DECISION ANALYSIS

Module 15

July 28, 2014

DECISION THEORY

- General Approach to Decision Making

- Many Uses:
  - Capacity Planning
  - Product/Service Design
  - Equipment Selection
  - Location Planning
  - Others

DECISION THEORY

- Typically Used for Decisions Characterized by the Following:
  - Set of Possible Future Conditions that Will Have a Bearing on the Results of the Decision
  - List of Alternatives to Choose From
  - Known "Payoff" for Each Alternative Under Each Possible Future Condition

DECISION THEORY

- Steps:
  - Identify Possible Future Conditions
    - Example: Demand is Low, Medium, or High
    - Referred to as “States of Nature”
  - Develop List of Possible Alternatives
    - Often Featuring the “Do Nothing” Alternative

DECISION THEORY

- Steps:
  - Determine Payoff Associated with Each Alternative for Each Possible Future Condition
  - If Possible, Estimate the Likelihood of Future Condition
  - Evaluate Alternatives by Some Criterion and Select Best

PAYOFF TABLE

- Shows Expected Payoffs for Various States of Nature

		Demand for Ice Cream		
		Low	**Moderate**	**High**
Type of Parlor	**Indoor**	500	1200	2000
	Drive-In	700	1500	1250
	Both	-2000	-1000	3000

* Payoffs in Predicted Profit Per Month

DECISION ENVIRONMENTS

- Certainty
  - All Parameters Known
- Risk
  - Certain Parameters Probabilistic
- Uncertainty
  - Impossible to Assess Likelihood of Possible Future Events

DECISION MAKING

- Under Certainty
  - We Know Which Future Condition(s) Will Occur
  - Choose Alternative with Best Payoff

		Demand for Ice Cream		
		Low	**Moderate**	**High**
Type of Parlor	**Indoor**	500	1200	2000
	Drive-In	700	1500	1250
	Both	-2000	-1000	3000

* Payoffs in Predicted Profit Per Month

DECISION MAKING

- Under Uncertainty
  - Four Decision Criteria
  - Maximin
    - Find Worst Possible Payoff for Each Alternative, Choose Alternative with "Best Worst"
    - Pessimistic → Gives Guaranteed Minimum
  - Maximax
    - Determine Best Possible Payoff, Choose Alternative with Best Payoff
    - Optimistic

DECISION MAKING

- Under Uncertainty
  - Laplace
    - Determine Average Payoff for Each Alternative, Choose Alternative with Best Average
    - Assumes States of Nature Equally Likely
  - Minimax Regret
    - Determine Worst “Regret”, Choose Alternative with the “Best Worst”
    - Seeks to Minimize Difference Between Actual Payoff and Best Payoff for Each State of Nature

EXAMPLE

		Demand for Ice Cream		
		Low	**Moderate**	**High**
Type of Parlor	**Indoor**	500	1200	2000
	Drive-In	700	1500	1250
	Both	-2000	-1000	3000

* Payoffs in Predicted Profit Per Month

- Maximin
  - Indoor → 500
  - Drive-In → 700
  - Both → -2000
  - Choose "Best of Worst" → Drive-In

EXAMPLE

		Demand for Ice Cream		
		Low	**Moderate**	**High**
Type of Parlor	**Indoor**	500	1200	2000
	Drive-In	700	1500	1250
	Both	-2000	-1000	3000

* Payoffs in Predicted Profit Per Month

- Maximax
  - Indoor → 2000
  - Drive-In → 1500
  - Both → 3000
  - Choose “Best of Best” → Both

EXAMPLE

		Demand for Ice Cream		
		Low	**Moderate**	**High**
Type of Parlor	**Indoor**	500	1200	2000
	Drive-In	700	1500	1250
	Both	-2000	-1000	3000

* Payoffs in Predicted Profit Per Month

- Laplace
  - Indoor → (500 + 1200 + 2000)/3 = 1233.3
  - Drive-In → (700 + 1500 + 1250)/3 = 1150
  - Both → (-2000 – 1000 + 3000)/3 = 0
  - Choose Indoor

DECISION MAKING

- Minimax Regret
  - Criterion for Decision Making Under Uncertainty
- Develop a Table of Regrets (Opportunity Losses)
- Subtract EVERY Payoff in Each Column from the BEST Payoff in that Column

DECISION MAKING

Demand for Ice Cream

Type of Parlor		Low	Moderate	High
	Indoor	500	1200	2000
	Drive-In	700	1500	1250
	Both	-2000	-1000	3000

Demand for Ice Cream

Type of Parlor		Low	Moderate	High
	Indoor			
	Drive-In			
	Both			

DECISION MAKING

- Identify "Worst" Regret for Each Alternative
  - Indoor →1000
  - Drive-In →1750
  - Both → 2700

- Choose LOWEST of These Regrets
  - Choose Indoor Alternative

DECISION MAKING

- Under Risk
  - We Know the Probability of Occurrence for Each State of Nature
  - Common Approach is the Expected Monetary Value (EMV) Criterion
    - Determine Expected Payoff for Each Alternative
    - Choose Alternative with Best Expected Payoff

DECISION MAKING

- Under Risk

		Demand Probabilities		
		0.3	0.5	0.2
		Low	**Moderate**	**High**
Type of Parlor	**Indoor**	500	1200	2000
	Drive-In	700	1500	1250
	Both	-2000	-1000	3000

- Expected Payoffs:
  - Indoor: (0.3)(500) + (0.5)(1200) + (0.2)(2000) = 1150
  - Drive-In: (0.3)(700) + (0.5)(1500) + (0.2)(1250) = 1210
  - Both: (0.3)(-2000) + (0.5)(-1000) + (0.2)(3000) = -500

- Select Drive-In

EXPECTED VALUE OF PERFECT INFO

- In Some Situations, it May Be Possible to Delay Making a Decision Until it is Clear Which State of Nature Will Occur in the Future
- EVPI is the Difference Between the Expected Payoff with Perfect Information and the Expected Payoff Under Risk

EXPECTED VALUE OF PERFECT INFO

- Steps:
  - Compute Payoff Under Certainty
  - Compute Payoff Under Risk
  - EVPI is Difference

- Example
  - Payoff Under Certainty
    - $(0.3)(700) + (0.5)(1500) + (0.2)(3000) = 1560$
  - Payoff Under Risk = 1210
  - EVPI = 1560 – 1210 = 350

EXPECTED VALUE OF PERFECT INFO

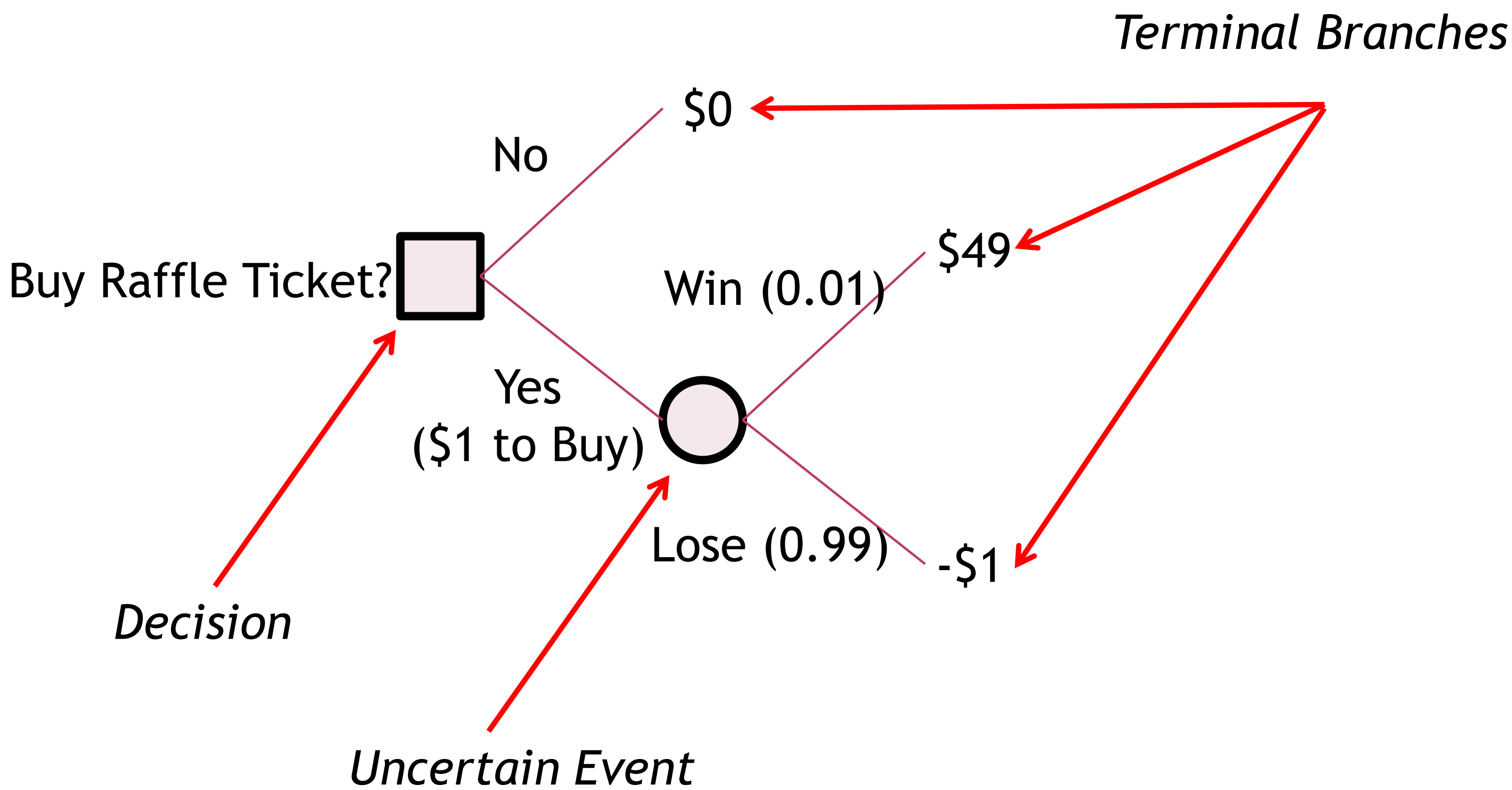
- NOTE:
  - EVPI is the UPPER LIMIT on the Amount That the Decision Maker Should Be Willing to Pay to Obtain Perfect Information

DECISION TREES

- Visual tool to represent a decision model
- Squares: ☐ - Decisions
- Circles: ○ - Uncertain Events (Subject to Probability)
- Branches: Potential Actions or Results
  - Some Branches are Terminal (End) → Terminal Branches Have Payoffs (Payoffs Should Reflect All Costs/Revenues)

DECISION TREES

- Simple Example

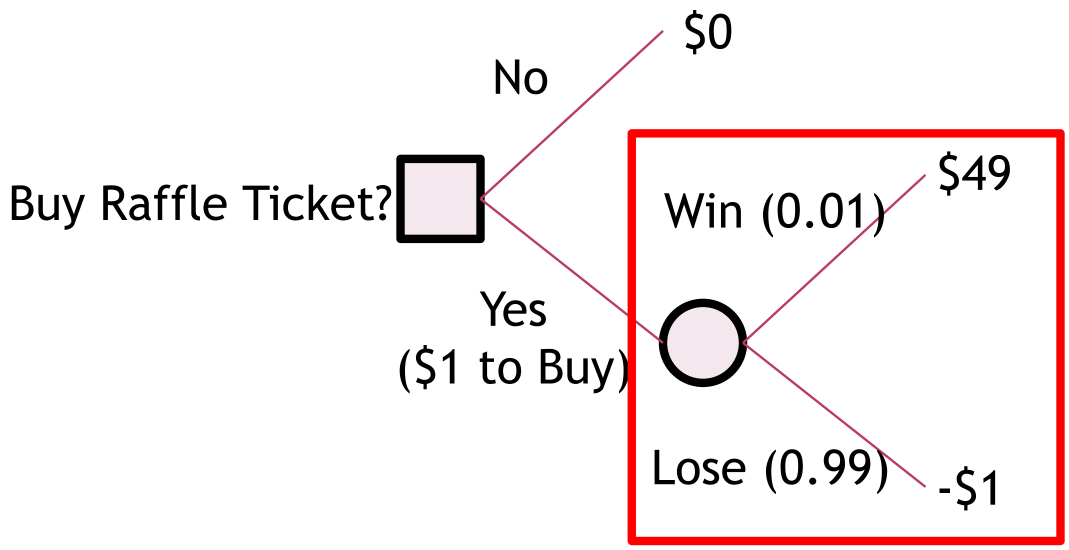


DECISION TREES

- Build Decision Trees from LEFT to RIGHT
- Solve Decision Trees from RIGHT to LEFT
- Determine Expected Values at Chance Nodes
- Choose “Best” Expected Value at Decision Nodes
- Identify “Best” Path of Decisions

DECISION TREES

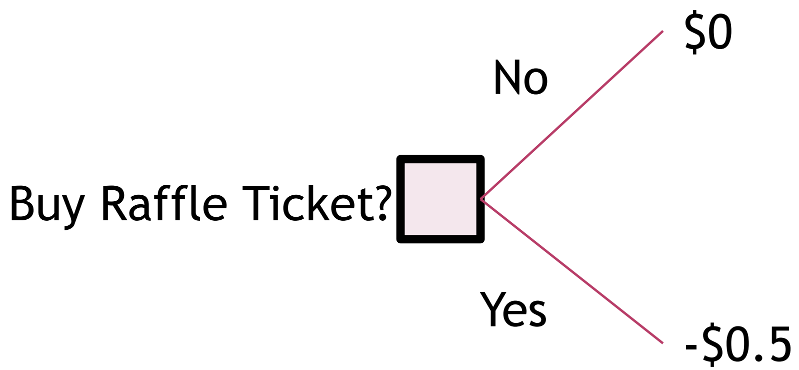
- Simple Example



Expected Value = (0.01)(49) + (0.99)(-1) = 0.49 – 0.99 = -0.5

DECISION TREES

- Simple Example



- Should You Buy a Raffle Ticket?
- NO! Your Expected Value is Negative

DECISION TREES

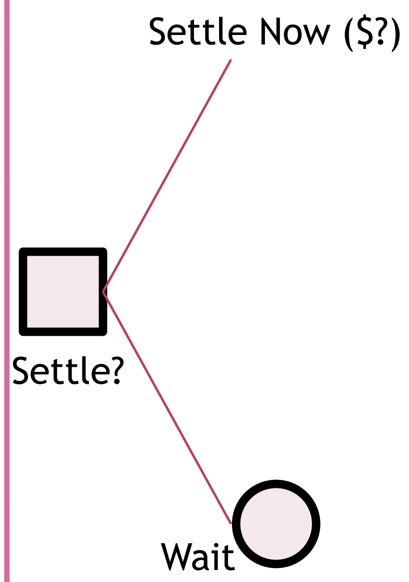
- More Complex Example

EXAMPLE
A Patent-Infringement Suit

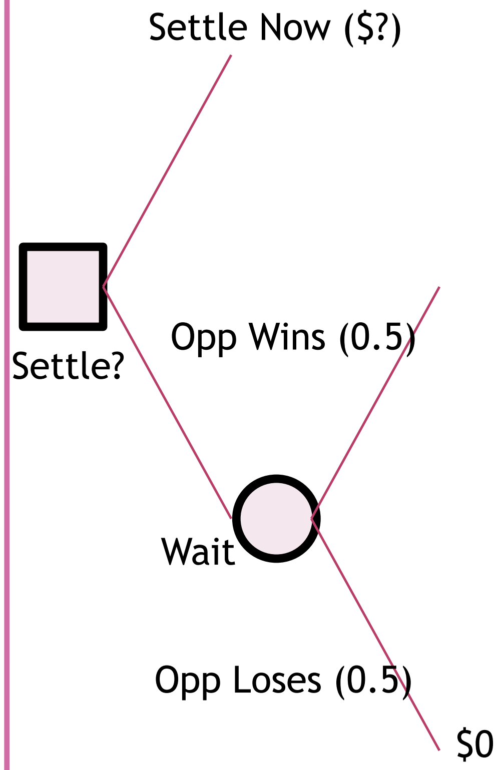
One of our corporate competitors is threatening us with a lawsuit for patent infringement. The competitor is already in court in a similar lawsuit against another firm, and our legal staff estimates that there is a 50 percent chance that our competitor will prevail. One option open to us is to settle out of court now; the alternative is to wait until the current case is resolved before taking action. If our competitor loses the other suit, it will not pursue an action against us. On the other hand, if the competitor wins, it is likely to sue us. Our legal staff estimates that likelihood at 80 percent. They further estimate that the suit would be brought for $10 million.

If the competitor sues us, we can negotiate a settlement, go to trial and contest the patent-infringement claim, or go to trial and concede the patent infringement but fight the settlement amount. In either case, of course, the trial will dictate the monetary outcome. Our legal staff estimates that a negotiated settlement would cost us roughly $8 million. If we contest the patent, we have a 30 percent chance of winning the suit. If we concede the patent and contest the settlement amount, then the only question would be the size of that amount. Our legal staff envisions two possibilities: High, at $15 million, with a 60 percent probability, and Low, at $5 million, with a 40 percent probability. ■

DECISION TREES



DECISION TREES



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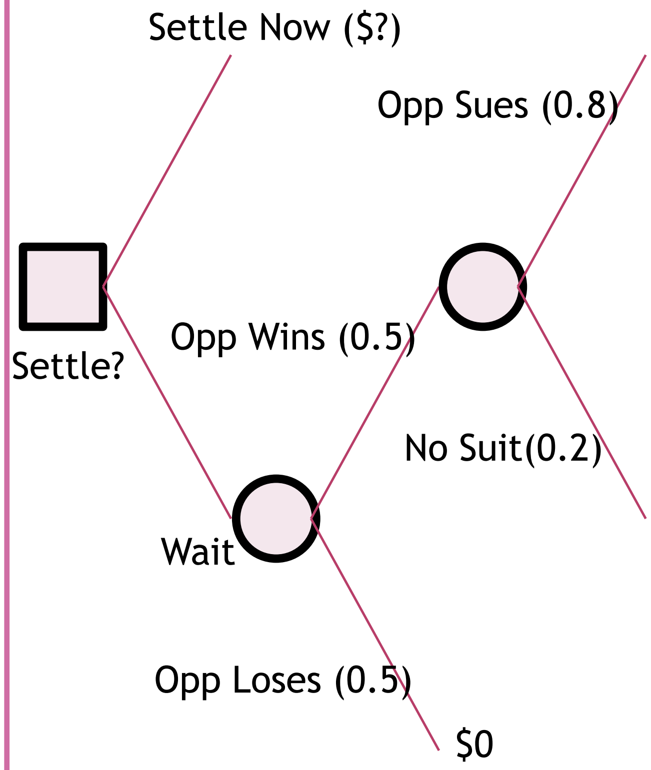

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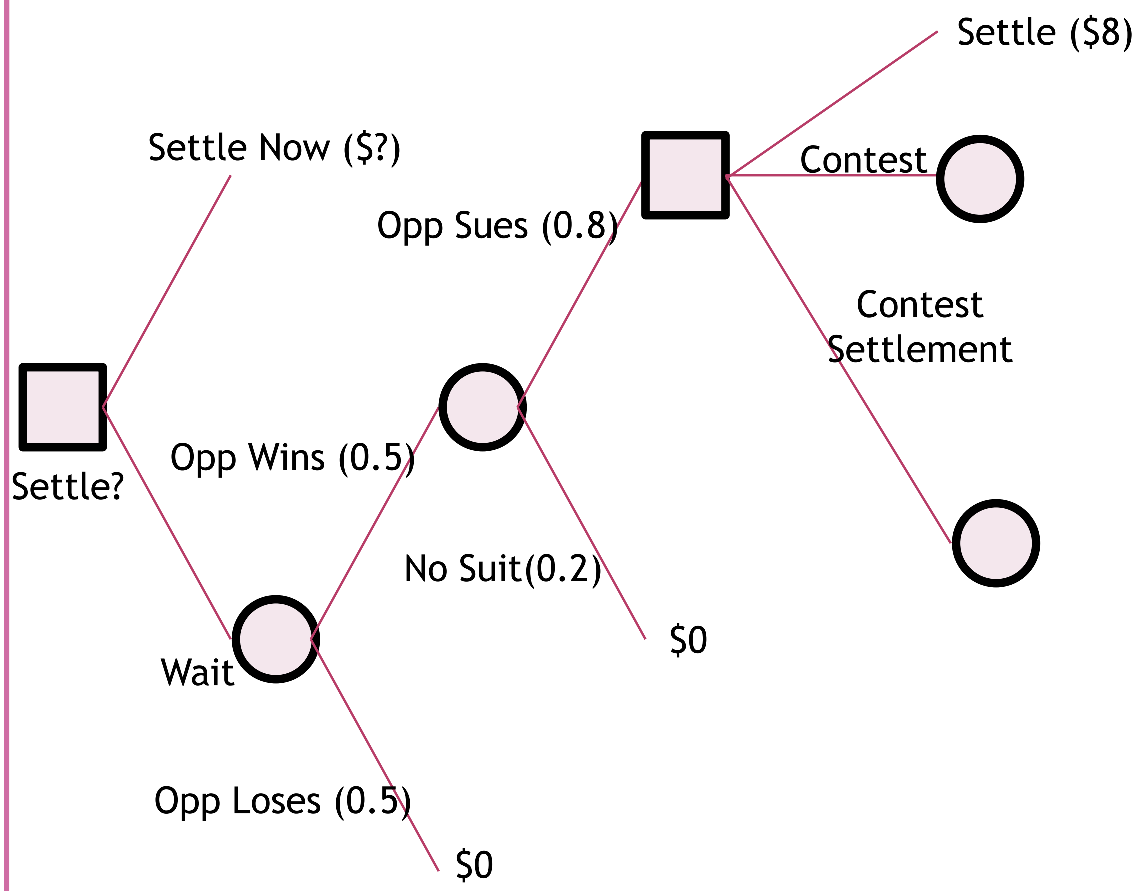

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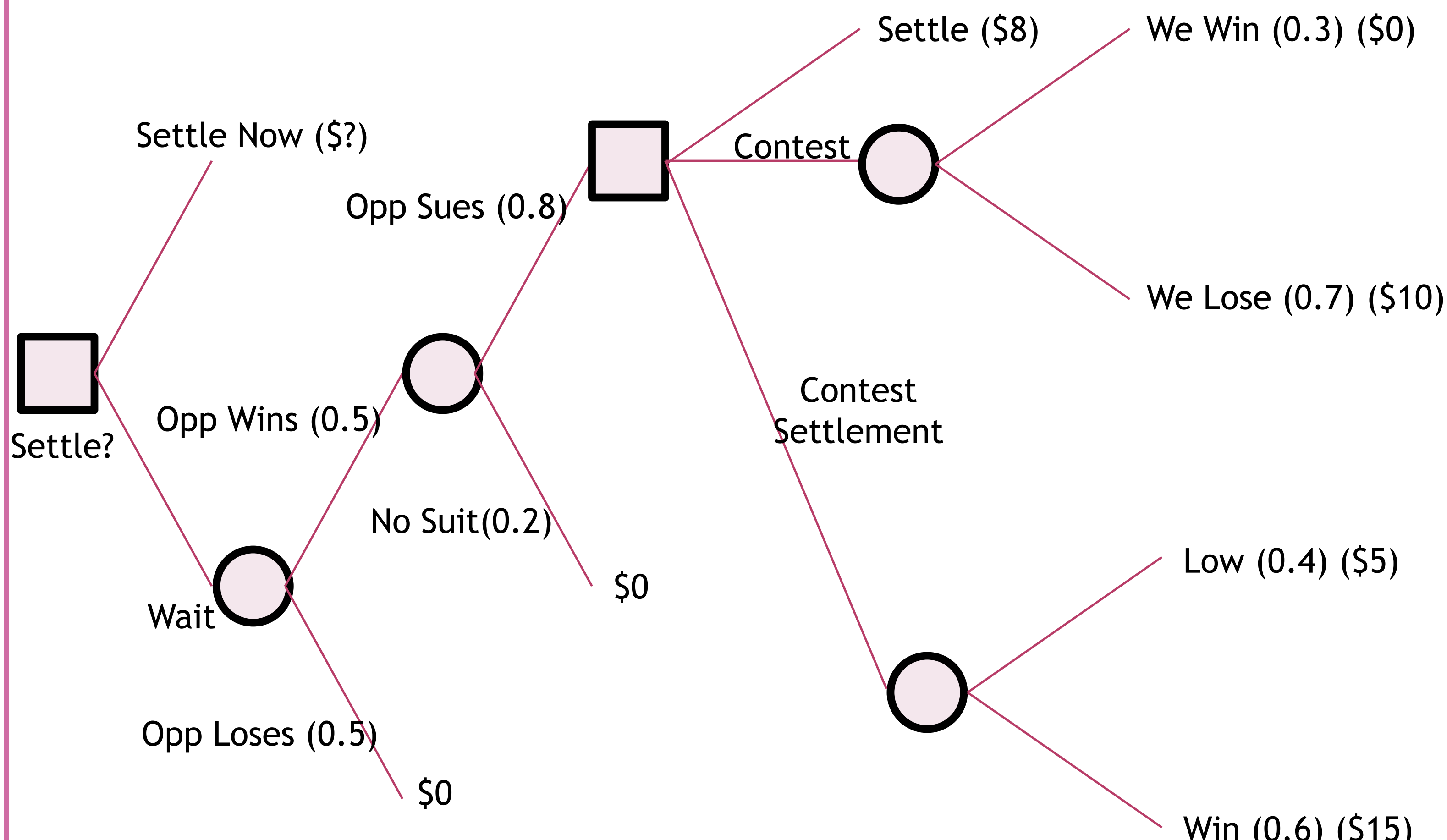

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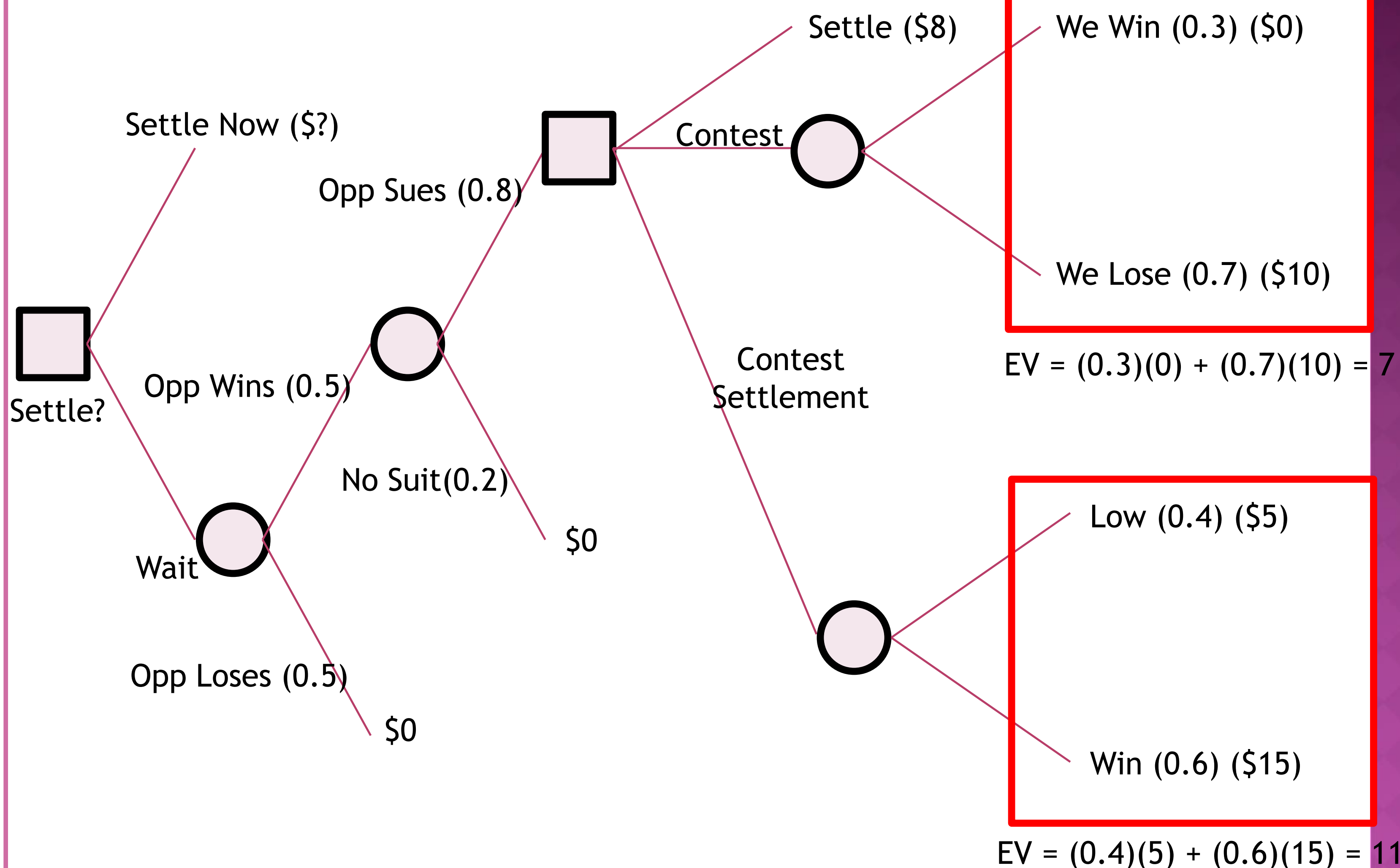

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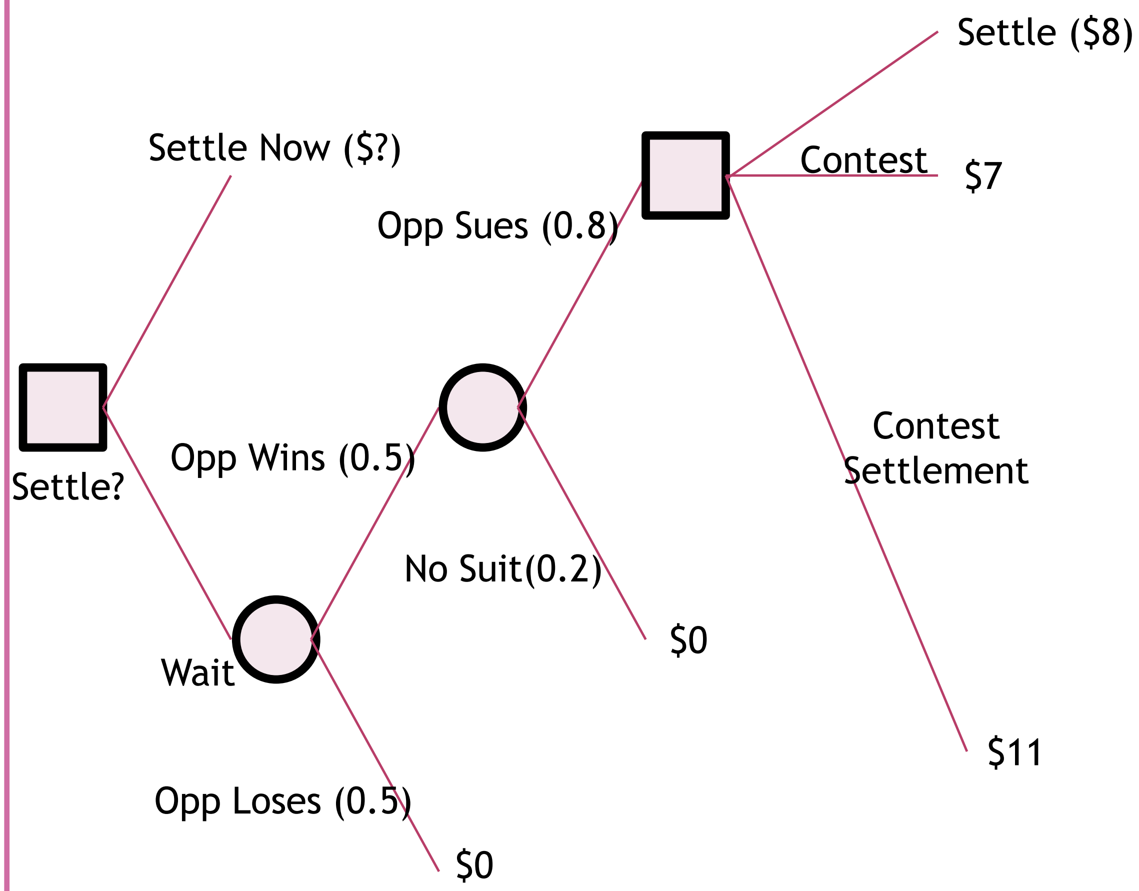

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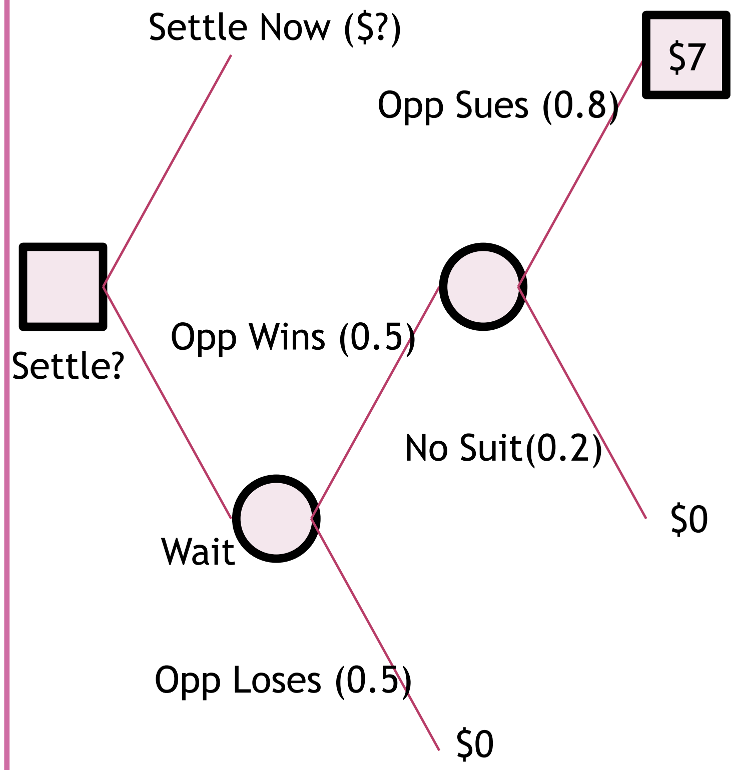

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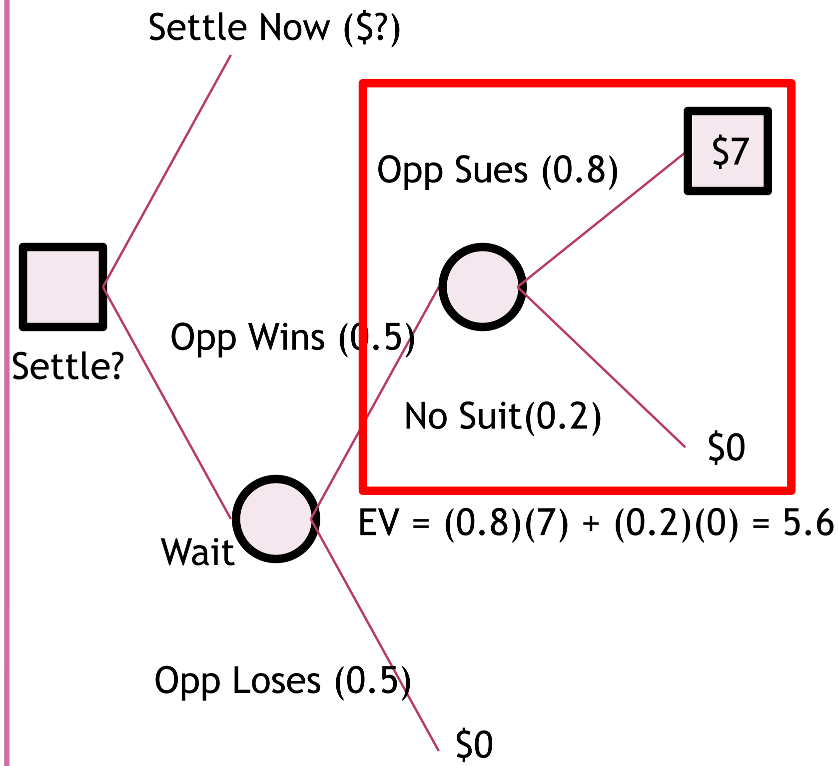

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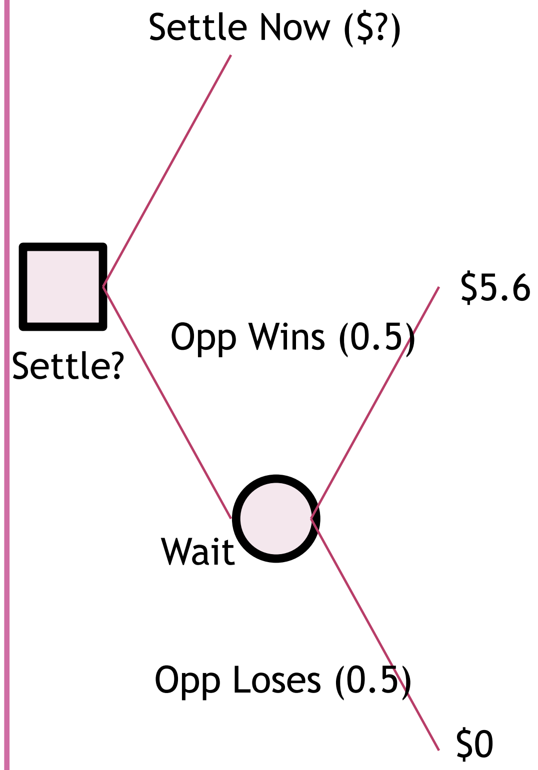
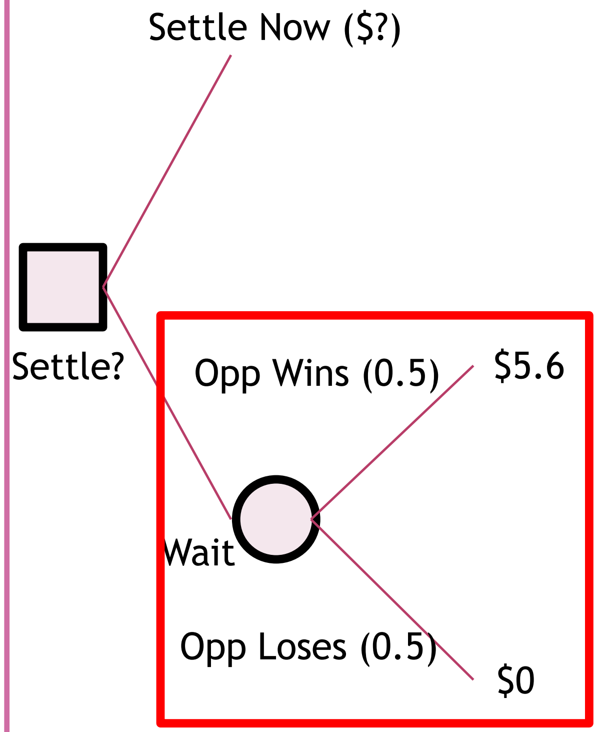
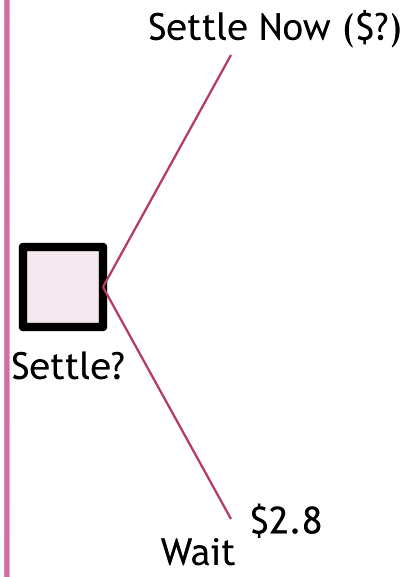


DECISION TREES



EV = (0.5)(5.6) + (0.5)(0) = 2.8

DECISION TREES



SUMMARY

- Uses of decision analysis
- Decision environment
- Uncertainty approaches
- Risk approaches
- EVPI
- Decision Trees