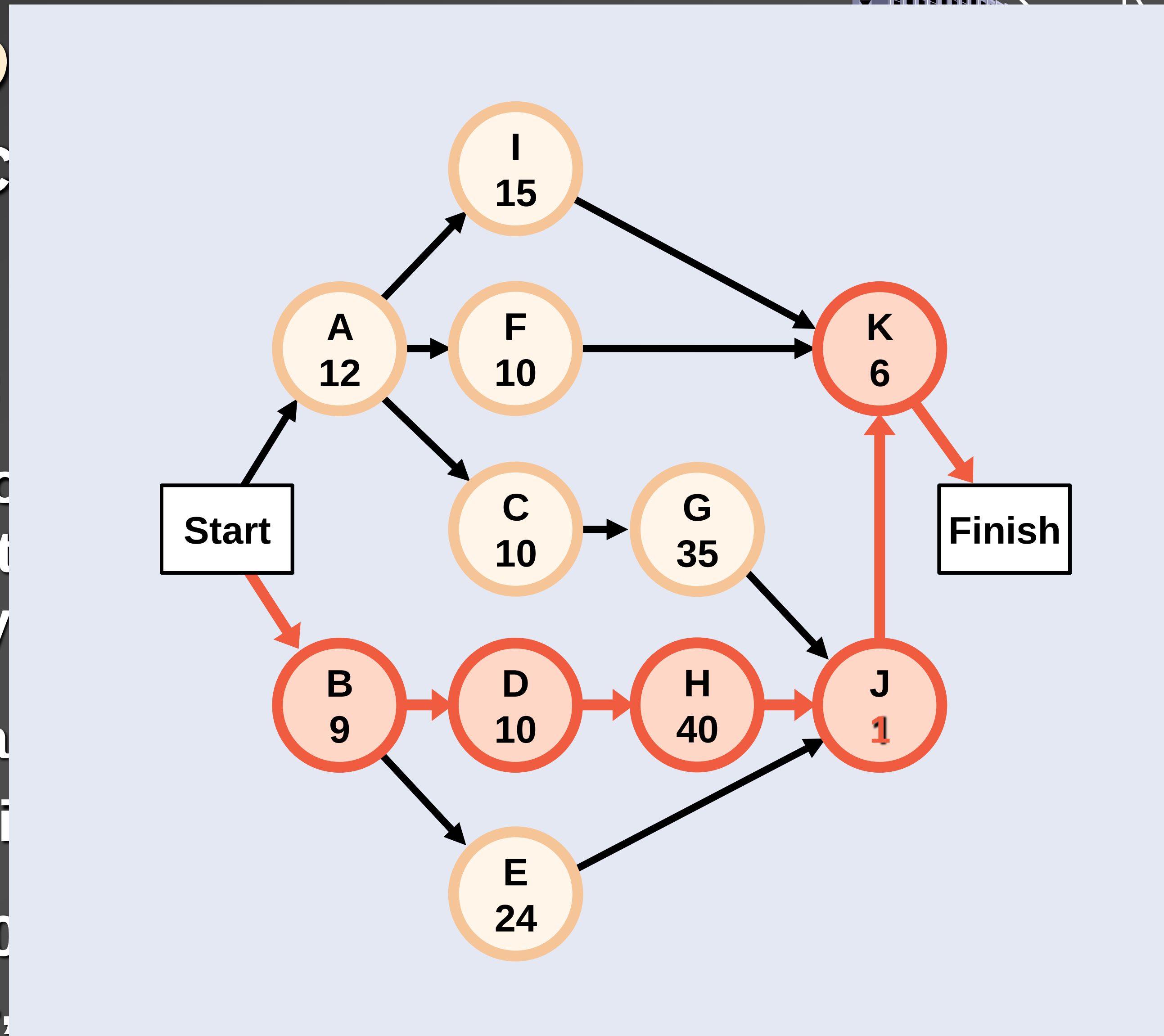
A-I-K:
A-F-K:
A-C-G-J-K:

Total co
Indirect
Penalty

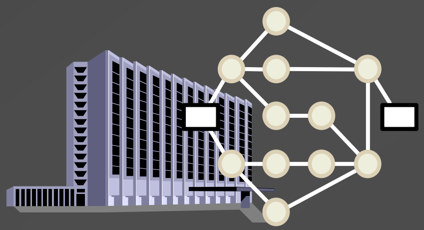
Critical Pa

Crash Acti

3($28,0
$2,624,



St. Adolf’s Hospital



Minimum-Cost Schedule

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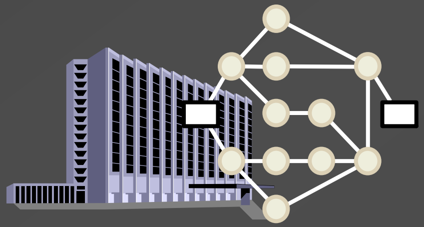
Total cost = ~~$2,624,000~~ $2,543,000
Indirect costs = $8,000/week
Penalty cost = $20,000/week after week 65

Critical Path B-D-H-J-K: 66 weeks

Crash Activity D by 2 weeks @ $2,000/week

St. Adolf's Hospital



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A-C-G-J-K:	67 weeks		

Total cost = ~~$2,624,000~~ $2,543,000

Indirect costs = $8,000/week

Penalty cost = $20,000/week after week 65

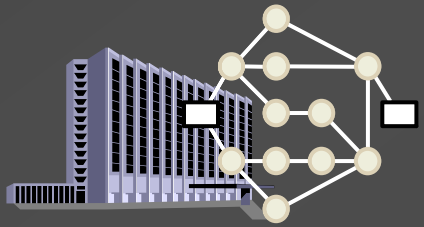
Critical Path B-D-H-J-K: 66 weeks

Crash Activity D by 2 weeks @ $2,000/week

$28,000 + $8,000 – 2($2,000) = $32,000

$2,543,000 – $32,000 = $2,511,000

St. Adolf's Hospital



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A-C-G-J-K:	67 weeks		

Total cost = ~~$2,624,000~~ $2,511,000
Indirect costs = $8,000/week
Penalty cost = $20,000/week after week 65

Critical Path B-D-H-J-K: 64 weeks

Crash Activity D by 2 weeks @ $2,000/week

$28,000 + $8,000 – 2($2,000) = $32,000
$2,543,000 – $32,000 = $2,511,000

St. Ado

Minimum-C

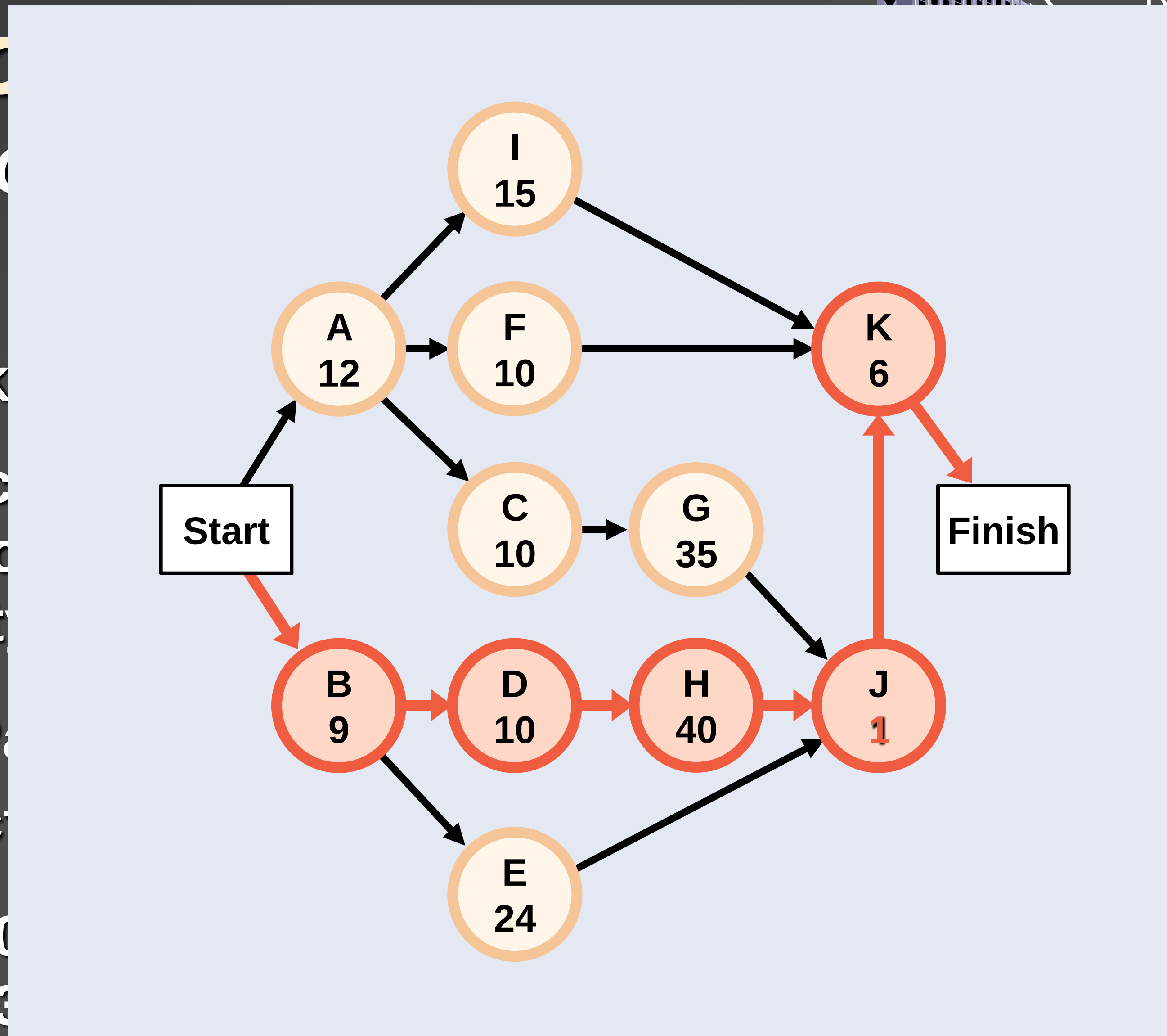
~~A-I-K:~~
~~A-F-K:~~
A-C-G-J-K

Total c
Indirec
Penalty

Critical Pa

Crash Act

$28,00
$2,543



St. Ado

Minimum-C

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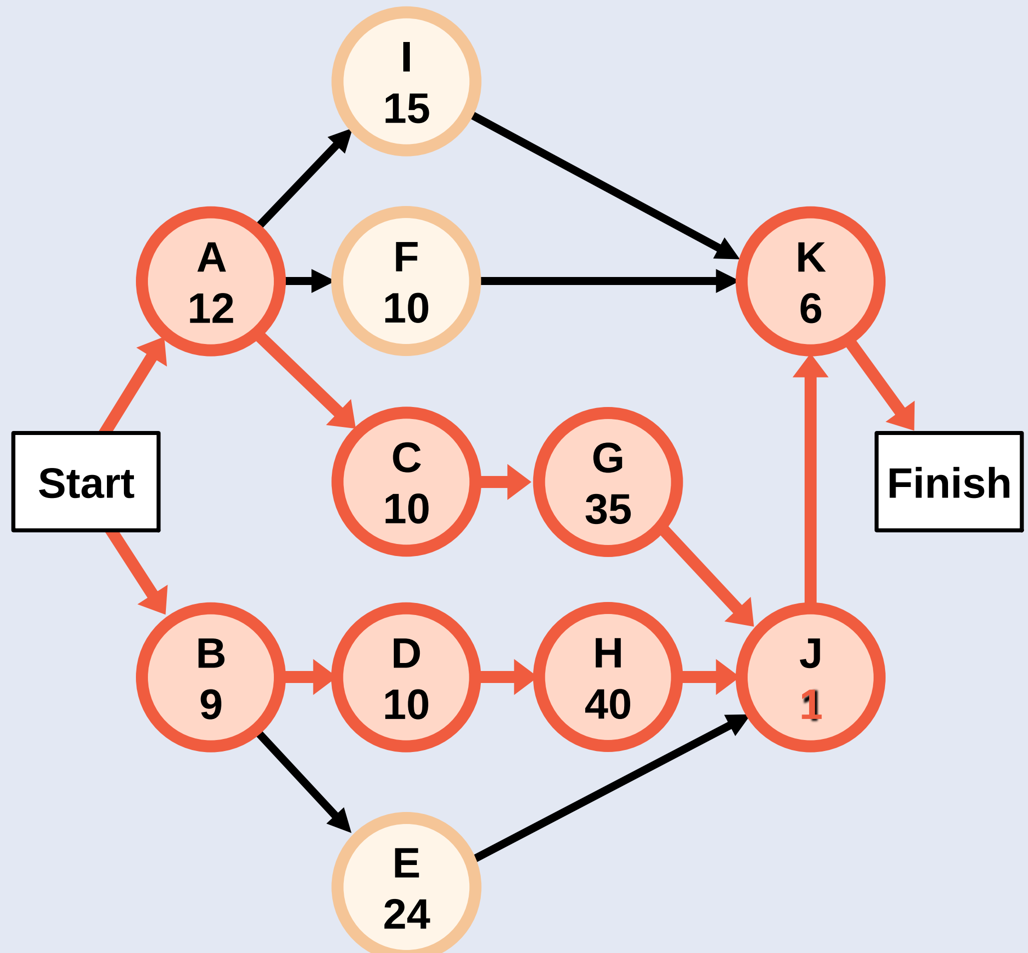
A-C-G-J-K

Total c
Indirec
Penalty

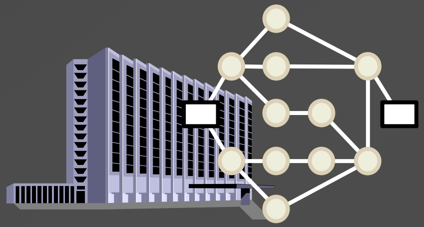
Critical Pa

Crash Act

$28,00
$2,543



St. Adolf’s Hospital



Minimum-Cost Schedule

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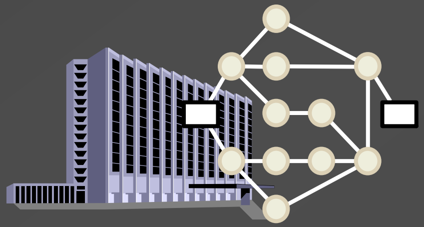
A-C-G-J-K: 67 weeks
B-D-H-J-K: 69 weeks
~~B-E-J-K:~~ 43 weeks

Total cost = ~~$2,624,000~~ $2,511,000
Indirect costs = $8,000/week
Penalty cost = $20,000/week after week 65

Critical Paths B-D-H-J-K and A-C-G-J-K: 64 weeks

Crash Activity K by 1 week @ $4,000/week

St. Adolf’s Hospital



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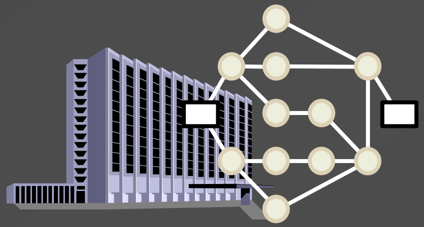
Critical Paths B-D-H-J-K and A-C-G-J-K: 64 weeks

Crash Activity K by 1 week @ $4,000/week

$8,000 – $4,000 = $4,000
$2,511,000 – $4,000 = $2,507,000

St. Adolf’s Hospital



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St. Ado

Minimum-

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~~A-F-K:~~
A-C-G-J-K

Total c
Indirec
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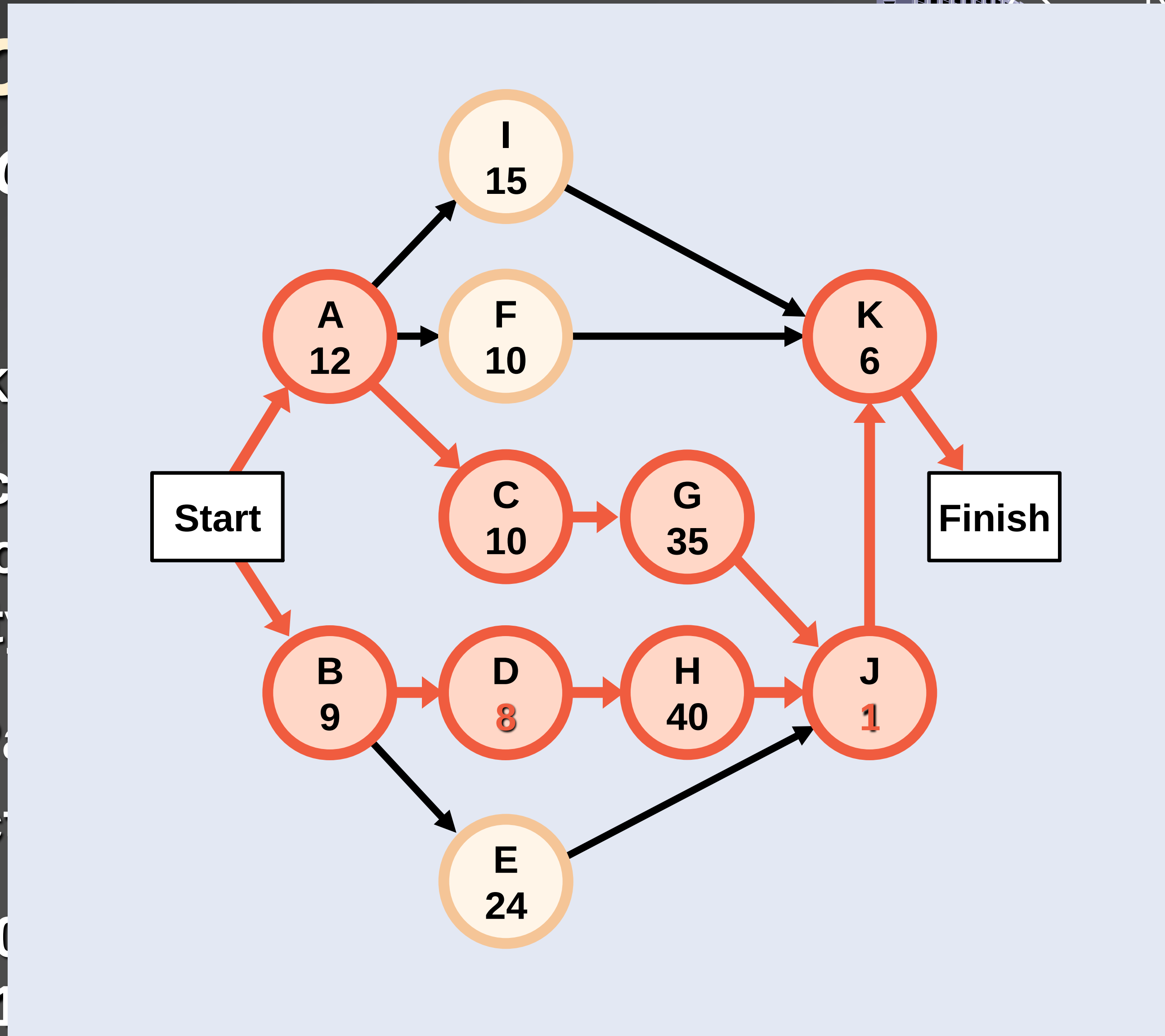
Crash Ac

$8,000
$2,511



St. Ado

Minimum-C

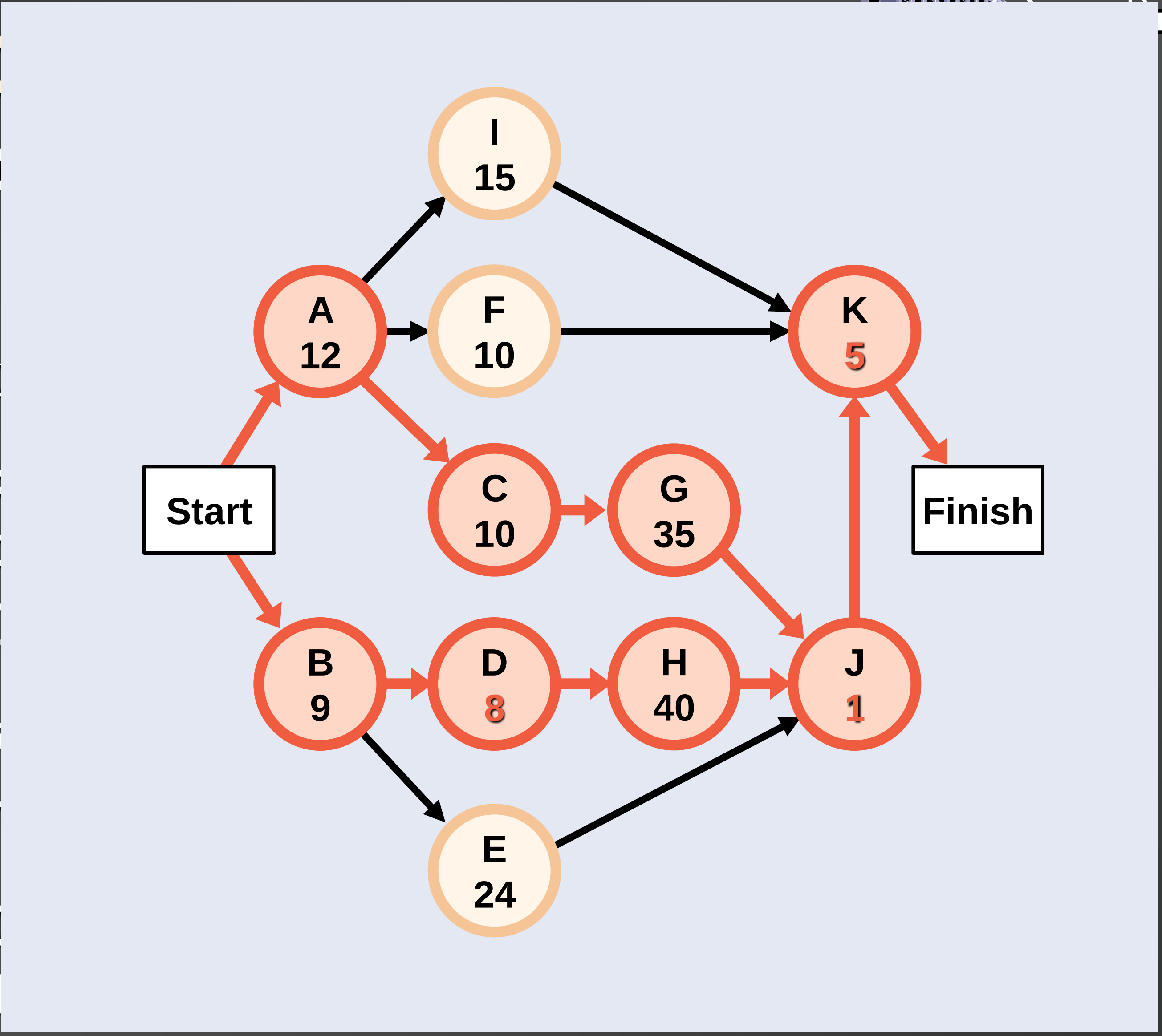
~~A-I-K:~~
~~A-F-K:~~
A-C-G-J-K

Total c
Indirec
Penalty

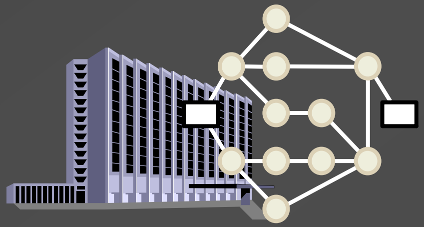
Critical Pa

Crash Act

$8,000
$2,511



St. Adolf's Hospital



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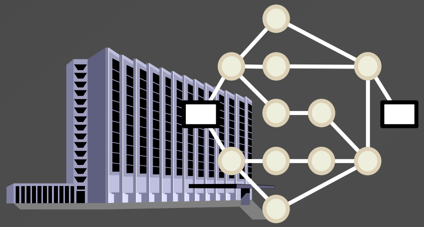
~~A-F-K:~~	28 weeks	~~B-E-J-K:~~	43 weeks
A-C-G-J-K:	67 weeks		

Total cost = ~~$2,624,000~~ $2,507,000
Indirect costs = $8,000/week
Penalty cost = $20,000/week after week 65

Critical Paths B-D-H-J-K and A-C-G-J-K: 63 weeks

Crash Activities B and C by 2 weeks
@ $7,000/week and $600/week

St. Adolf's Hospital



Minimum-Cost Schedule

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A-C-G-J-K:	67 weeks		

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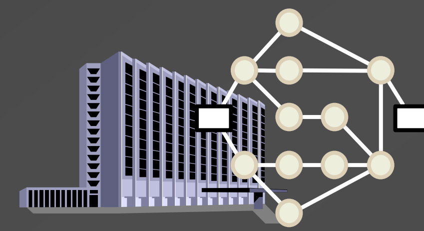
Penalty cost = $20,000/week after week 65

Critical Paths B-D-H-J-K and A-C-G-J-K: 63 weeks

Crash Activities B and C by 2 weeks
@ $7,000/week and $600/week

2($8,000) – 2($7,600) = $800
$2,507,000 – $800 = $2,506,200

St. Adolf's Hospital



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St. Adc

Minimum-(

~~A-I-K:~~
~~A-F-K:~~
A-C-G-J-K

Total c
Indirec
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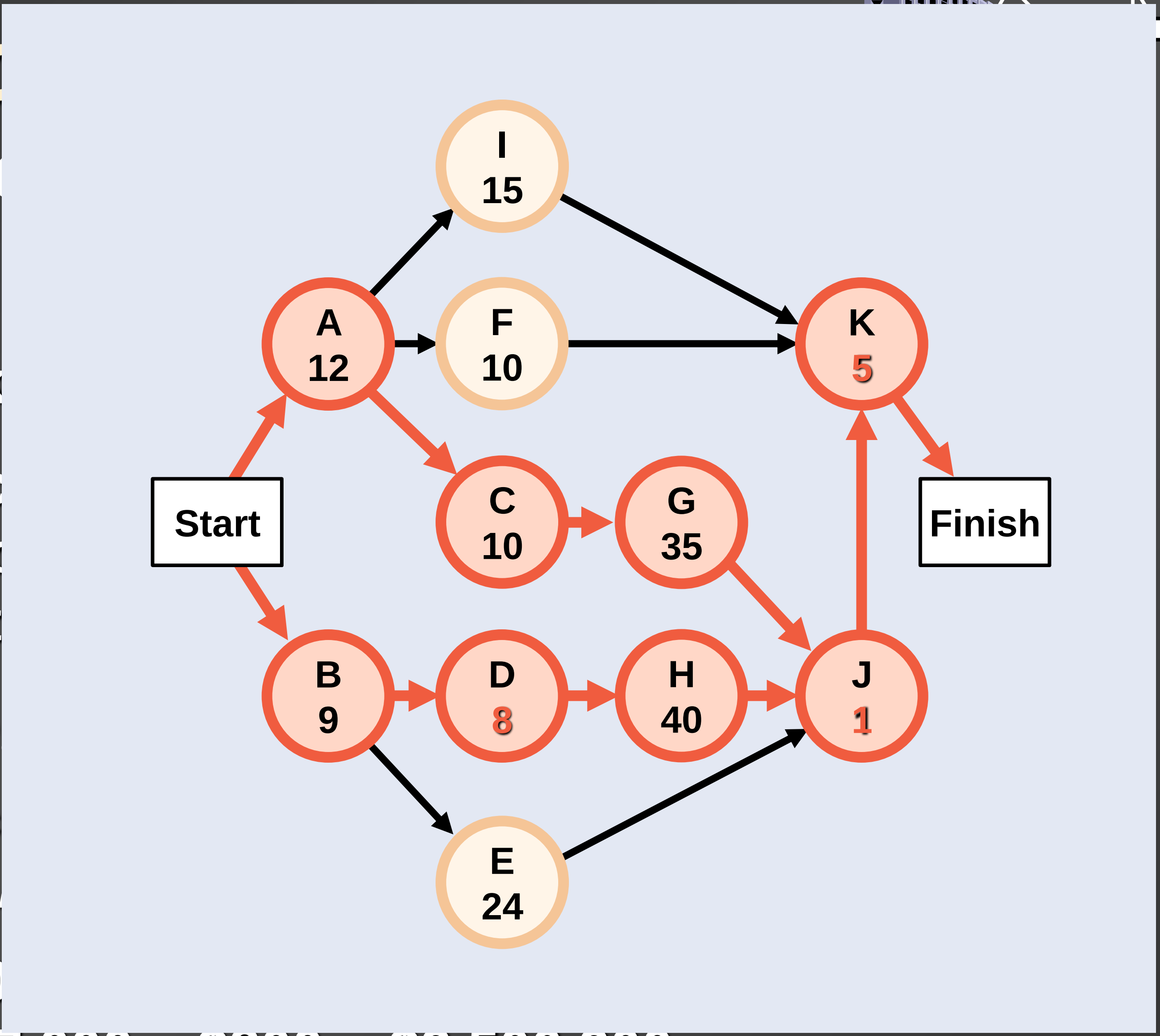
Critical P

Crash Ac
@ $7,000/

2($8,0
$2,507,000 – $800 = $2,506,200



St. Ado

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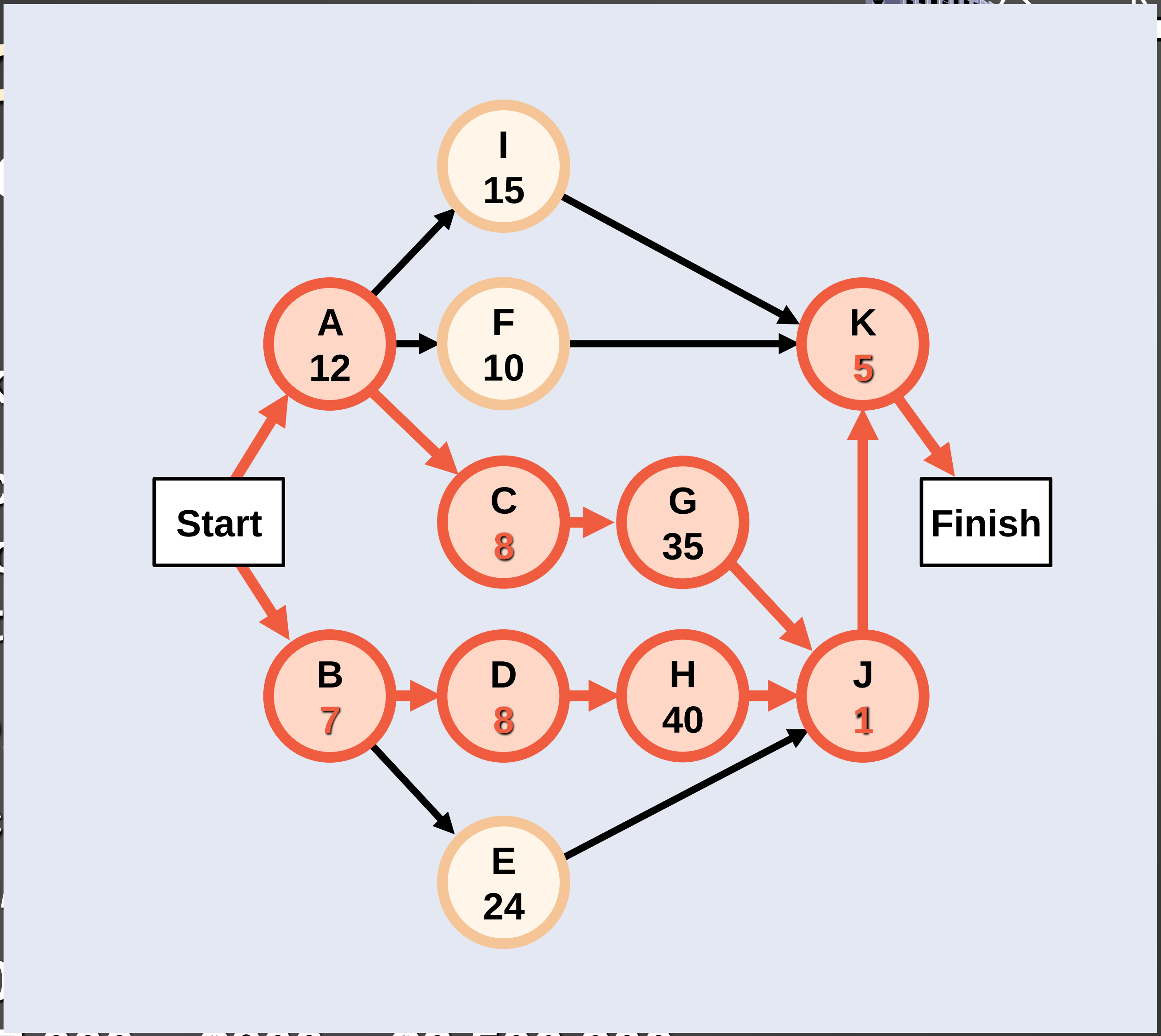
Total c
Indirec
Penalt

Critical P

Crash Ac
@ $7,000/



2($8,0
$2,507,000 – $800 = $2,506,200

Coors Field

Probabilistic Time Estimates

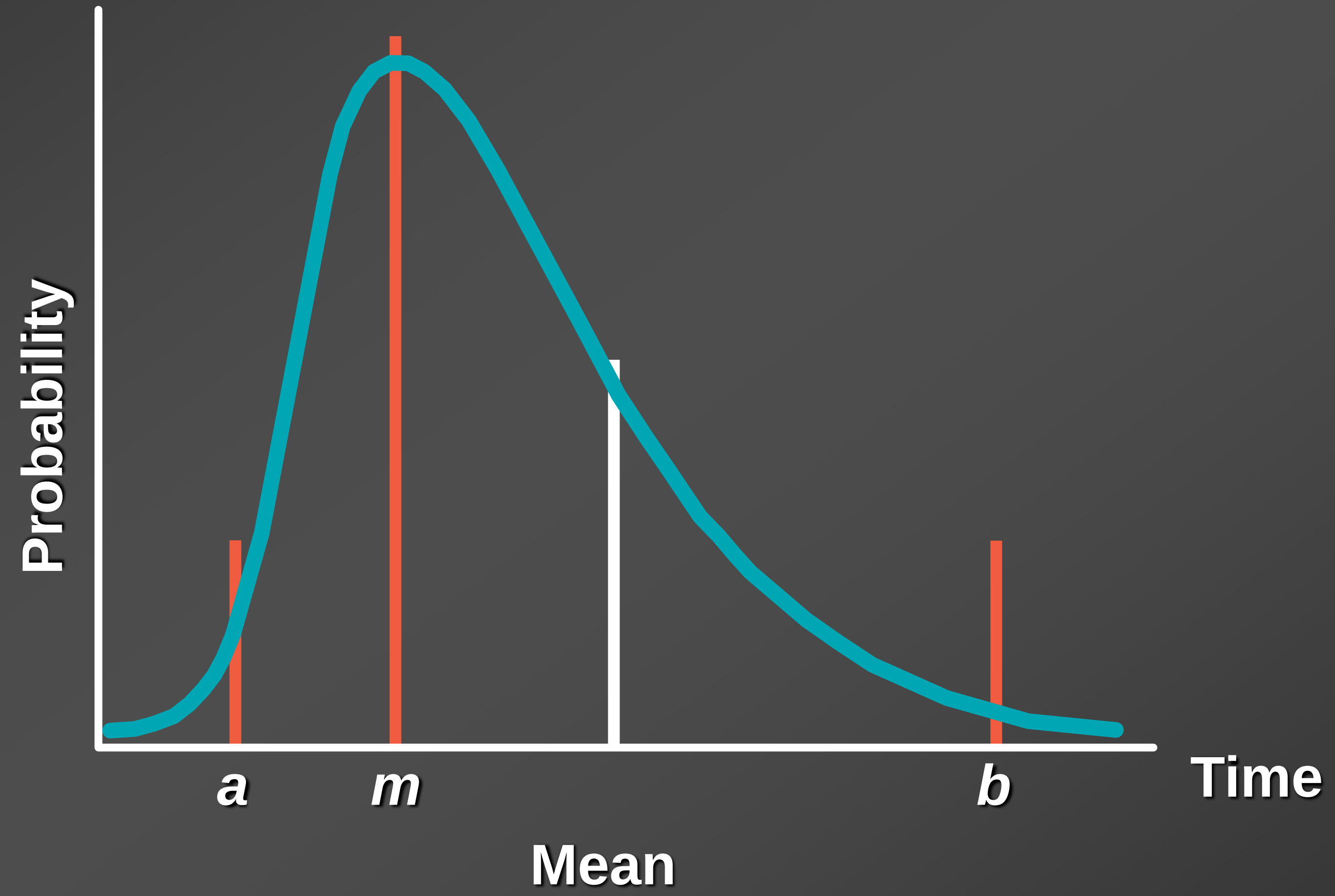
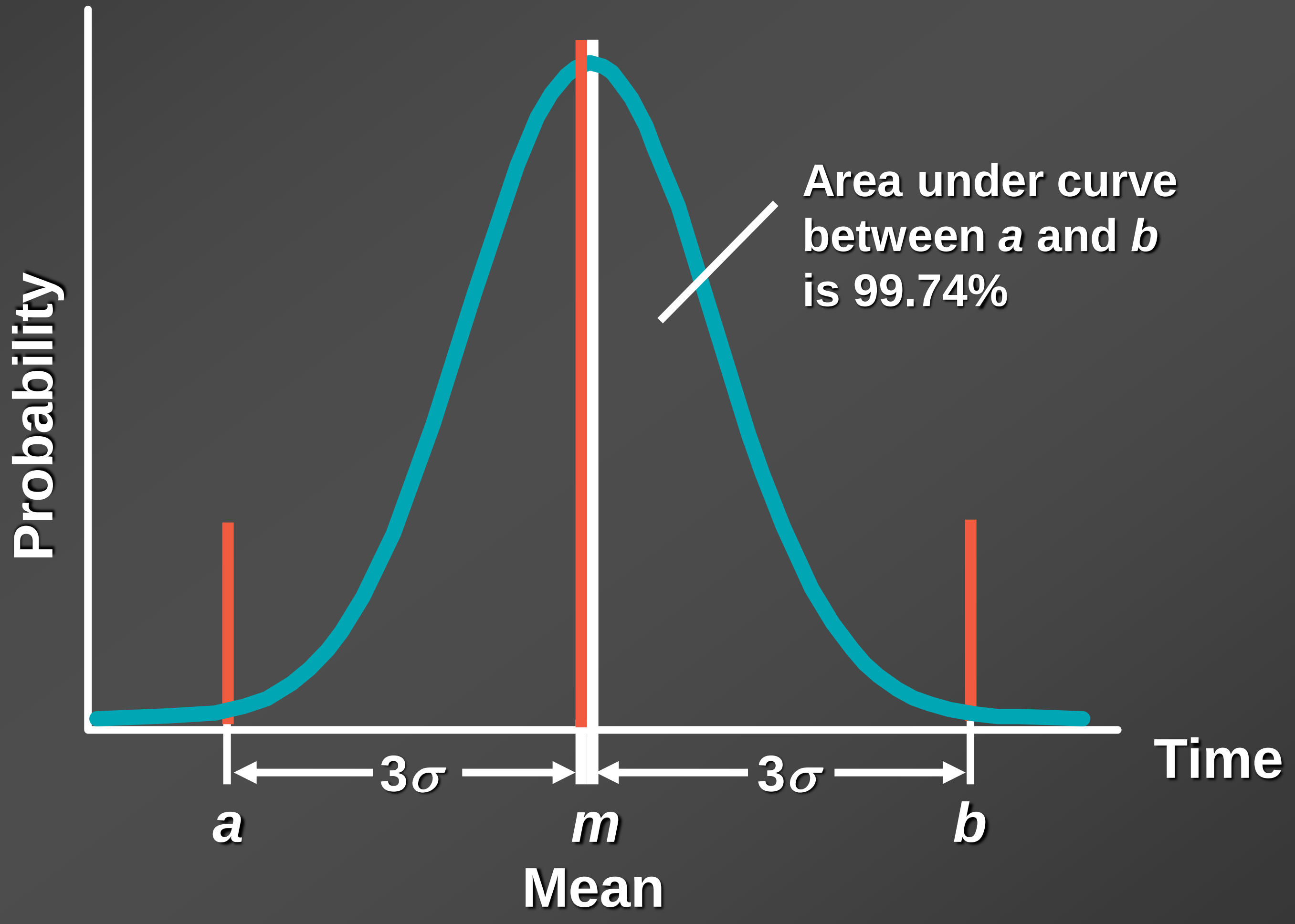


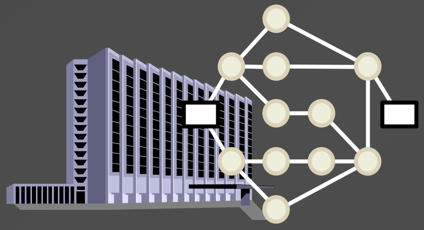
Figure 8.12 (a) Beta Distribution

Probabilistic Time Estimates

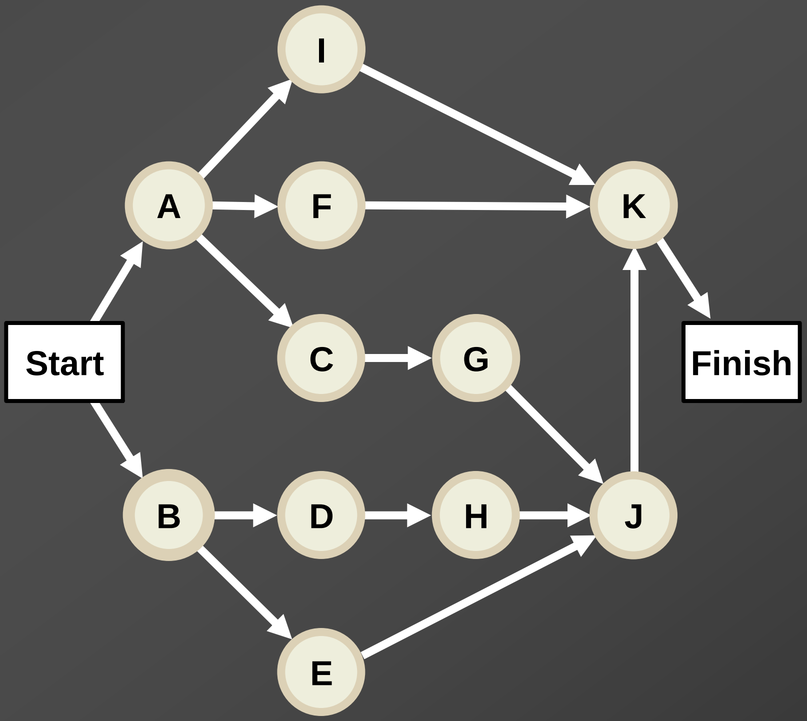


) *Normal Distribution*

St. Adolf's Hospital



Probabilistic Time Estimates



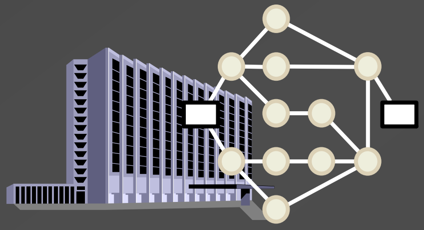
Mean

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

Variance

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

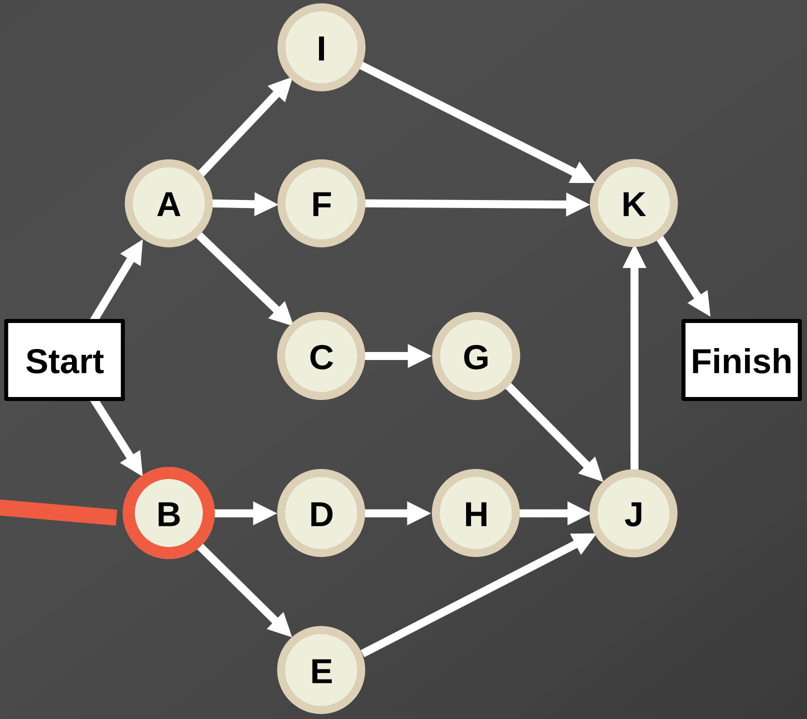
St. Adolf’s Hospital



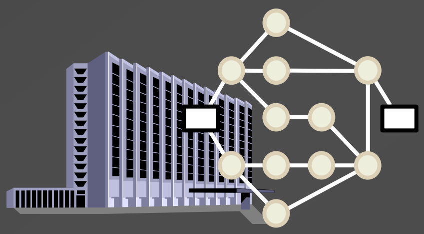
Probabilistic Time Estimates

Activity B

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



St. Adolf's Hospital



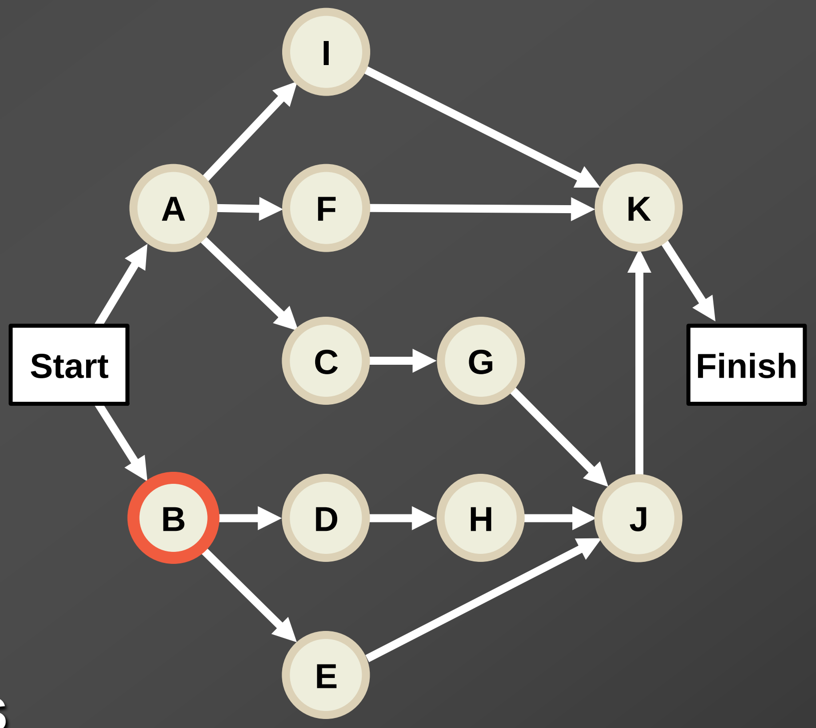
Probabilistic Time Estimates

Activity B

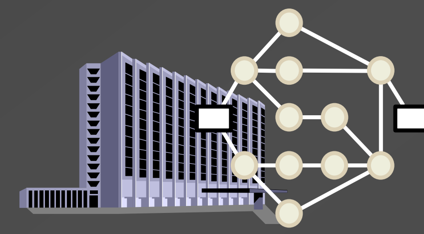
Optimistic (a)	Most Likely (m)	Pessimistic (b)
7	8	15

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

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

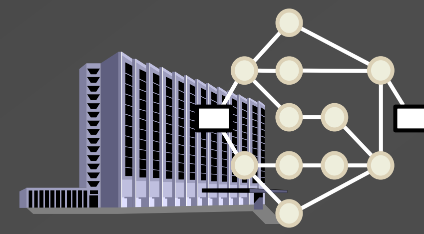


St. Adolf's Hospital



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

St. Adolf's Hospital



Probabilities

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

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

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

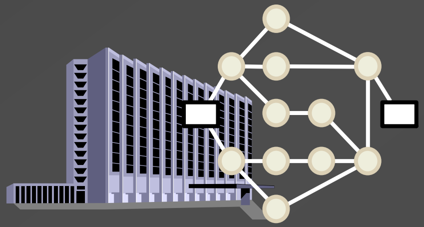
$$\sigma^2 = 1.78 + 1.78 + 2.78 + 5.44 + 0.11 = 11.89$$

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

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

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

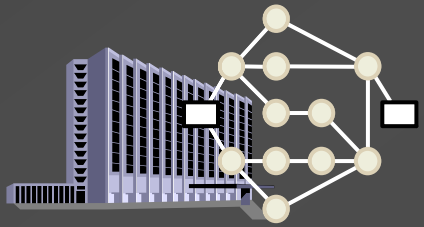
$$\sigma^2 = 1.78 + 1.78 + 2.78 + 5.44 + 0.11 = 11.89$$

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

From Appendix 2

$P_z = .8078 \approx .81$

St. Adolf’s Hospital



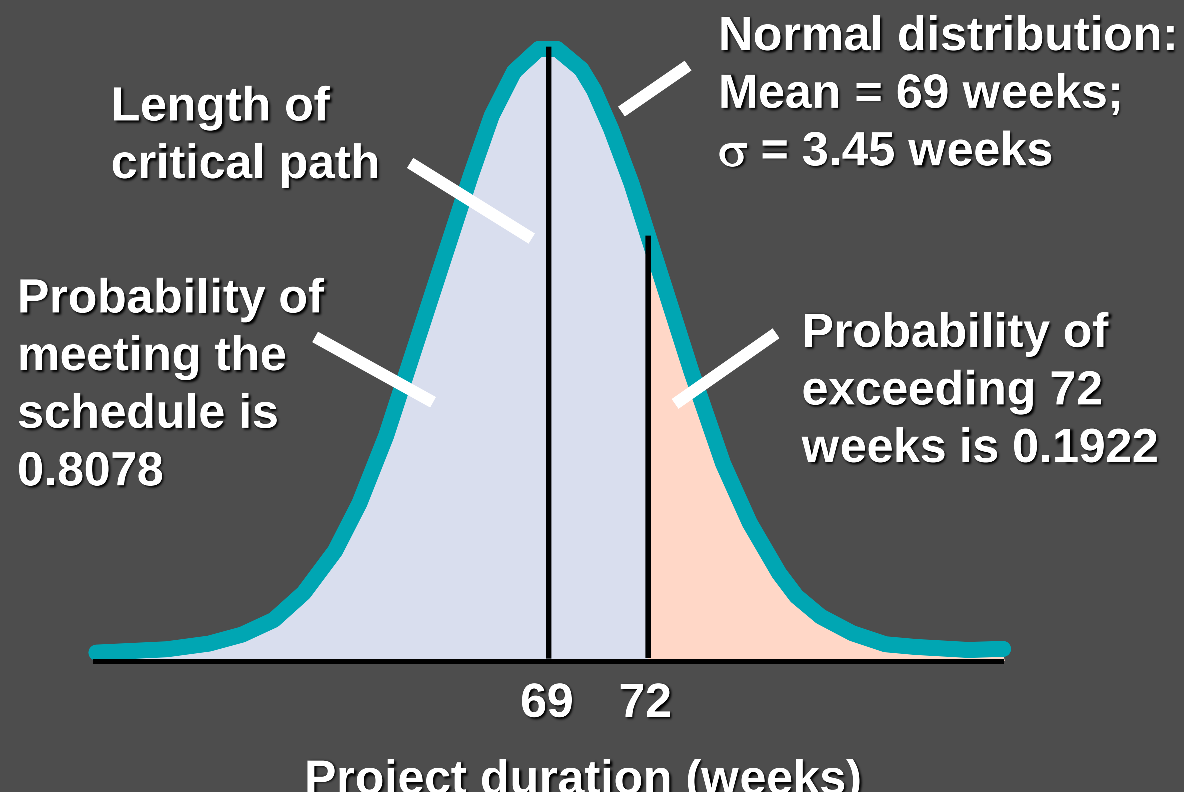
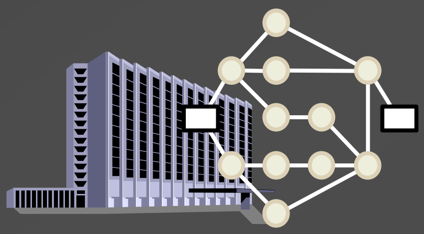


Figure 8.13

Example 8.7

St. Adolf’s Hospital



Probabilities

Path = A - C - G - J - K

T = 72 days $\qquad$ T_E = 67 days

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

$$\sigma^2 = 0.11 + 2.78 + 7.11 + 5.44 + 0.11 = 15.55$$

$$z = \frac{72 - 67}{\sqrt{15.55}} = 1.27$$

From Appendix 2
$P_z = .8980 \approx .90$

St. Adolf’s Hospital

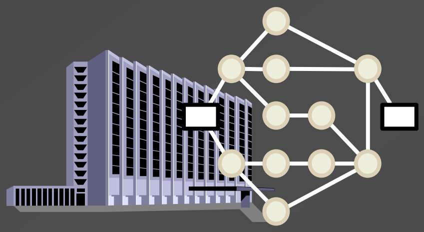
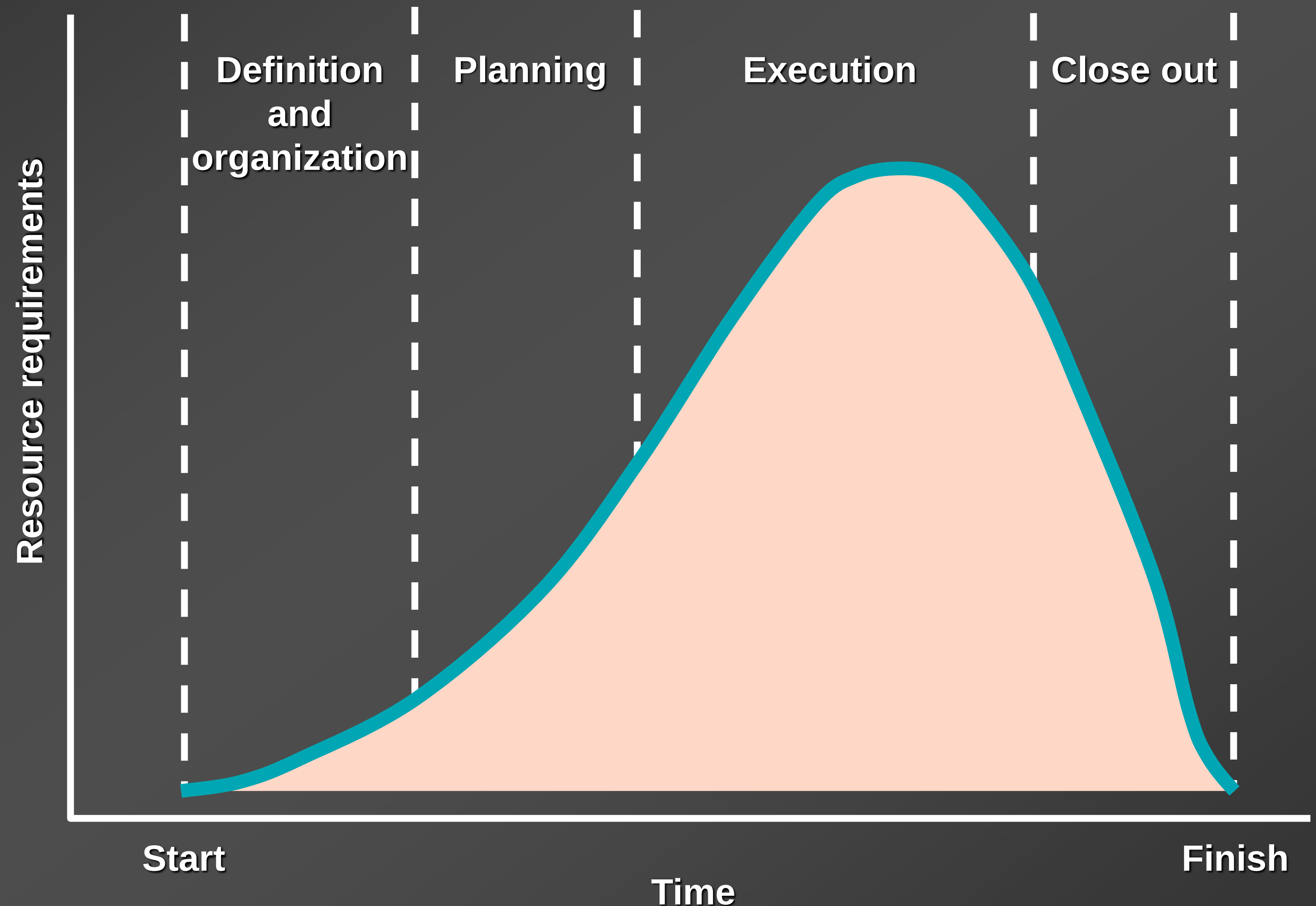


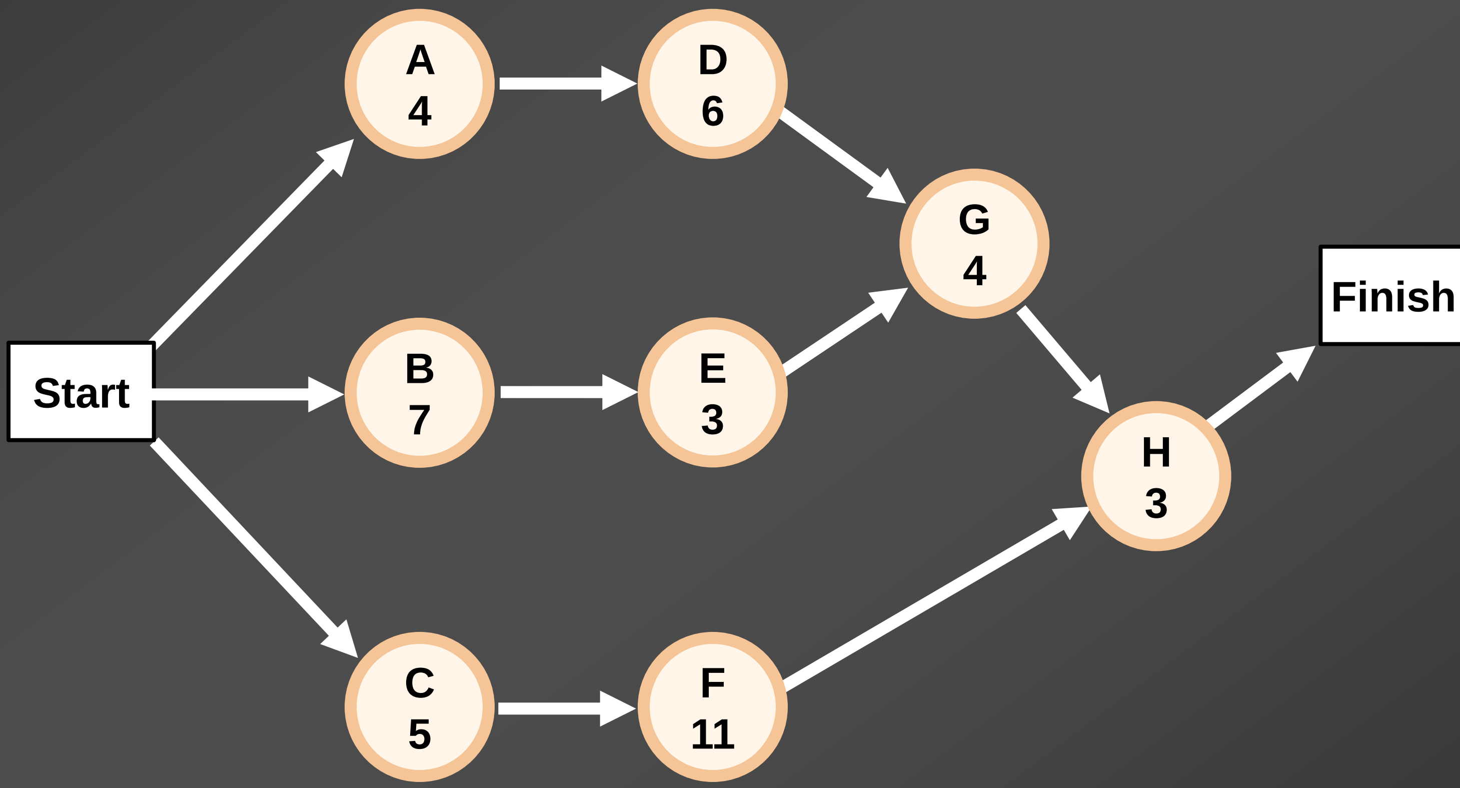
TABLE 8.2 SLACK CALCULATIONS AFTER ACTIVITIES A AND B HAVE BEEN COMPLETED

Activity	Duration	Earliest Start	Latest Start	Slack
C	10	16	14	–2
G	35	26	24	–2
J	4	61	59	–2
K	6	65	63	–2
D	10	10	9	–1
H	40	20	19	–1
E	24	10	35	25
I	15	16	48	32
F	10	16	53	37

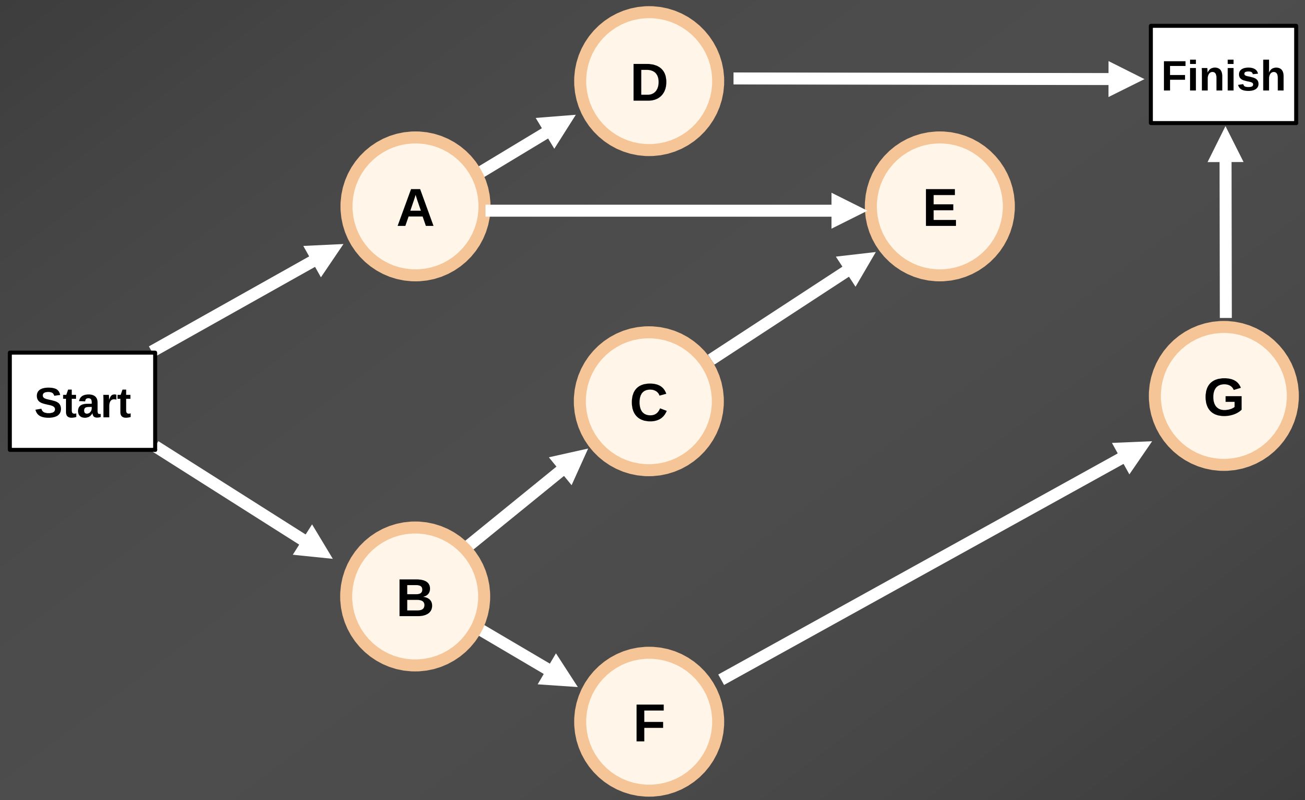
Project Life Cycle



Solved Problem 1

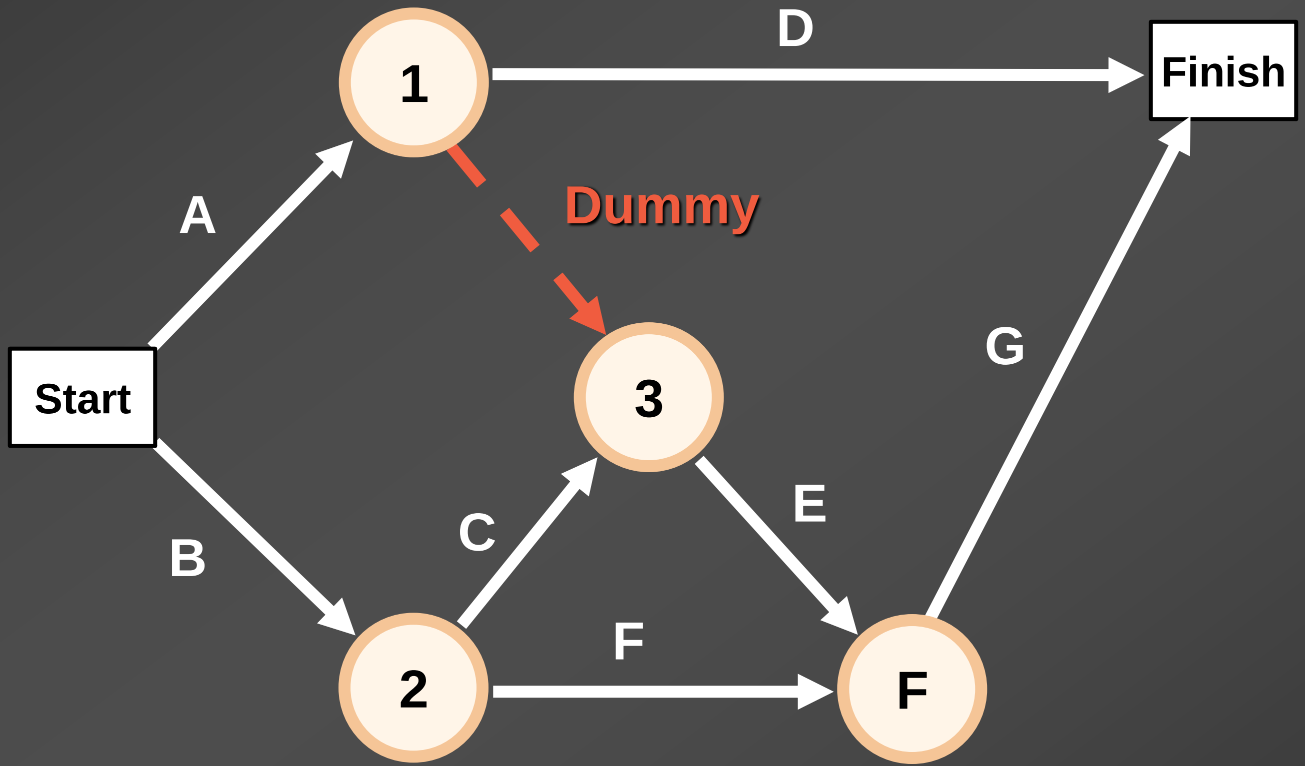


Solved Problem 2



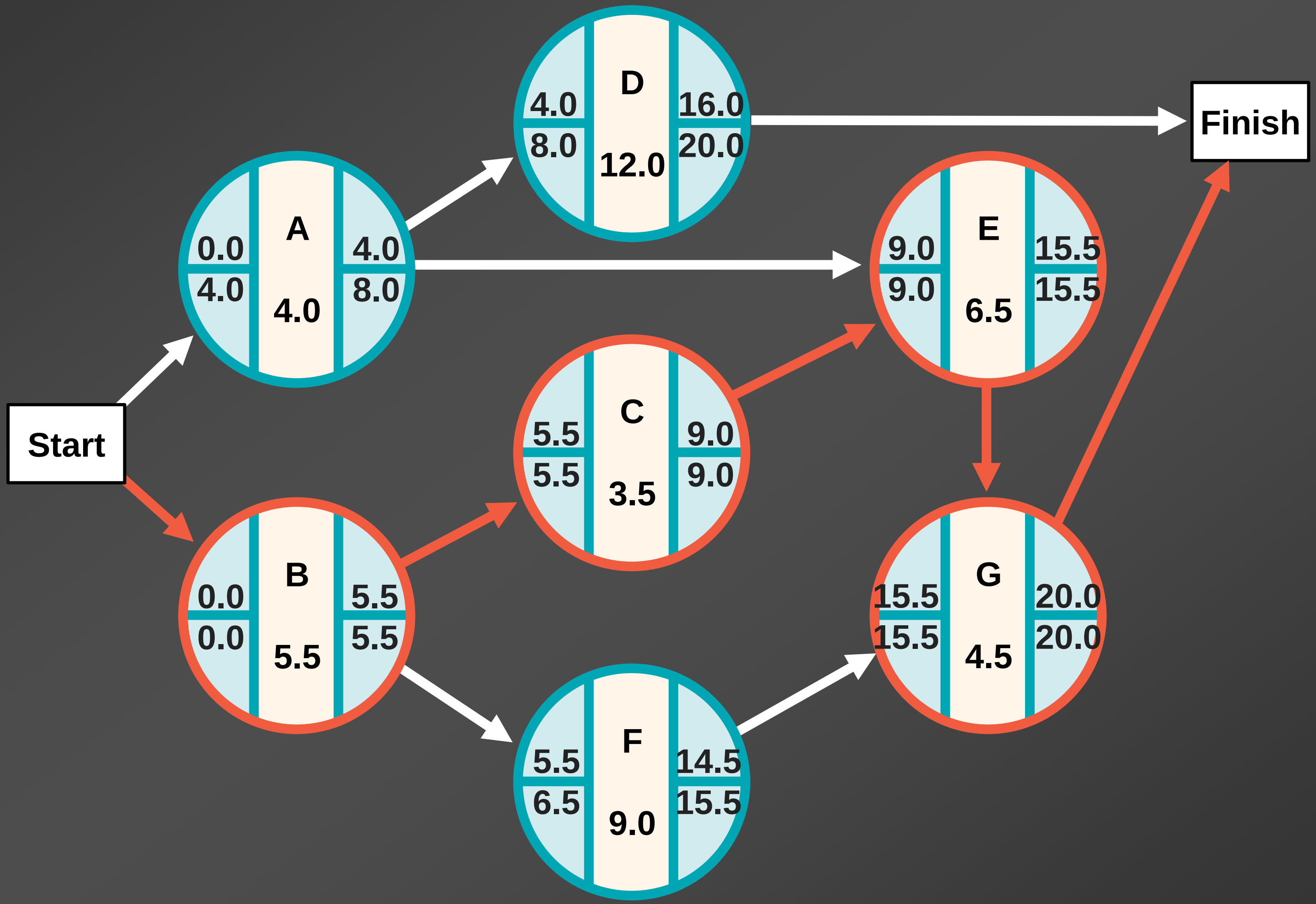
AON Network

Solved Problem 2

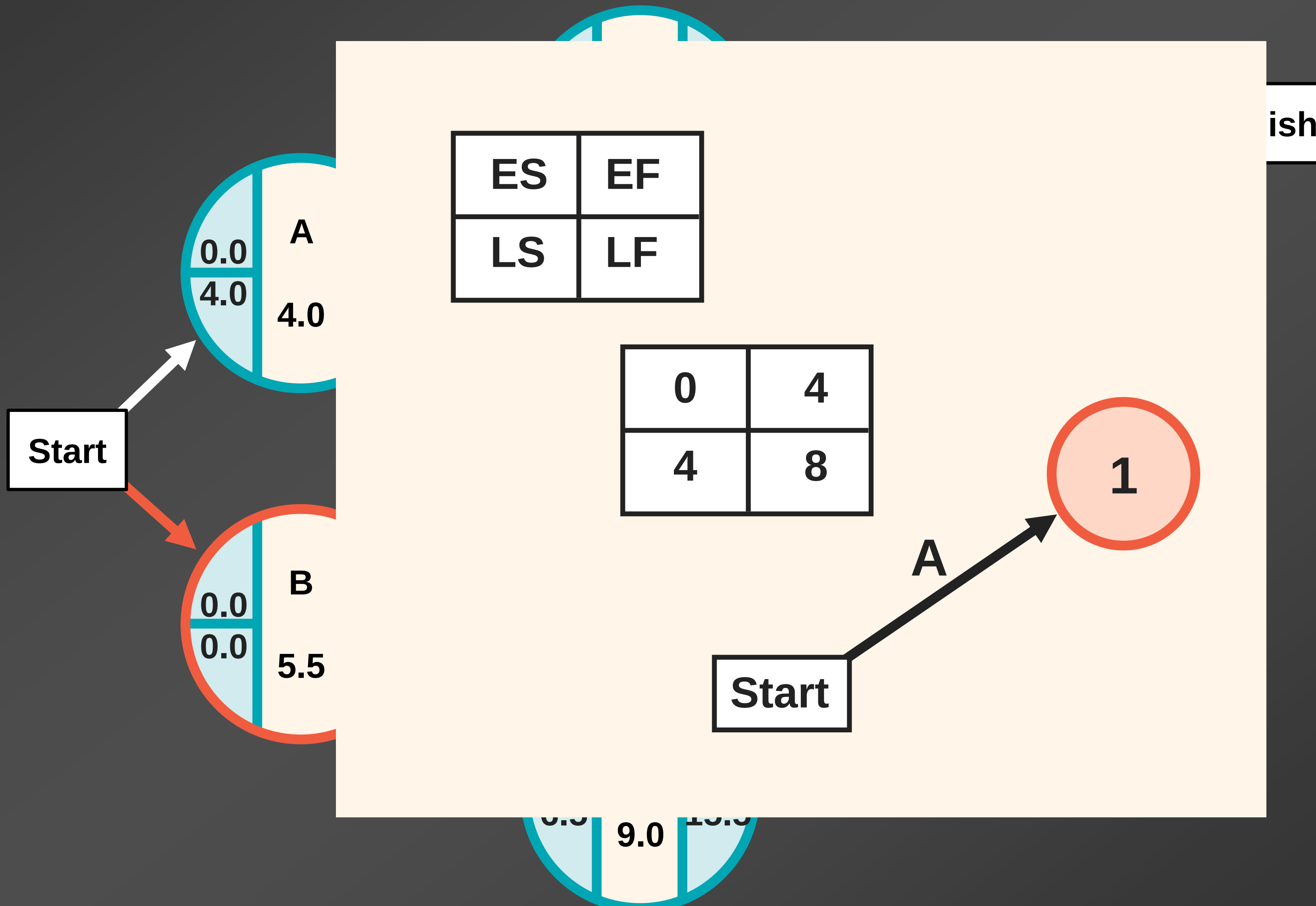


6(b) AOA Network

Solved Problem 2



Solved Problem 2



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

D_j=annual demand from market j

K_i= potential capacity of plant i

f_i = annualized fixed cost of keeping factory i open

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

y_i=1 if plant is open, 0 otherwise

x_{ij}=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

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

Demand at each regional market is satisfied

$$\sum_{j=1}^{m} x_{ij} \leqslant K_i y_i \quad \text{for } i = 1, \dots, n$$

No plant can supply more than its capacity

(0 or 1)

$$y_i \in \{0, 1\} \quad \text{for } i = 1, \dots, n, \; x_{ij} \geqslant 0$$

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.