



# Decision Trees

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# Overview

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- Introduction to Decision Trees
- Illustrate the process
- Gold Plate this problem
- Summarize the results
- Work a typical problem



# Introduction to Decision Trees

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- Why use a Decision Tree ?



# Introduction to Decision Trees

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- Why use a Decision Tree ?
  - Use Decision Trees to analyze choices
  - A tool in Quantitative Risk Analysis



# Introduction to Decision Trees

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- Why use a Decision Tree ?
  - Use Decision Trees to analyze choices
  - A tool in Quantitative Risk Analysis
- Process is fairly simple
  - Assign values to each choice
  - Weight the values with probabilities
  - Calculate the expected value



# Introduction to Decision Trees

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- Process
  - List the alternatives
  - Assign probabilities
  - Draw the tree
  - Assign probable benefits and costs
  - Calculate the expected value
    - Either for the whole
    - Or to identify the best branches



# Overview

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- Introduction to Decision Trees
- Illustrate the process
- Gold Plate this problem
- Summarize the results
- Work a typical problem



# Illustrate – List Alternatives

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- Make or Buy
  - A very common question



# Illustrate – List Alternatives

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- Make or Buy
  - A very common question
- High **Grade** or Low **Grade**
  - Always High **Quality**
  - For Software: Lots of features or few



# Illustrate – List Alternatives

---

- Make or Buy
  - A very common question
- High Grade or Low Grade
  - Always High Quality
  - For Software: Lots of features or few
- Sales Volume
  - Sometimes difficult to predict



# Illustrate the process

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- Process
  - List the alternatives
  - Assign probabilities
  - Draw the tree
  - Assign probable benefits and costs
  - Calculate the expected value
    - Either for the whole
    - Or to identify the best branches



# Illustrate – Assign probabilities

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- Based on Historical Information
- Or Based on an Assessment
  - Market Analysis
  - Feasibility Study



# Illustrate – Assign probabilities

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- Based on Historical Information:
- 0.7 Make vs 0.3 Buy
- 0.6 High vs 0.4 Low Grade
- 0.2 High vs 0.8 Low Sales



# Illustrate the process

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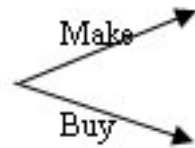
- Process
  - List the alternatives
  - Assign probabilities
  - Draw the tree
  - Assign probable benefits and costs
  - Calculate the expected value
    - Either for the whole
    - Or to identify the best branches



# Illustrate – Draw the Tree

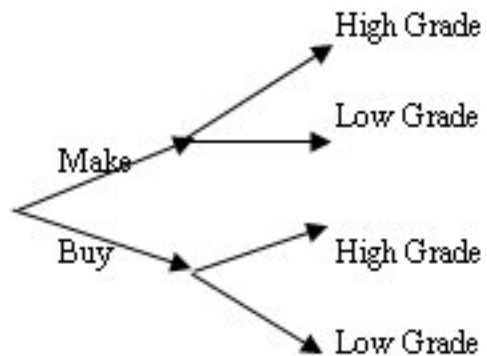
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- First branch from root



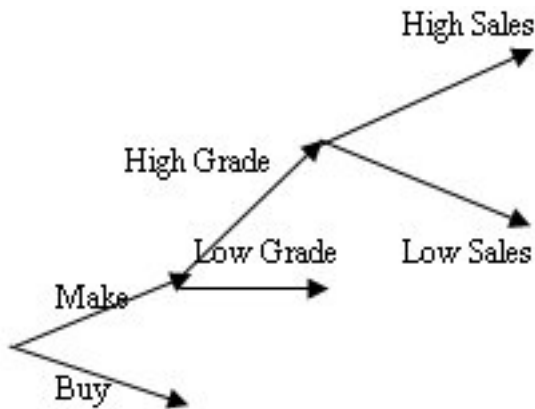
# Illustrate – Draw the Tree

- First branch from root
- Add next branch to each end point



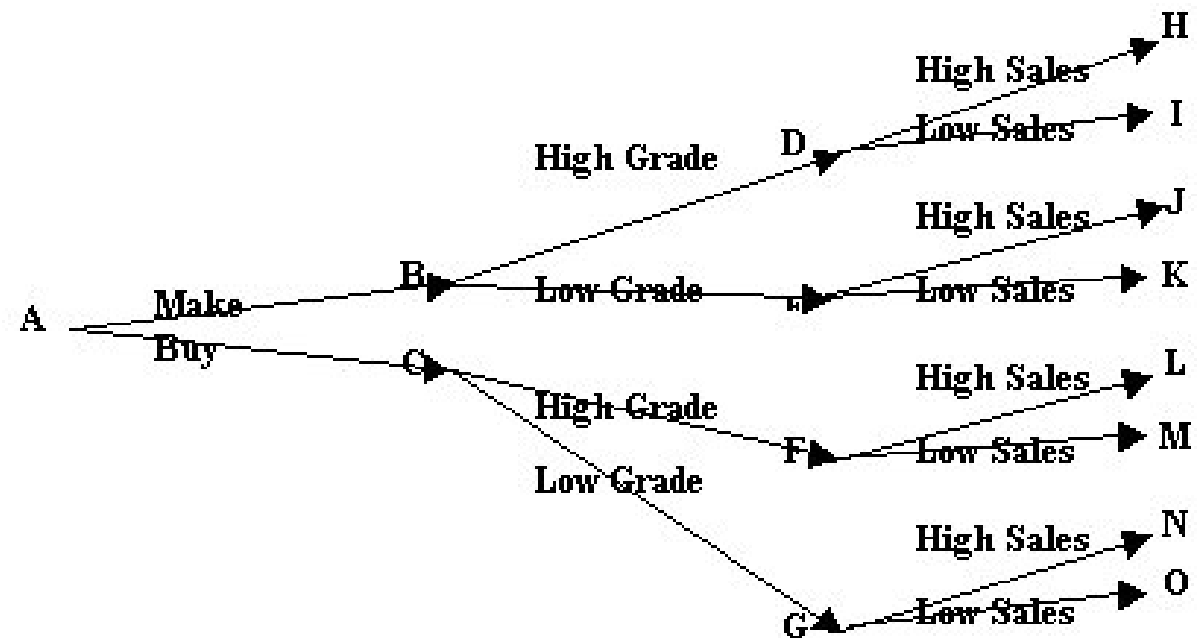
# Illustrate – Draw the Tree

- First branch from root
- Add next branch to each end point
- Keep going (one end point at a time)



# Illustrate – Draw the Tree

- Full Tree
  - Everything is here
  - But a bit too cluttered





# Illustrate the process

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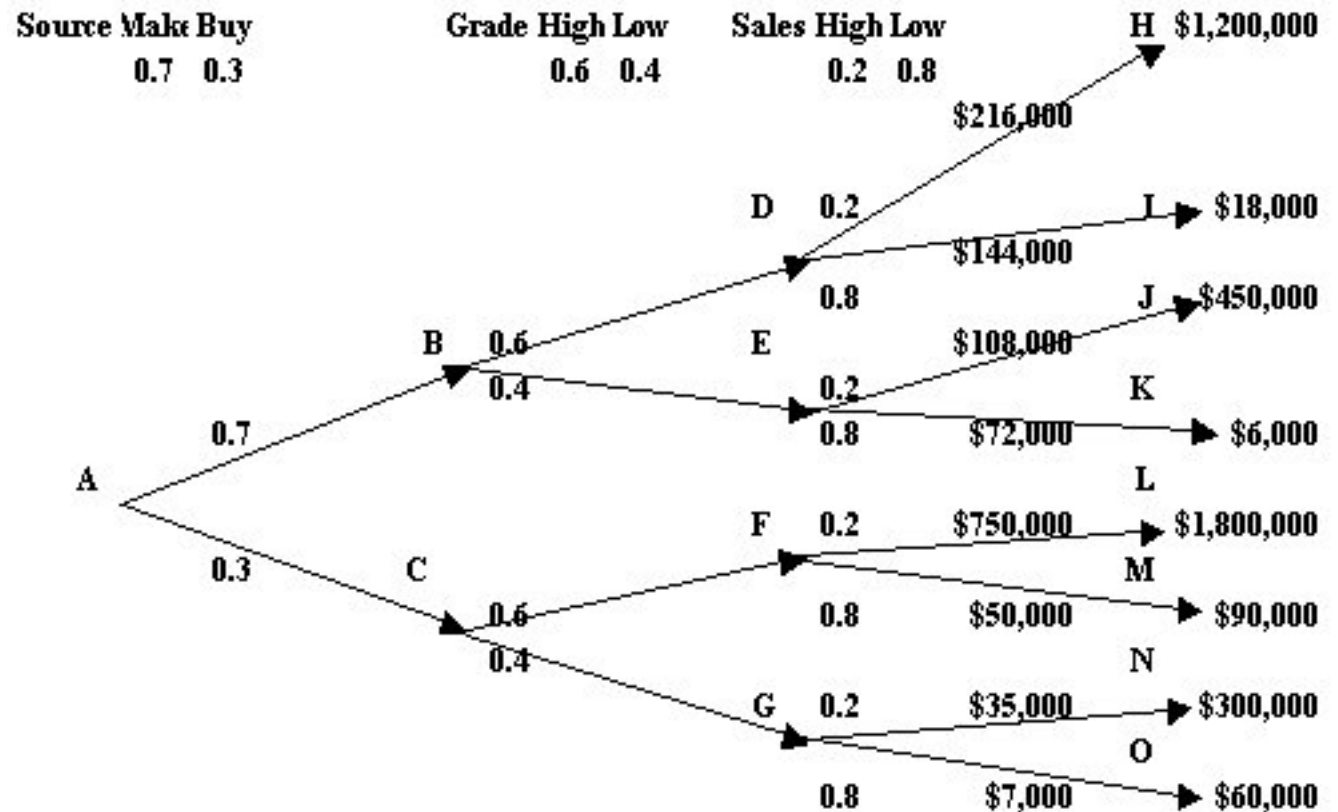
- Process
  - List the alternatives
  - Assign probabilities
  - Draw the tree
  - Assign probable benefits and costs
  - Calculate the expected value
    - Either for the whole
    - Or to identify the best branches



# Illustrate – Benefits & Costs

- Expand tree to add space
- Assign probable benefits and costs
- Typical Problem

“What is the expected value for this decision tree?”





# Illustrate the process

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- Process
  - List the alternatives
  - Assign probabilities
  - Draw the tree
  - Assign probable benefits and costs
  - Calculate the expected value
    - Either for the whole
    - Or to identify the best branches



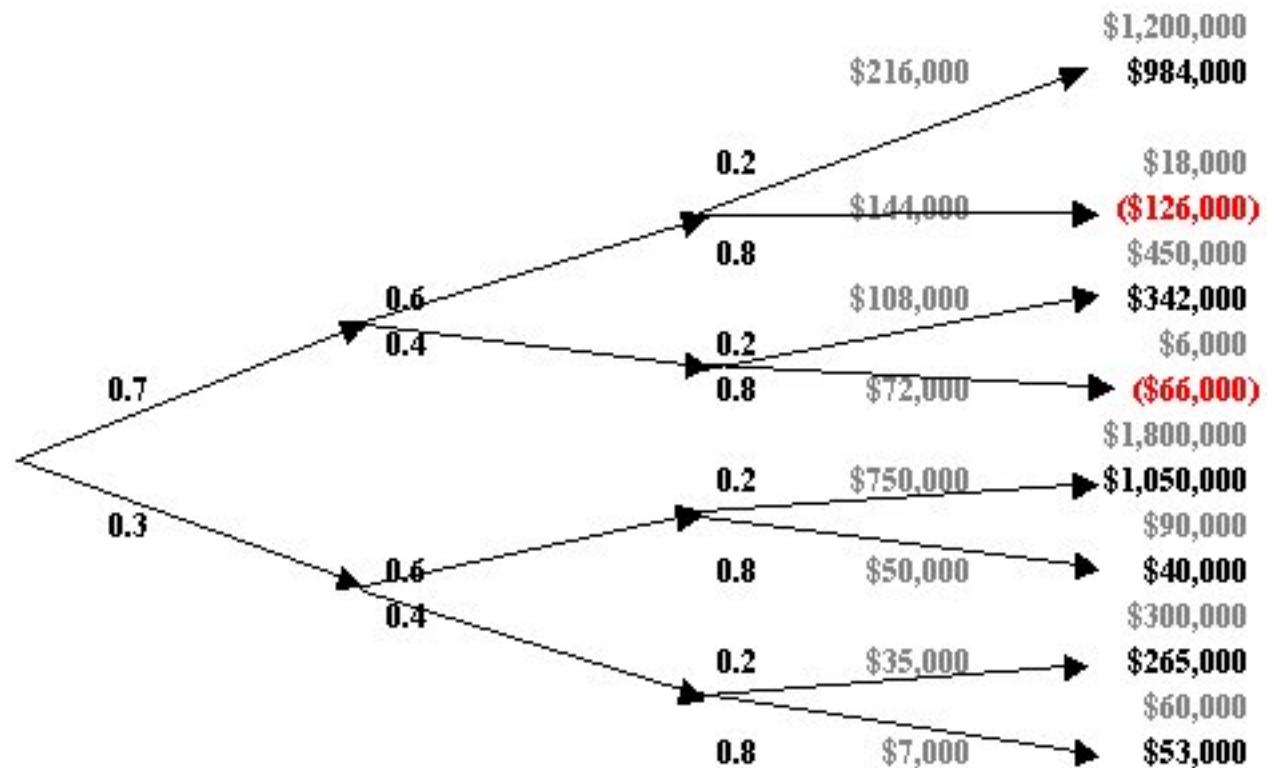
## Illustrate – Calculate Expected Value

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- Need **Net Revenue** at each leaf
- $\text{Net Revenue} = (\text{Benefit} - \text{Cost})$

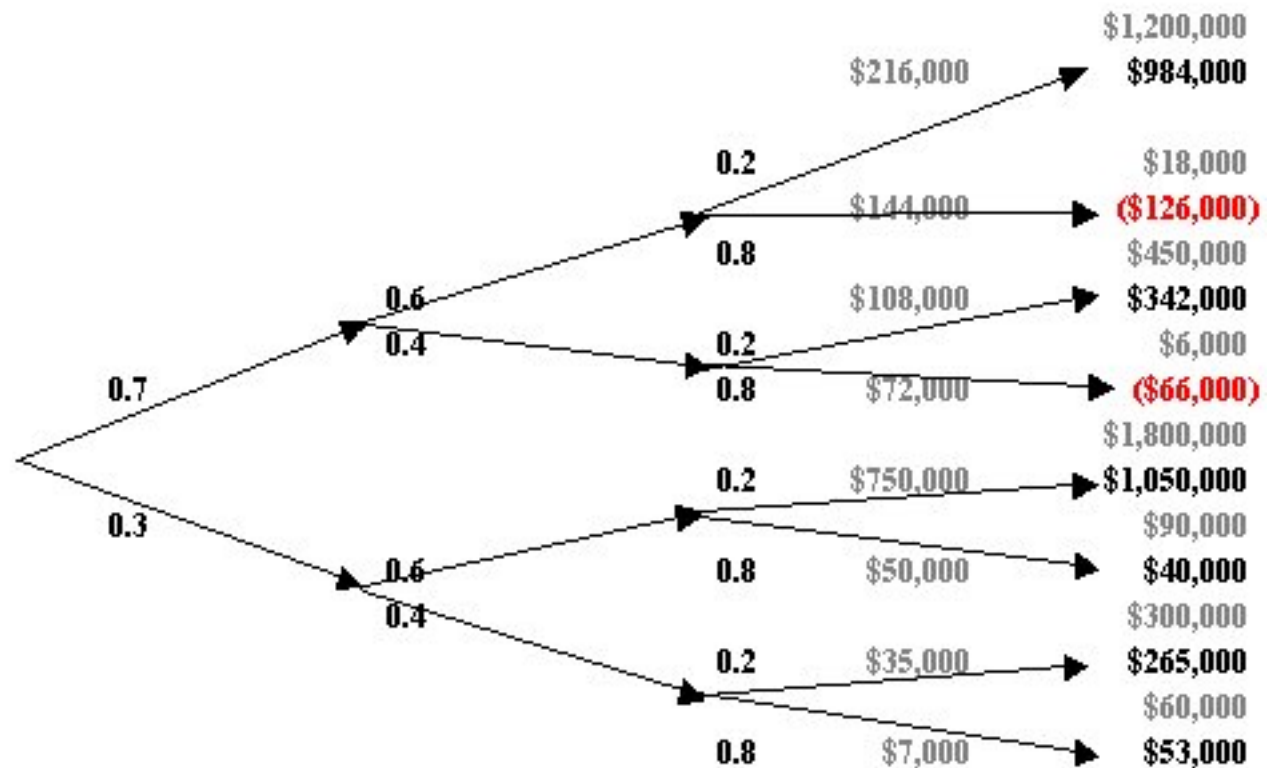
# Illustrate – Net Revenue

- Add Net Revenue to the tree



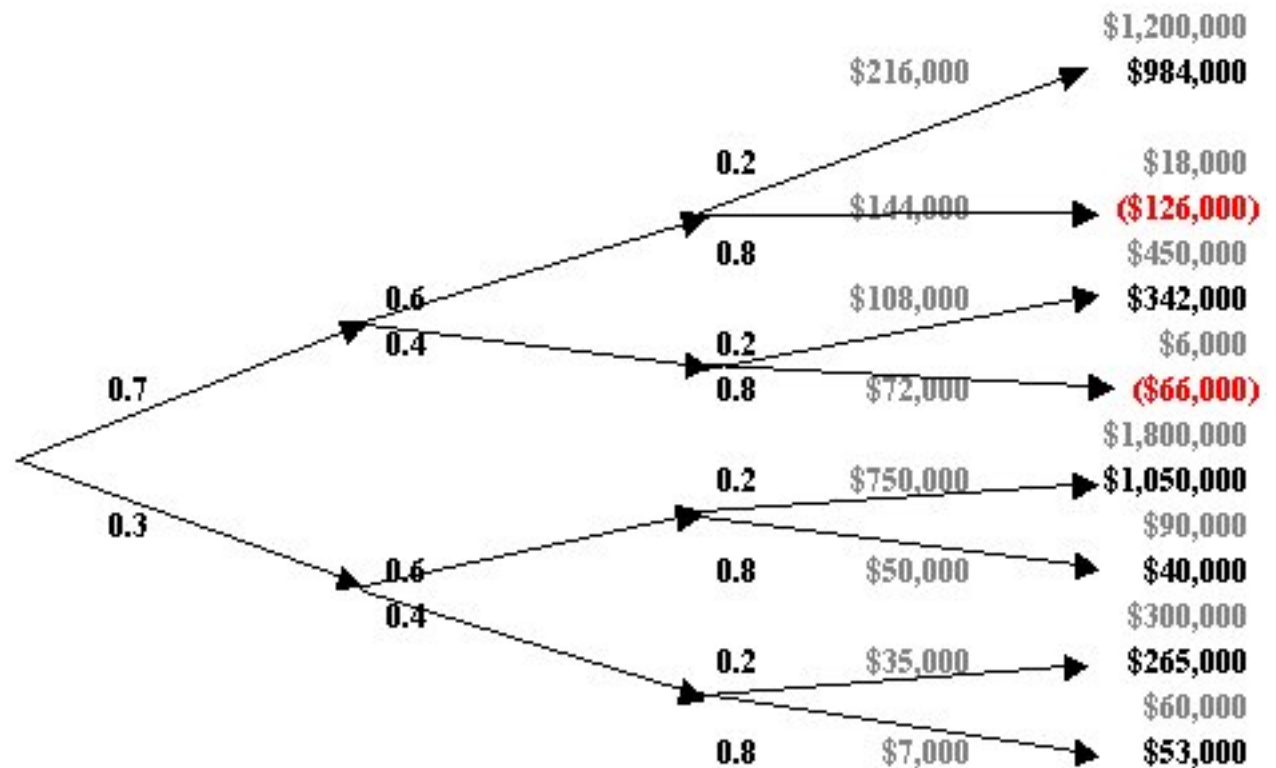
# Illustrate – Expected Value

- Expected Value = (Net Revenue) \* (Probability)



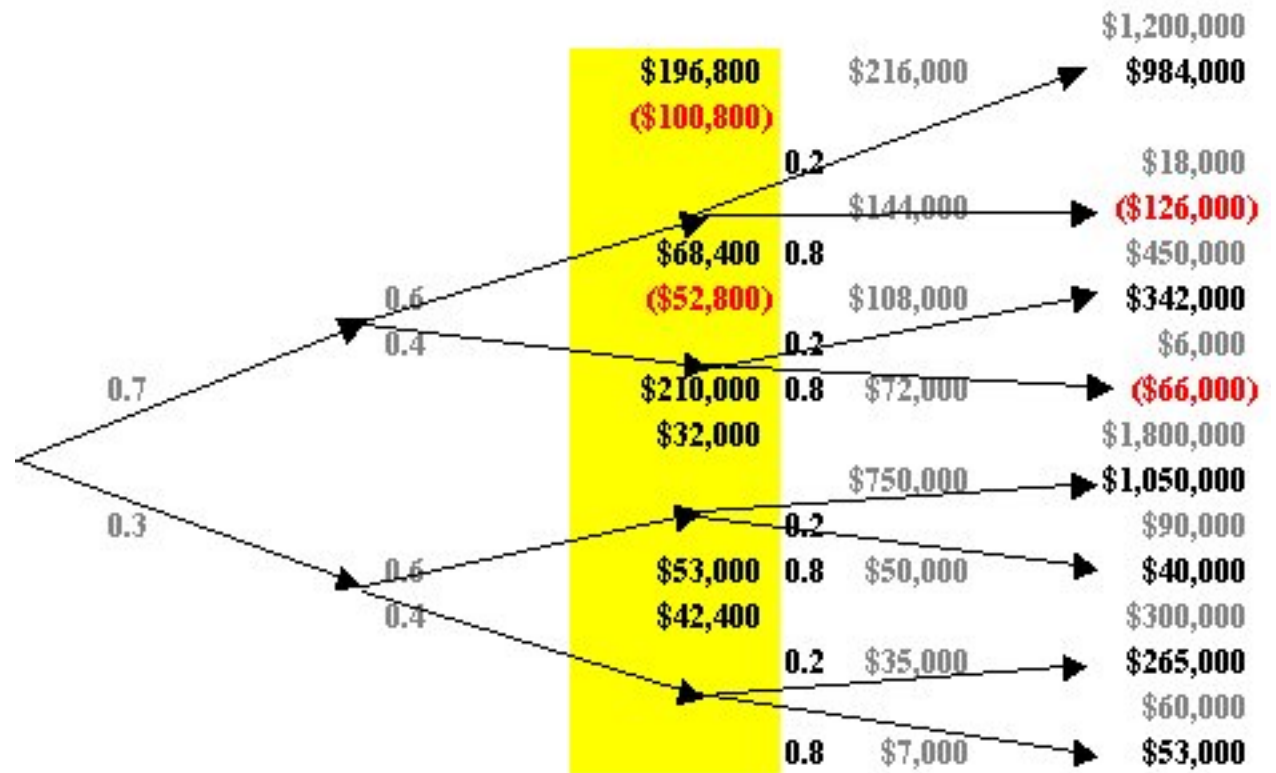
# Illustrate – Expected Value

- Expected Value = (Net Revenue) \* (Probability)
- EV = \$984,000 \* 0.2



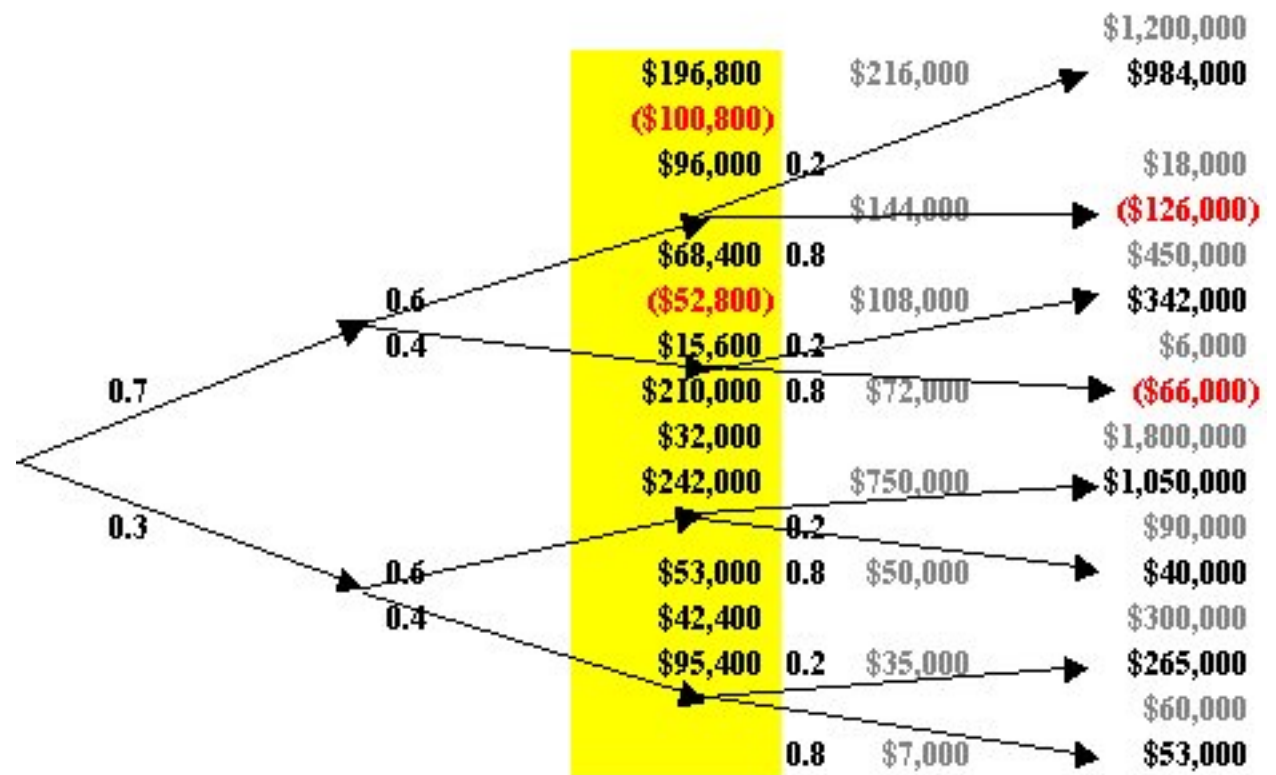
# Illustrate – Expected Value

- Expected Value = (Net Revenue) \* (Probability)
- Right to Left



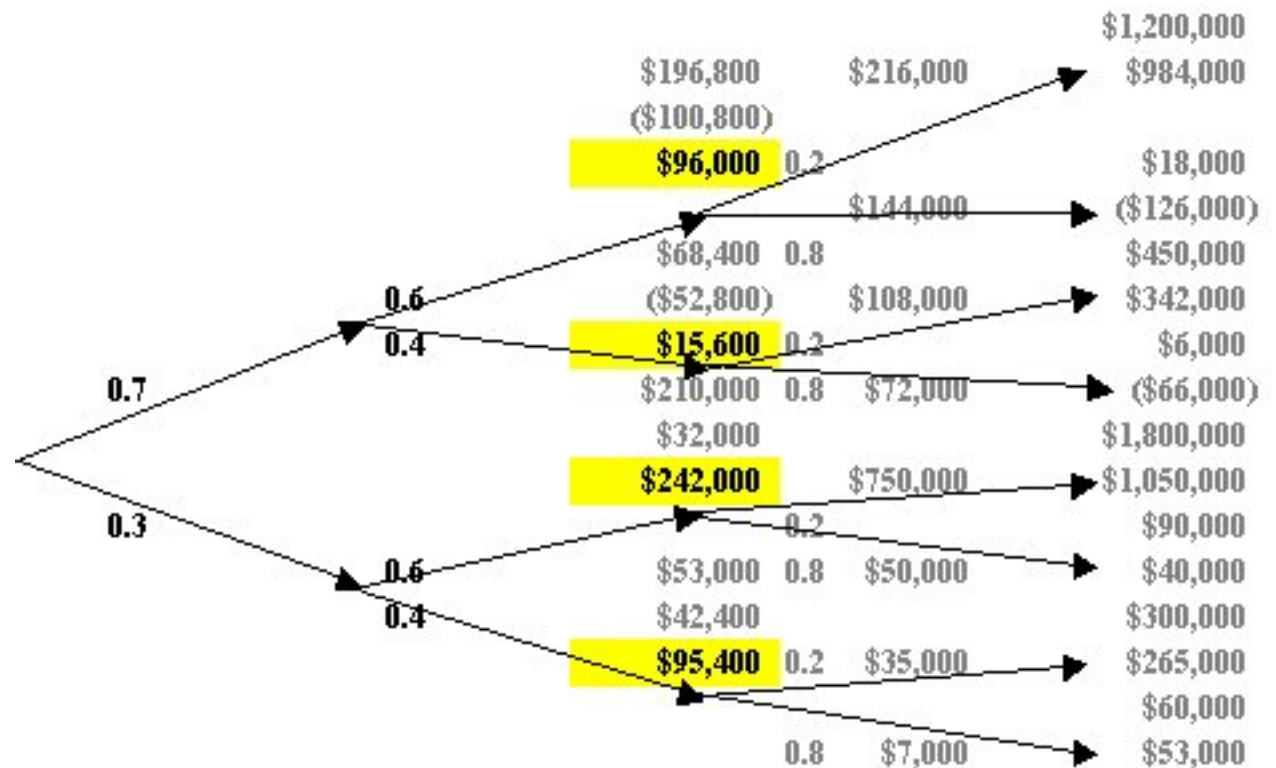
# Illustrate – Expected Value

- Expected Value = (Net Revenue) \* (Probability)
- Add branches at junction



# Illustrate – Expected Value

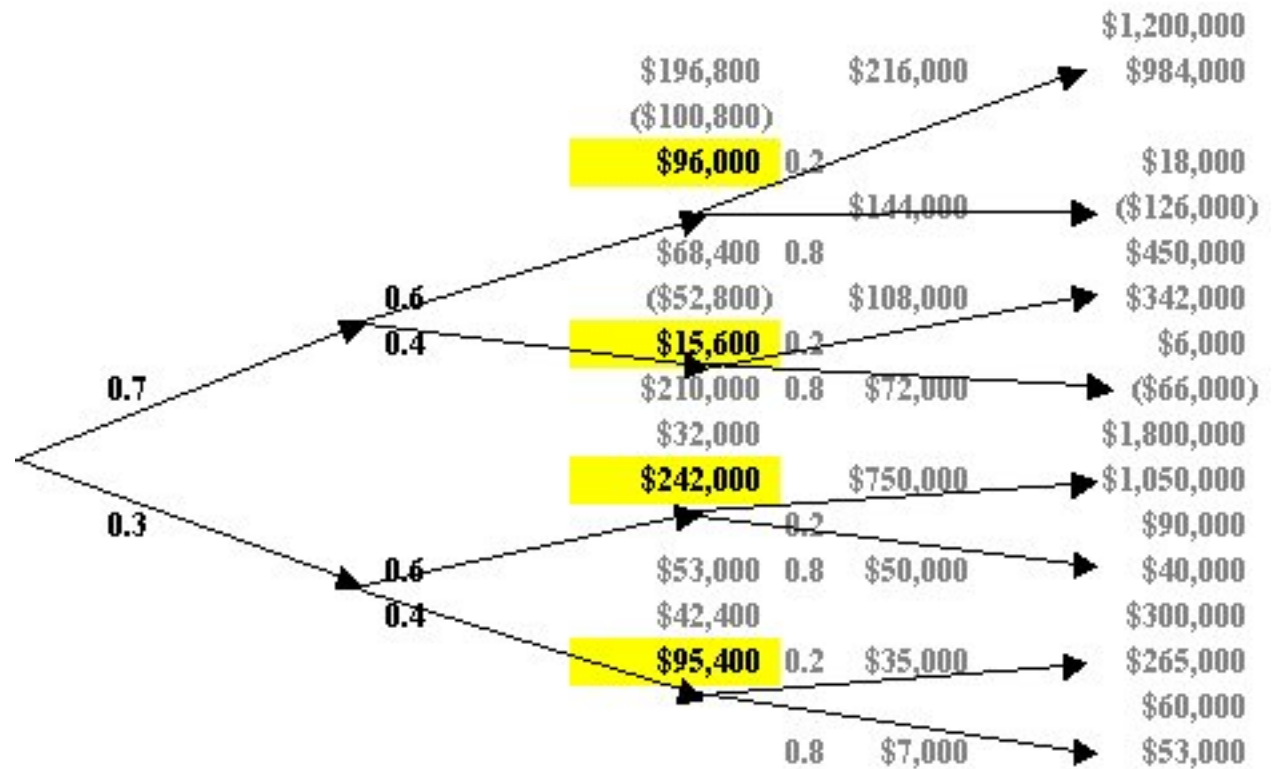
- What is the Expected Value at D?



# Illustrate – Expected Value

- What is the Expected Value at D?

**\$96,000**





# Illustrate the process

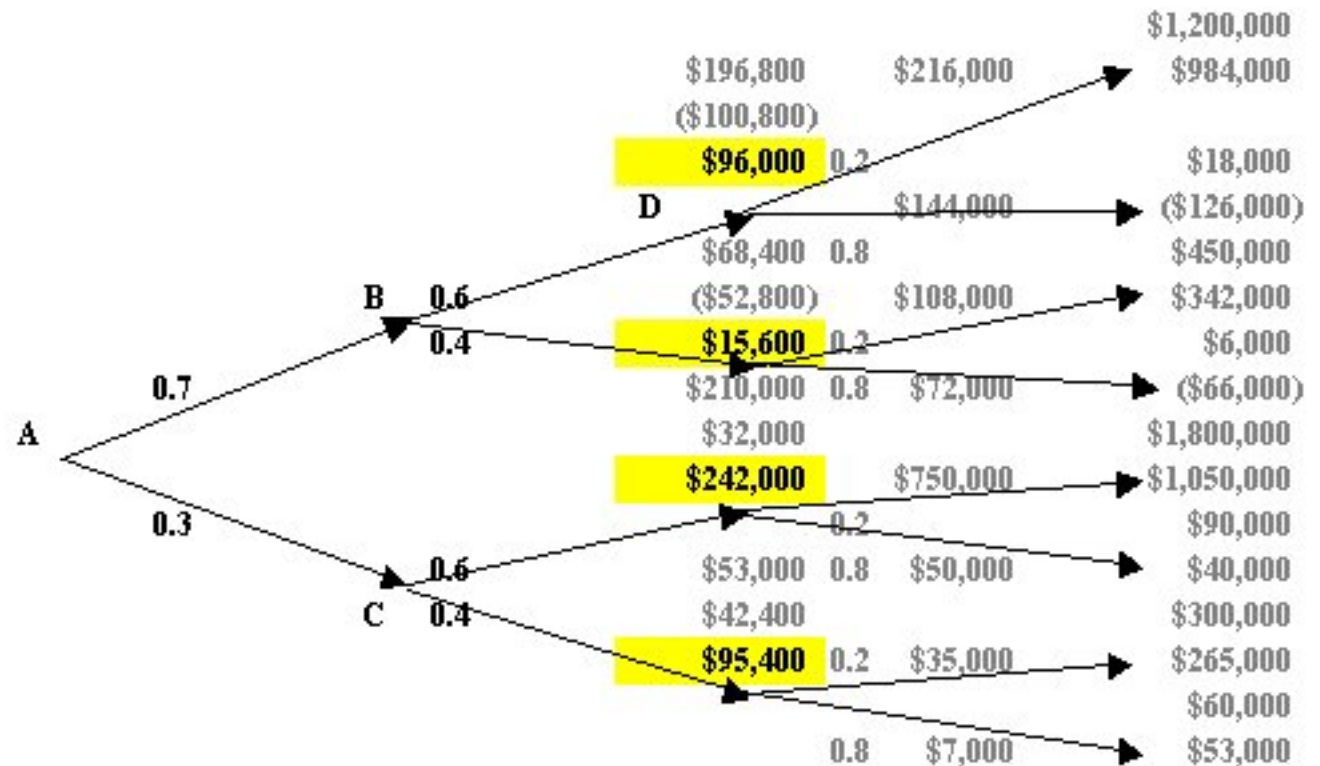
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- Process

- List the alternatives
- Assign probabilities
- Draw the tree
- Assign probable benefits and costs
- Calculate the expected value
  - $\text{Net Revenue} = (\text{Benefit} - \text{Cost})$
  - $\text{Expected Value} = (\text{Net Revenue}) * (\text{Probability})$
  - Expected Value at a junction is the sum of the branches
  - Work every branch and junction from right to left

# Illustrate – Expected Value

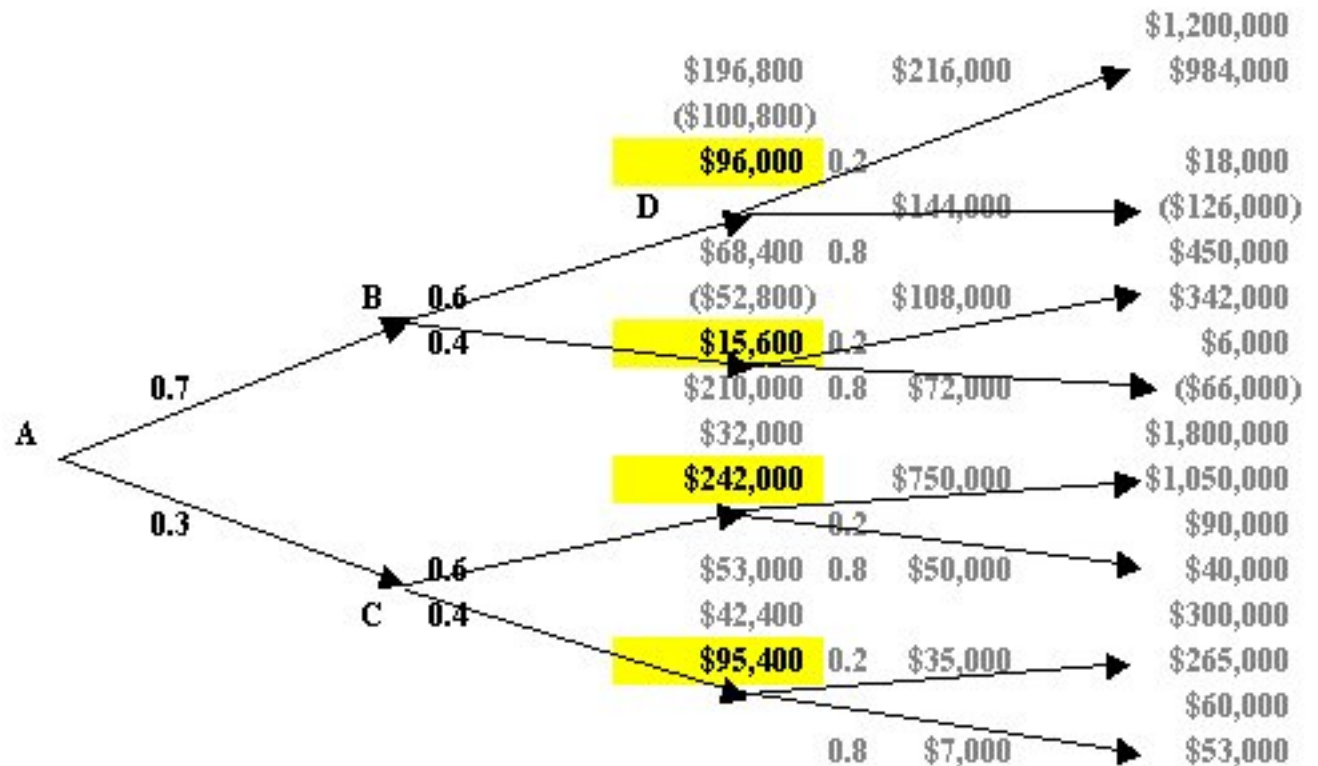
- What is the Expected Value at B?



# Illustrate – Expected Value

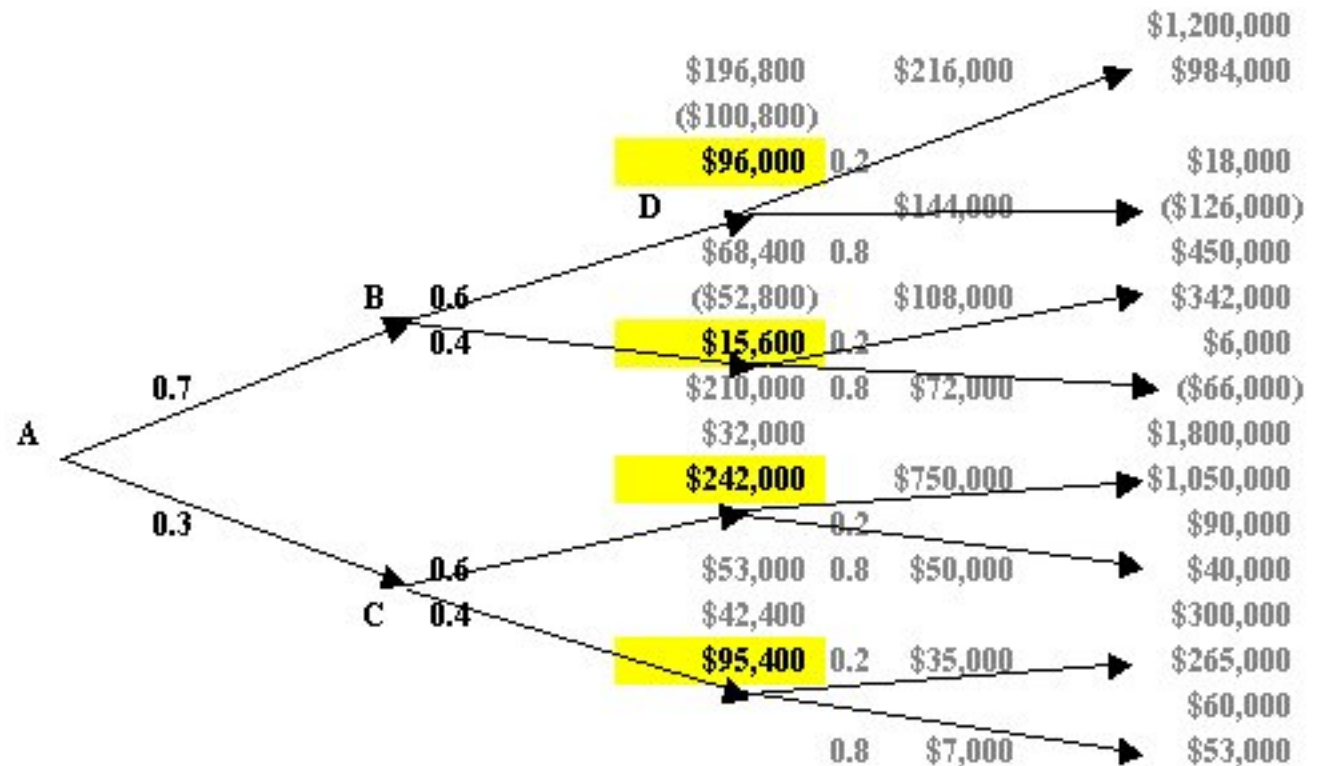
- Expected Value @ B?

$$\begin{aligned}
 & \$96,000 * 0.6 \\
 & + \$15,600 * 0.4 \\
 \hline
 & \$63,840
 \end{aligned}$$



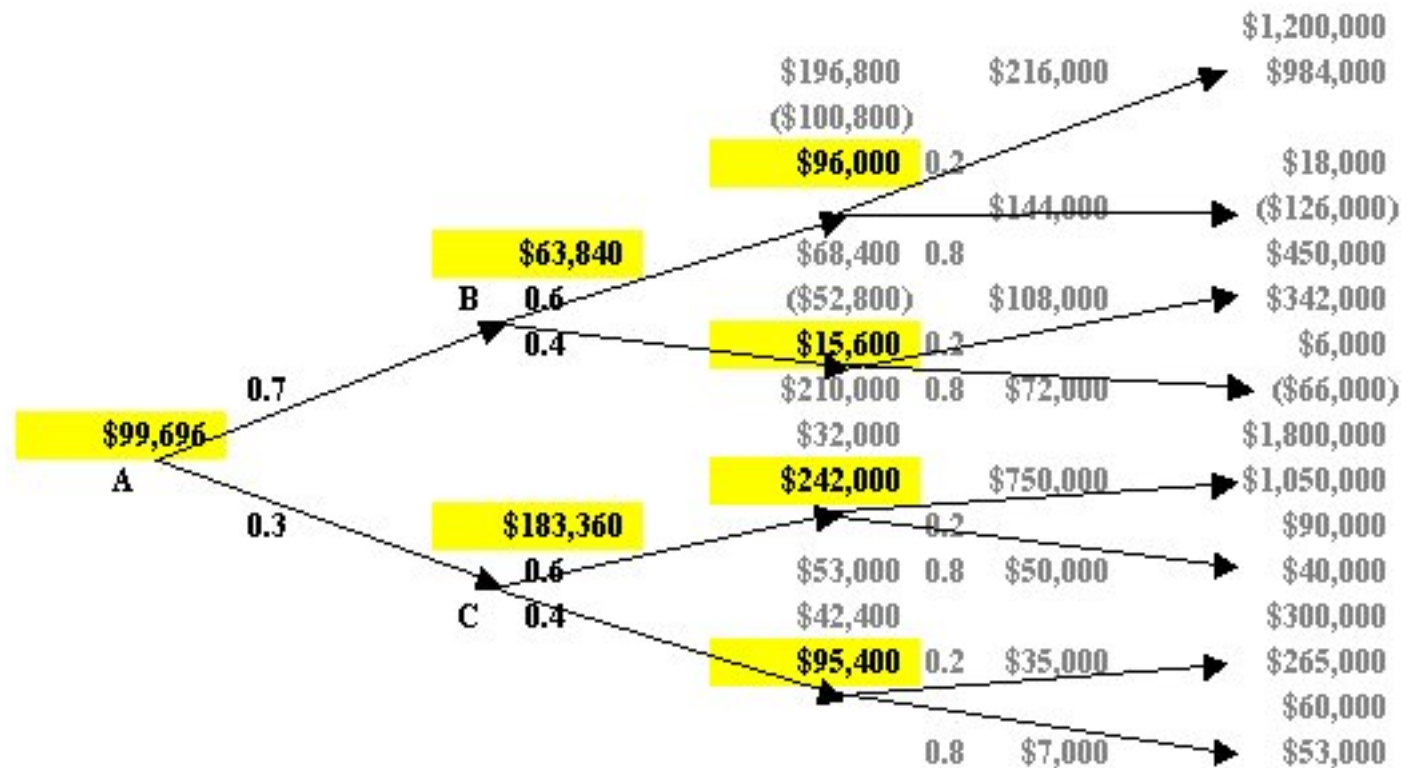
# Illustrate – Expected Value

- B = \$63,840
- Find C
- Find A



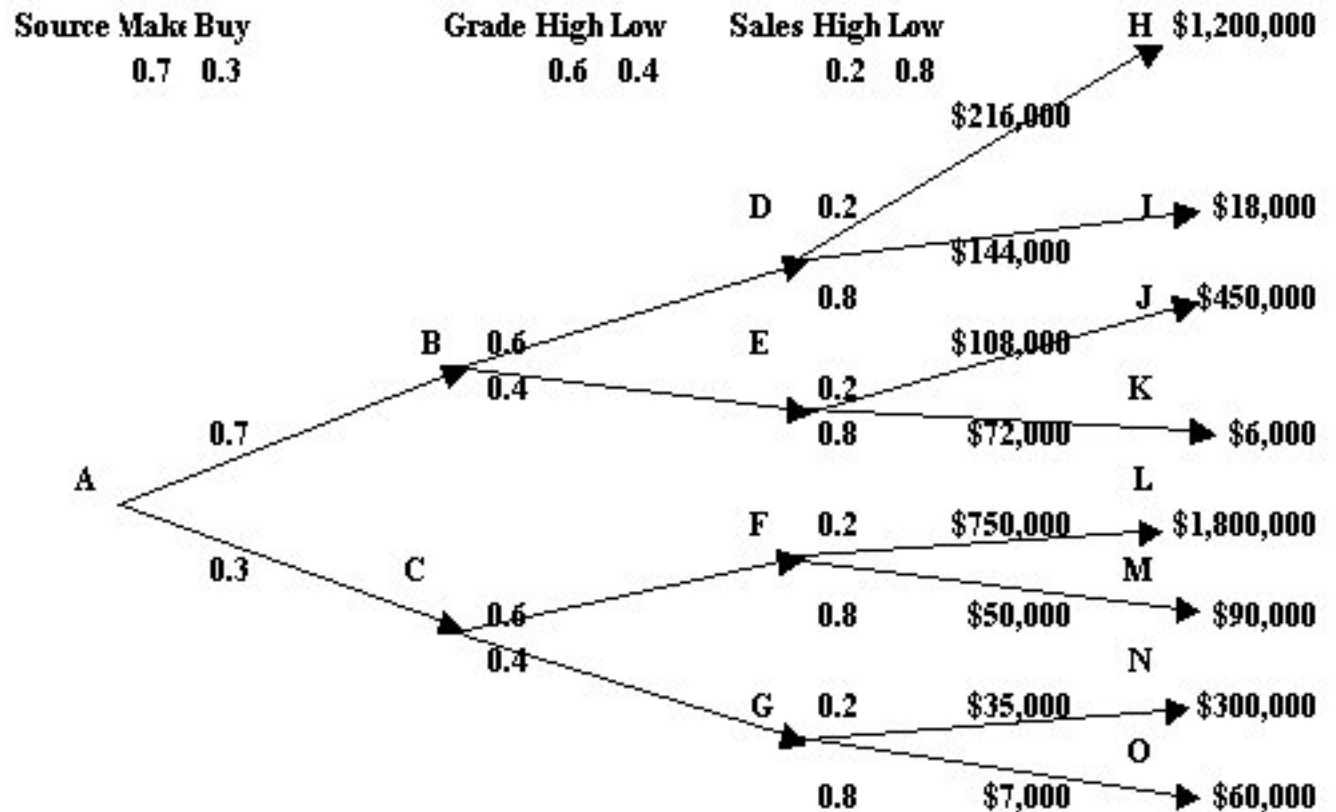
# Illustrate – Expected Value

- B=\$63,840
- C=\$183,360
- A=\$99,696



# Illustrate – Read the Problem

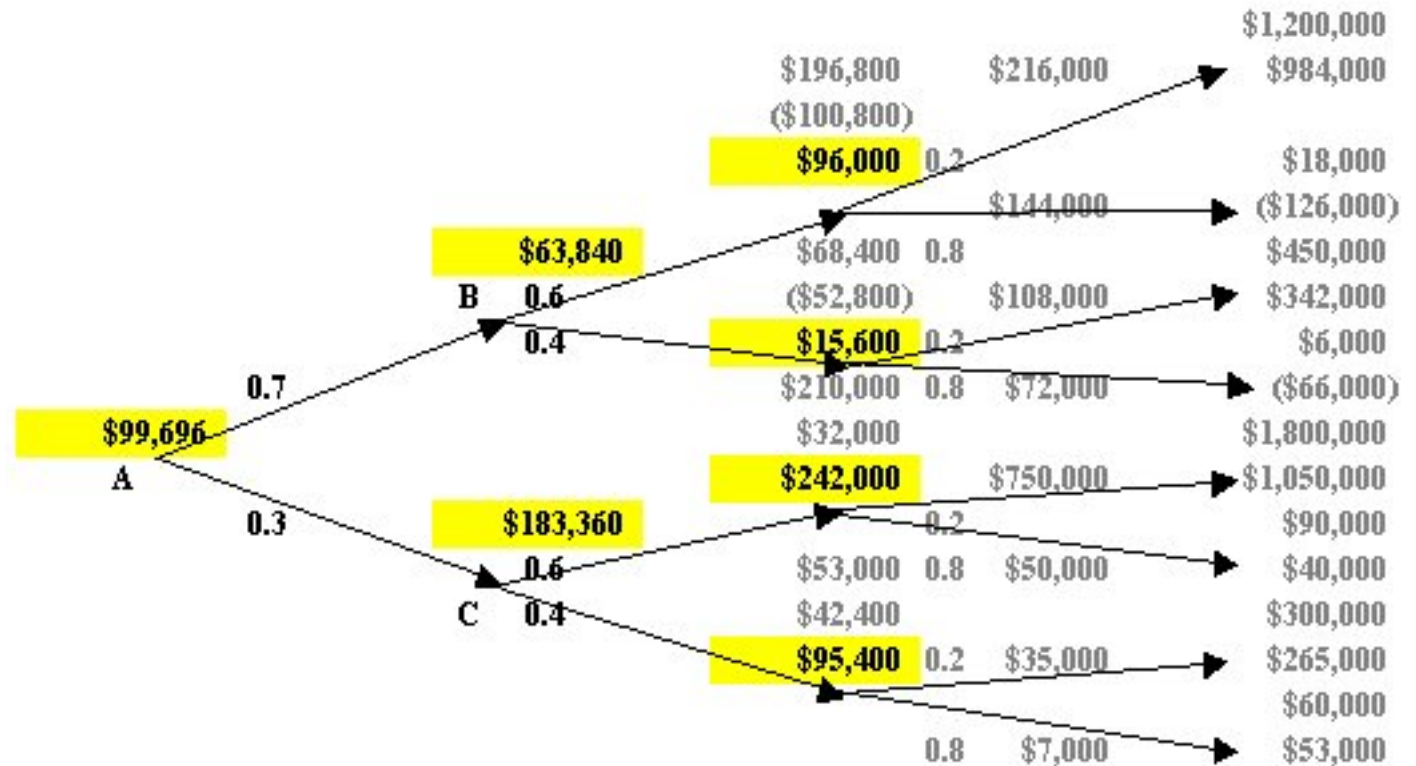
“What is the expected value for this decision tree?”



# Illustrate – Expected Value

“What is the expected value for this decision tree?”

**\$99,696**





# Illustrate the process – Summary

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## ■ Process

- List the alternatives
- Assign probabilities
- Draw the tree
- Assign probable benefits and costs
- Calculate the expected value
  - $\text{Net Revenue} = (\text{Benefit} - \text{Cost})$
  - $\text{Expected Value} = (\text{Net Revenue}) * (\text{Probability})$
  - Expected Value at a junction is the sum of the branches
  - Work every branch and junction from right to left
- Solve
  - Either for the whole
  - Or to identify the best branches



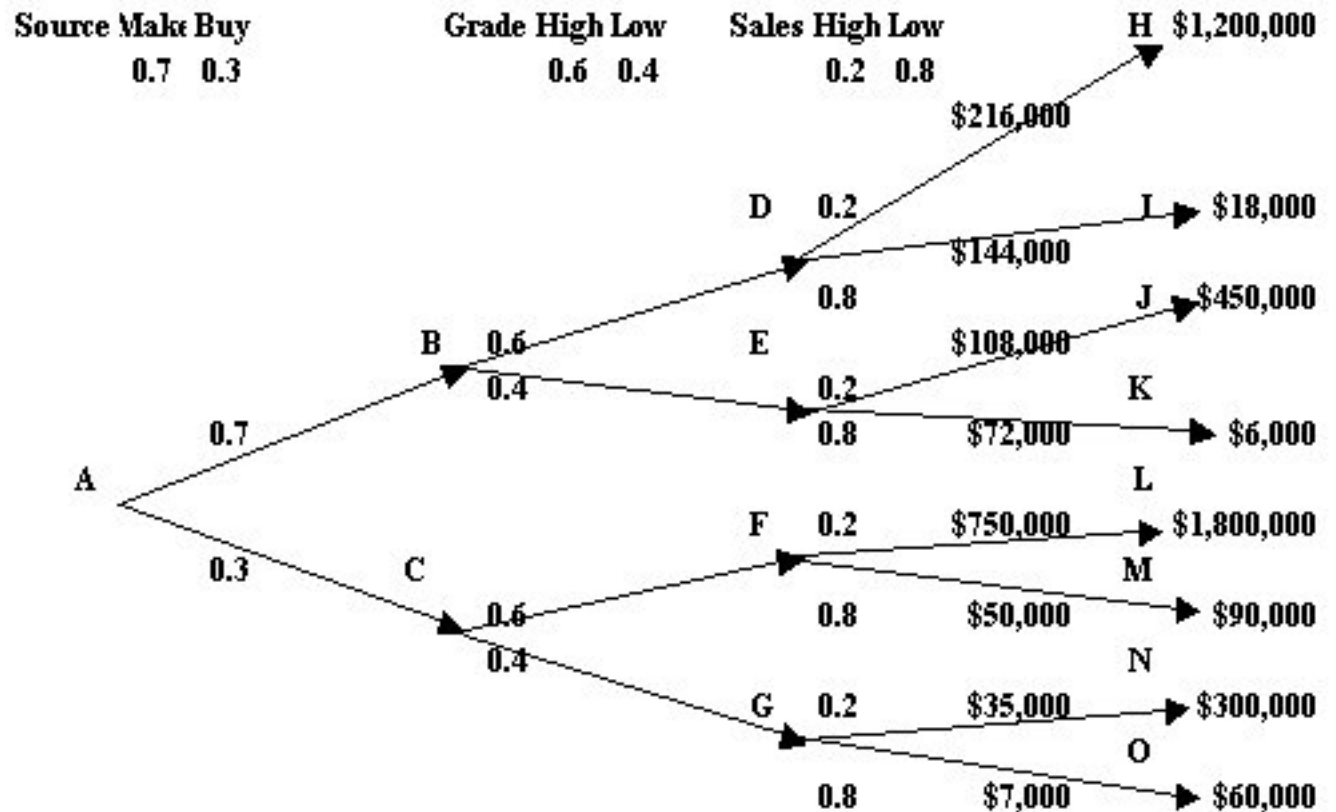
# Overview

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- Introduction to Decision Trees
- Illustrate the process
- **Gold Plate this problem**
- Summarize the results
- Work a typical problem

# Gold Plate the Problem

“What is the expected value for this decision tree?”





# Gold Plate the Problem

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- Where did these Benefits & Costs come from ?



# Gold Plate the Problem

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- Where did these numbers come from ?
- Following 2 slides show **Benefits & Costs**
  - Similar to a real problem I worked
  - Goal is to help you understand logic underneath
  - Minor violation of focusing on “Pass the Test”

Source		Grade		Sales		End Node Revenue		Evaluation Criteria					
Make	Buy	High	Low	High	Low								
0.7	0	0.6	0	0	1								
				0	1	\$1,200,000	Benefit	10,000	units x	\$5	/month	24	months
				0	1	\$216,000	Cost =	180	days x	\$1,200	/day	1	person
				0	1	\$984,000	H						
				0	1	\$196,800	Contribution to D						
						\$18,000	Benefit	200	units x	\$5	/month	18	months
						\$144,000	Cost =	120	days x	\$1,200	/day	1	person
						(\$126,000)	I						
				1	0	(\$100,800)	Contribution to D						
						\$96,000	Revenue D						
						0.6	High Grade						
						\$57,600	Contribution to B						
						\$254,400	Benefit						
						\$158,400	Cost						
						1.6	B / C						
						\$450,000	Benefit	5,000	units x	\$5	/month	18	months
						\$108,000	Cost =	90	days x	\$1,200	/day	1	person
						\$342,000	J						
						\$68,400	Contribution to E						
						\$6,000	Benefit	100	units x	\$5	/month	12	months
						\$72,000	Cost =	60	days x	\$1,200	/day	1	person
						(\$66,000)	K						
				1	0	(\$52,800)	Contribution to E						
						\$15,600	Revenue E						
						0.4	Low Grade						
						\$6,240	Contribution to B						
						\$94,800	Benefit						
						\$79,200	Cost						
						1.2	B / C						
						\$1,800,000	Benefit	15,000	units x	\$5	/month	24	months
						\$750,000	Cost =	15,000	units x	\$50	/license	1	time
						\$1,050,000	L						
						\$210,000	Contribution to F						
						\$90,000	Benefit	1,000	units x	\$5	/month	18	months
						\$50,000	Cost =	1,000	units x	\$50	/license	1	time
						\$40,000	M						
				1	0	\$32,000	Contribution to F						
						\$242,000	Revenue F						
						0.5	High Grade						
						\$145,200	Contribution to C						
						\$432,000	Benefit						
						\$190,000	Cost						
						2.3	B / C						
						\$300,000	Benefit	5,000	units x	\$5	/month	12	months
						\$35,000	Cost =	5,000	units x	\$7	/license	1	time
						\$265,000	N						
						\$53,000	Contribution to G						
						\$60,000	Benefit	1,000	units x	\$5	/month	12	months
						\$7,000	Cost =	1,000	units x	\$7	/license	1	time
						\$53,000	O						
				1	0	\$42,400	Contribution to G						
						\$95,400	Revenue G						
						0.4	Low Grade						
						\$38,160	Contribution to C						

\$99,696 Revenue A  
 \$224,112 Benefit  
 \$124,416 Cost  
 1.8 B / C

\$63,840 Revenue B  
 0.7 Make  
 \$44,688 Contribution to A  
 \$150,560 Benefit  
 \$126,720 Cost  
 1.5 B / C

\$183,360 Revenue C  
 0.3 Buy  
 \$55,008 Contribution to A  
 \$302,400 Benefit  
 \$119,040 Cost  
 2.5 B / C

# Gold Plate – Benefits & Costs

<u>Node</u>	<u>Effect at Node</u>	<u>Units</u>	<u>Dollars</u>	<u>Terms</u>
H	\$1,200,000 Benefit =	10,000 units x	\$5 /month x	24 months
H	\$216,000 Cost =	180 days x	\$1,200 /day x	1 person
I	\$18,000 Benefit =	200 units x	\$5 /month x	18 months
I	\$144,000 Cost =	120 days x	\$1,200 /day x	1 person
J	\$450,000 Benefit =	5,000 units x	\$5 /month x	18 months
J	\$108,000 Cost =	90 days x	\$1,200 /day x	1 person
K	\$6,000 Benefit =	100 units x	\$5 /month x	12 months
K	\$72,000 Cost =	60 days x	\$1,200 /day x	1 person
L	\$1,800,000 Benefit =	15,000 units x	\$5 /month x	24 months
L	\$750,000 Cost =	15,000 units x	\$50 /license	1 time
M	\$90,000 Benefit =	1,000 units x	\$5 /month x	18 months
M	\$50,000 Cost =	1,000 units x	\$50 /license	1 time
N	\$300,000 Benefit =	5,000 units x	\$5 /month x	12 months
N	\$35,000 Cost =	5,000 units x	\$7 /license	1 time
O	\$60,000 Benefit =	1,000 units x	\$5 /month x	12 months
O	\$7,000 Cost =	1,000 units x	\$7 /license	1 time



# Gold Plate – More Calculations

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## ■ Process

- List the alternatives
- Assign probabilities
- Draw the tree
- Assign probable benefits and costs
- Calculate the expected value
  - Net Revenue = (Benefit – Cost)
  - Expected Value = (Net Revenue) \* (Probability)
  - Expected Value at a junction is the sum of the branches
  - Work every branch and junction from right to left
- Solve
  - Either for the whole
  - Or to identify the best branches

Source Make/Buy	Grade High/Low	Sales		End Node Revenue	Evaluation Criteria			
		High	Low		Benefit	Cost	Units	Time
\$99,696 Revenue A \$224,112 Benefit \$124,416 Cost 1.8 B/C	0.7 Make \$63,840 Revenue B \$44,688 Contribution to A \$150,560 Benefit \$126,720 Cost 1.5 B/C	0	1	\$1,200,000 Benefit \$216,000 Cost = <b>\$984,000 H</b> 0 High Sales <b>\$196,800 Contribution to D</b>	10,000 units x \$5 /month x 24 months	180 days x \$1,200 /day x 1 person		
		1	\$18,000 Benefit \$144,000 Cost = <b>(\$126,000) I</b> 1 Low Sales <b>(\$100,800) Contribution to D</b> <b>\$96,000 D</b>	200 units x \$5 /month x 18 months	120 days x \$1,200 /day x 1 person			
	0.6 High Grade \$96,000 Revenue D \$57,600 Contribution to B \$254,400 Benefit \$158,400 Cost 1.6 B/C	0	1	\$450,000 Benefit \$108,000 Cost = <b>\$342,000 J</b> 0 High Sales <b>\$68,400 Contribution to E</b>	5,000 units x \$5 /month x 18 months	90 days x \$1,200 /day x 1 person		
		1	\$6,000 Benefit \$72,000 Cost = <b>(\$66,000) K</b> 1 Low Sales <b>(\$52,800) Contribution to E</b> <b>\$15,600 E</b>	100 units x \$5 /month x 12 months	60 days x \$1,200 /day x 1 person			
	0.4 Low Grade \$6,240 Contribution to B \$94,800 Benefit \$79,200 Cost 1.2 B/C	0	1	\$1,800,000 Benefit \$750,000 Cost = <b>\$1,050,000 L</b> 0 High Sales <b>\$210,000 Contribution to F</b>	15,000 units x \$5 /month x 24 months	15,000 units x \$50 /license x 1 time		
		1	\$90,000 Benefit \$50,000 Cost = <b>\$40,000 M</b> 1 Low Sales <b>\$32,000 Contribution to F</b> <b>\$242,000 F</b>	1,000 units x \$5 /month x 18 months	1,000 units x \$50 /license x 1 time			
	0.3 Buy \$55,008 Contribution to A \$302,400 Benefit \$119,040 Cost 2.5 B/C	0	1	\$300,000 Benefit \$35,000 Cost = <b>\$265,000 N</b> 0 High Sales <b>\$53,000 Contribution to G</b>	5,000 units x \$5 /month x 12 months	5,000 units x \$7 /license x 1 time		
		1	\$60,000 Benefit \$7,000 Cost = <b>\$53,000 O</b> 1 Low Sales <b>\$42,400 Contribution to G</b> <b>\$95,400 G</b>	1,000 units x \$5 /month x 12 months	1,000 units x \$7 /license x 1 time			
	0.4 Low Grade \$38,160 Contribution to C \$108,000 Benefit	0	1					
		1						

Source	Make Buy		Grade	High Low		Sales	High Low		End Node Revenue	Evaluation Criteria			
	0.7	0		0.6	0		0	1					
									\$1,200,000 Benefit \$216,000 Cost = \$984,000 H \$196,800 Contribution to D	10,000 units x \$5 /month x 24 months	180 days x \$1,200 /day x 1 person		
									\$18,000 Benefit \$144,000 Cost = (\$126,000) I (\$100,800) Contribution to D	200 units x \$5 /month x 18 months	120 days x \$1,200 /day x 1 person		
									<b>\$96,000 Revenu D</b> 0.6 High Grade \$57,600 Contribution to B \$254,400 Benefit \$158,400 Cost 1.6 B / C				
									\$450,000 Benefit \$108,000 Cost = \$342,000 J \$68,400 Contribution to E	5,000 units x \$5 /month x 18 months	90 days x \$1,200 /day x 1 person		
									\$6,000 Benefit \$72,000 Cost = (\$66,000) K (\$52,800) Contribution to E	100 units x \$5 /month x 12 months	60 days x \$1,200 /day x 1 person		
									<b>\$63,840 Revenu B</b> 0.7 Make \$44,688 Contribution to A <b>\$15,600 Revenu E</b> 0.4 Low Grade \$6,240 Contribution to B				
									\$1,800,000 Benefit \$750,000 Cost = \$1,050,000 L \$210,000 Contribution to F	15,000 units x \$5 /month x 24 months	15,000 units x \$50 /license x 1 time		
									<b>\$99,696 Revenu A</b> \$224,112 Benefit \$124,416 Cost 1.8 B / C				
									<b>\$183,360 Revenu C</b> 0.3 Buy \$55,008 Contribution to A \$302,400 Benefit \$119,040 Cost 2.5 B / C				
									\$90,000 Benefit \$50,000 Cost = \$40,000 M \$32,000 Contribution to F	1,000 units x \$5 /month x 18 months	1,000 units x \$50 /license x 1 time		
									<b>\$242,000 Revenu F</b> 0.6 High Grade \$145,200 Contribution to C \$432,000 Benefit \$190,000 Cost 2.3 B / C				
									\$300,000 Benefit \$35,000 Cost = \$265,000 N \$53,000 Contribution to G	5,000 units x \$5 /month x 12 months	5,000 units x \$7 /license x 1 time		
									\$60,000 Benefit \$7,000 Cost = \$53,000 O \$42,400 Contribution to G	1,000 units x \$5 /month x 12 months	1,000 units x \$7 /license x 1 time		
									<b>\$95,400 Revenu G</b> 0.4 Low Grade \$38,160 Contribution to C				



# Gold Plate – Alternatives

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- Expected Value for tree is one goal
  - Did this already
  - What else can you do with a Decision Tree ?



# Gold Plate – Alternatives

---

- Expected Value for tree is one goal
  - Did this already
  - What else can you do with a Decision Tree ?
  - Aid decision making



# Gold Plate – Alternatives

---

- Expected Value for tree is one goal
  - Did this already
  - What else can you do with a Decision Tree ?
  - Aid decision making
- **Calculate Expected Value for:**
  - **Net Revenue**
  - **Benefits**
  - **Costs**



# Gold Plate – Expected Benefits

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- Expected Value of Benefits  
= (Benefits) \* (Probability)
- Same as with Net Revenue

Source	Grade	Sales	End Node Revenue		Evaluation Criteria				
			High	Low	Benefit	Cost	Units	Days	Months
0.7 Make	0.6 High	0 High	1 High	\$1,200,000	\$216,000	10,000	180	24	1
0.7 Buy	0.6 Low	1 High	0 High	\$984,000	H				
				\$196,800	Contribution to D				
				\$18,000	\$144,000	200	120	18	1
				(\$126,000)	I				
				(\$100,800)	Contribution to D				
				\$96,000	Revenu D				
				\$57,600	Contribution to B				
				\$254,400	Benefit				
				\$158,400	Cost				
				1.6	B / C				
				\$450,000	Benefit	5,000	90	18	1
				\$108,000	Cost =				
				\$342,000	J				
				\$68,400	Contribution to E				
				\$6,000	Benefit	100	60	12	1
				\$72,000	Cost =				
				(\$66,000)	K				
				(\$52,800)	Contribution to E				
				\$15,600	Revenu E				
				\$6,240	Contribution to B				
				\$94,800	Benefit				
				\$79,200	Cost				
				1.2	B / C				
				\$1,800,000	Benefit	15,000	15,000	24	1
				\$750,000	Cost =				
				\$1,050,000	L				
				\$210,000	Contribution to F				
				\$90,000	Benefit	1,000	1,000	18	1
				\$50,000	Cost =				
				\$40,000	M				
				\$32,000	Contribution to F				
				\$242,000	Revenu F				
				\$145,200	Contribution to C				
				\$432,000	Benefit	5,000	5,000	12	1
				\$190,000	Cost				
				2.3	B / C				
				\$60,000	Benefit	1,000	1,000	12	1
				\$7,000	Cost =				
				\$53,000	O				
				\$42,400	Contribution to G				
				\$95,400	Revenu G				
				\$38,160	Contribution to C				
				\$102,000	Benefit				

**\$99,696 Revenu A**  
 \$224,112 Benefit  
 \$124,416 Cost  
 1.8 B / C

**\$63,840 Revenu B**  
 0.7 Make  
 \$44,688 Contribute to  
 \$190,560 Benefit  
 \$126,720 Cost  
 1.5 B / C

**\$183,360 Revenu C**  
 0.3 Buy  
 \$55,008 Contribute to A  
 \$302,400 Benefit  
 \$119,040 Cost  
 2.5 B / C

**\$96,000 Revenu D**  
 0.6 High Grade  
 \$57,600 Contribution to B  
**\$254,400 Benefit**  
**\$158,400 Cost**  
 1.6 B / C

**\$15,600 Revenu E**  
 0.4 Low Grade  
 \$6,240 Contribution to B  
 \$94,800 Benefit  
 \$79,200 Cost  
 1.2 B / C

**\$242,000 Revenu F**  
 0.6 High Grade  
 \$145,200 Contribution to C  
 \$432,000 Benefit  
 \$190,000 Cost  
 2.3 B / C

**\$95,400 Revenu G**  
 0.4 Low Grade  
 \$38,160 Contribution to C  
 \$102,000 Benefit

			Make H High Grade 0 High Sales	\$1,200,000 Benefit \$216,000 Cost = \$984,000 H \$196,800 Contribution to D	10,000 units x 180 days x	\$5 /month \$1,200 /day	24 months 1 person
			Make I High Grade 1 Low Sales	\$18,000 Benefit \$144,000 Cost = (\$126,000) I (\$100,800) Contribution to D \$96,000 D	200 units x 120 days x	\$5 /month \$1,200 /day	18 months 1 person
		<b>\$96,000 Revenu D</b> 0.6 High Grade \$57,600 Contribution to B	Make J Low Grade 0 High Sales	\$450,000 Benefit \$108,000 Cost = \$342,000 J \$68,400 Contribution to E	5,000 units x 90 days x	\$5 /month \$1,200 /day	18 months 1 person
		<b>\$254,400 Benefit</b> <b>\$158,400 Cost</b> 1.6 B / C	Make K Low Grade 1 Low Sales	\$6,000 Benefit \$72,000 Cost = (\$66,000) K (\$52,800) Contribution to E \$15,600 E	100 units x 60 days x	\$5 /month \$1,200 /day	12 months 1 person
	<b>\$63,840 Revenu B</b> 0.7 Make \$44,688 Contribution to A	<b>\$15,600 Revenu E</b> 0.4 Low Grade \$6,240 Contribution to B	Buy L High Grade 0 High Sales	\$1,800,000 Benefit \$750,000 Cost = \$1,050,000 L \$210,000 Contribution to F	15,000 units x 15,000 units x	\$5 /month \$50 /license	24 months 1 time
<b>\$99,696 Revenu A</b> \$224,112 Benefit \$124,416 Cost 1.8 B / C	<b>\$183,360 Revenu C</b> 0.3 Buy \$55,008 Contribution to A \$302,400 Benefit \$119,040 Cost 2.5 B / C	<b>\$94,800 Benefit</b> <b>\$79,200 Cost</b> 1.2 B / C	Buy M High Grade 1 Low Sales	\$90,000 Benefit \$50,000 Cost = \$40,000 M \$32,000 Contribution to F \$242,000 F	1,000 units x 1,000 units x	\$5 /month \$50 /license	18 months 1 time
		<b>\$242,000 Revenu F</b> 0.5 High Grade \$145,200 Contribution to C	Buy N Low Grade 0 High Sales	\$300,000 Benefit \$35,000 Cost = \$265,000 N \$53,000 Contribution to G	5,000 units x 5,000 units x	\$5 /month \$7 /license	12 months 1 time
		<b>\$432,000 Benefit</b> <b>\$190,000 Cost</b> 2.3 B / C	Buy O Low Grade 1 Low Sales	\$60,000 Benefit \$7,000 Cost = \$53,000 O \$42,400 Contribution to G \$95,400 G	1,000 units x 1,000 units x	\$5 /month \$7 /license	12 months 1 time
		<b>\$95,400 Revenu G</b> 0.4 Low Grade \$38,160 Contribution to C <b>\$108,000 Benefit</b> <b>\$12,600 Cost</b> 8.6 B / C					

			Make H High Grade 0 High Sales	\$1,200,000 Benefit \$216,000 Cost = \$984,000 H \$196,800 Contribution to D	10,000 units x \$5 /month : 24 months 180 days x \$1,200 /day x 1 person
			Make I High Grade 1 Low Sales	\$18,000 Benefit \$144,000 Cost = (\$126,000) I (\$100,800) Contribution to D	200 units x \$5 /month : 18 months 120 days x \$1,200 /day x 1 person
		<b>\$96,000 Revenu D</b> 0.6 High Grade \$57,600 Contribution to B		\$96,000 D	
		\$254,400 Benefit \$158,400 Cost 1.6 B / C	Make J Low Grade 0 High Sales	\$450,000 Benefit \$108,000 Cost = \$342,000 J \$68,400 Contribution to E	5,000 units x \$5 /month : 18 months 90 days x \$1,200 /day x 1 person
			Make K Low Grade 1 Low Sales	\$6,000 Benefit \$72,000 Cost = (\$66,000) K (\$52,800) Contribution to E	100 units x \$5 /month : 12 months 60 days x \$1,200 /day x 1 person
	<b>\$63,840 Revenu B</b> 0.7 Make \$44,688 Contribute to \$190,560 Benefit \$126,720 Cost 1.9 B / C	<b>\$15,600 Revenu E</b> 0.4 Low Grade \$6,240 Contribution to B		\$15,600 E	
<b>\$99,696 Revenu A</b> \$224,112 Benefit \$124,416 Cost 1.8 B / C		\$94,800 Benefit \$79,200 Cost 1.2 B / C	Buy L High Grade 0 High Sales	\$1,800,000 Benefit \$750,000 Cost = \$1,050,000 L \$210,000 Contribution to F	15,000 units x \$5 /month : 24 months 15,000 units x \$50 /license : 1 time
	<b>\$183,360 Revenu C</b> 0.3 Buy \$55,008 Contribute to A \$302,400 Benefit \$119,040 Cost 2.5 B / C		Buy M High Grade 1 Low Sales	\$90,000 Benefit \$50,000 Cost = \$40,000 M \$32,000 Contribution to F	1,000 units x \$5 /month : 18 months 1,000 units x \$50 /license : 1 time
		<b>\$242,000 Revenu F</b> 0.5 High Grade \$145,200 Contribution to C		\$242,000 F	
		\$432,000 Benefit \$190,000 Cost 2.3 B / C	Buy N Low Grade 0 High Sales	\$300,000 Benefit \$35,000 Cost = \$265,000 N \$53,000 Contribution to G	5,000 units x \$5 /month : 12 months 5,000 units x \$7 /license : 1 time
			Buy O Low Grade 1 Low Sales	\$60,000 Benefit \$7,000 Cost = \$53,000 O \$42,400 Contribution to G	1,000 units x \$5 /month : 12 months 1,000 units x \$7 /license : 1 time
		<b>\$95,400 Revenu G</b> 0.4 Low Grade \$38,160 Contribution to C \$108,000 Benefit \$12,600 Cost 8.6 B / C		\$95,400 G	

# Gold Plate – Make Decision

- Which has the highest Expected Revenue ?

D

E

F

G

<b>\$96,000</b>	<b>D</b>
<b>1.6</b>	

<b>\$15,600</b>	<b>E</b>
<b>1.2</b>	

<b>\$242,000</b>	<b>F</b>
<b>2.3</b>	

<b>\$95,400</b>	<b>G</b>
<b>8.6</b>	

# Gold Plate – Make Decision

- Which has the highest Expected Revenue ?

D \$96,000

E \$15,600

**F \$242,000**

G \$95,400

<b>\$96,000</b>	<b>D</b>
<b>1.6</b>	

<b>\$15,600</b>	<b>E</b>
<b>1.2</b>	

<b>\$242,000</b>	<b>F</b>
<b>2.3</b>	

<b>\$95,400</b>	<b>G</b>
<b>8.6</b>	

# Gold Plate – Make Decision

- Which has the highest Expected Revenue ?

D \$96,000

E \$15,600

F **\$242,000**

G \$95,400

- Which has the highest Benefit / Cost ratio ?

D

E

F

G

<b>\$96,000</b>	<b>D</b>
<b>1.6</b>	

<b>\$15,600</b>	<b>E</b>
<b>1.2</b>	

<b>\$242,000</b>	<b>F</b>
<b>2.3</b>	

<b>\$95,400</b>	<b>G</b>
<b>8.6</b>	

# Gold Plate – Make Decision

- Which has the highest Expected Revenue ?

D \$96,000

E \$15,600

F **\$242,000**

G \$95,400

- Which has the highest Benefit / Cost ratio ?

D 1.6

E 1.2

F 2.3

**G 8.6**

<b>\$96,000</b>	<b>D</b>
<b>1.6</b>	

<b>\$15,600</b>	<b>E</b>
<b>1.2</b>	

<b>\$242,000</b>	<b>F</b>
<b>2.3</b>	

<b>\$95,400</b>	<b>G</b>
<b>8.6</b>	

# Gold Plate – Make Decision

- Which has the highest Expected Revenue ?

D \$96,000

E \$15,600

**F \$242,000**

G \$95,400

- Which has the highest Benefit / Cost ratio ?

D 1.6

E 1.2

F 2.3

**G 8.6**

- Which one should you recommend ?

<b>\$96,000</b>	<b>D</b>
<b>1.6</b>	

<b>\$15,600</b>	<b>E</b>
<b>1.2</b>	

<b>\$242,000</b>	<b>F</b>
<b>2.3</b>	

<b>\$95,400</b>	<b>G</b>
<b>8.6</b>	



# Overview

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- Introduction to Decision Trees
- Illustrate the process
- Gold Plate this problem
- Summarize the results
- Work a typical problem



# Summarize the Results

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- Process

- List the alternatives
- Assign probabilities
- Draw the tree
- Assign probable benefits and costs
- Calculate the expected value
  - $\text{Net Revenue} = (\text{Benefit} - \text{Cost})$
  - $\text{Expected Value} = (\text{Net Revenue}) * (\text{Probability})$
  - Expected Value at a junction is the sum of the branches
  - Work every branch and junction from right to left
- Solve
  - Either for the whole
  - Or to identify the best branches



# Overview

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- Introduction to Decision Trees
- Illustrate the process
- Gold Plate this problem
- Summarize the results
- **Work a typical problem**



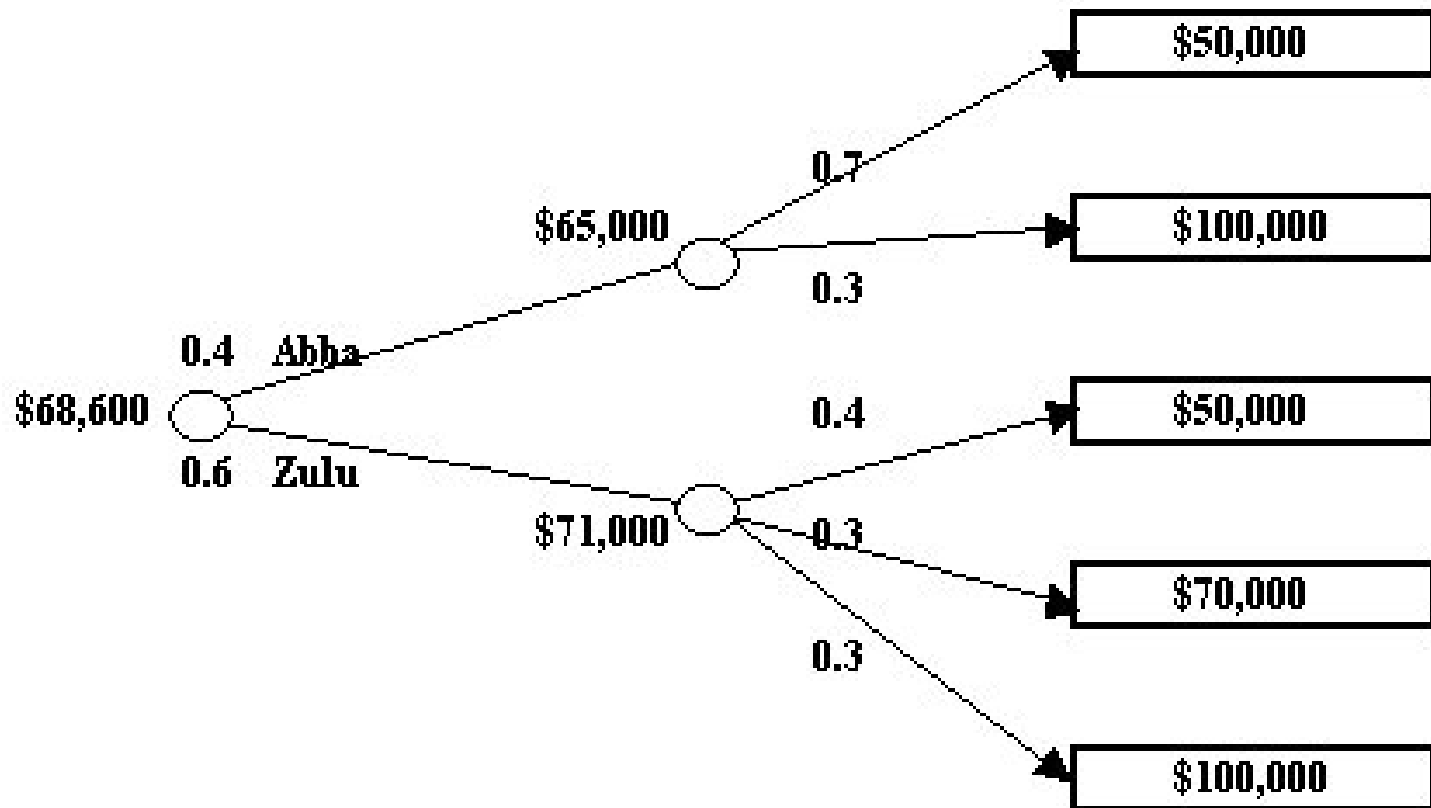
# Work a typical problem

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- Problem 3: You are the Project Manager for a facilities upgrade project. You need to budget communications services for the new building. You contacted two vendors, but both vendors told you they have major upgrade projects underway. Until they finish installing their new fiber optics they cannot give you the service you need.
- You believe there is a 40% chance that Spirit will have the service capability when you need it and a 60% chance that MCY will. Spirit says there is a 70% chance they can deliver the service for \$50,000, otherwise it will cost \$100,000 because of extra equipment.
- MCY has three ways they can try to get service to you. There is a 40% chance service will cost \$50,000, a 30% chance it will cost \$100,000. Otherwise it will cost \$70,000.
- What is the expected value you should use in your preliminary budget?

# Work a typical problem

- Did you get this answer ?





# Conclusion

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- Process

- List the alternatives
- Assign probabilities
- Draw the tree
- Assign probable benefits and costs
- Calculate the expected value
  - $\text{Net Revenue} = (\text{Benefit} - \text{Cost})$
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