

Introduction to Decision Theory

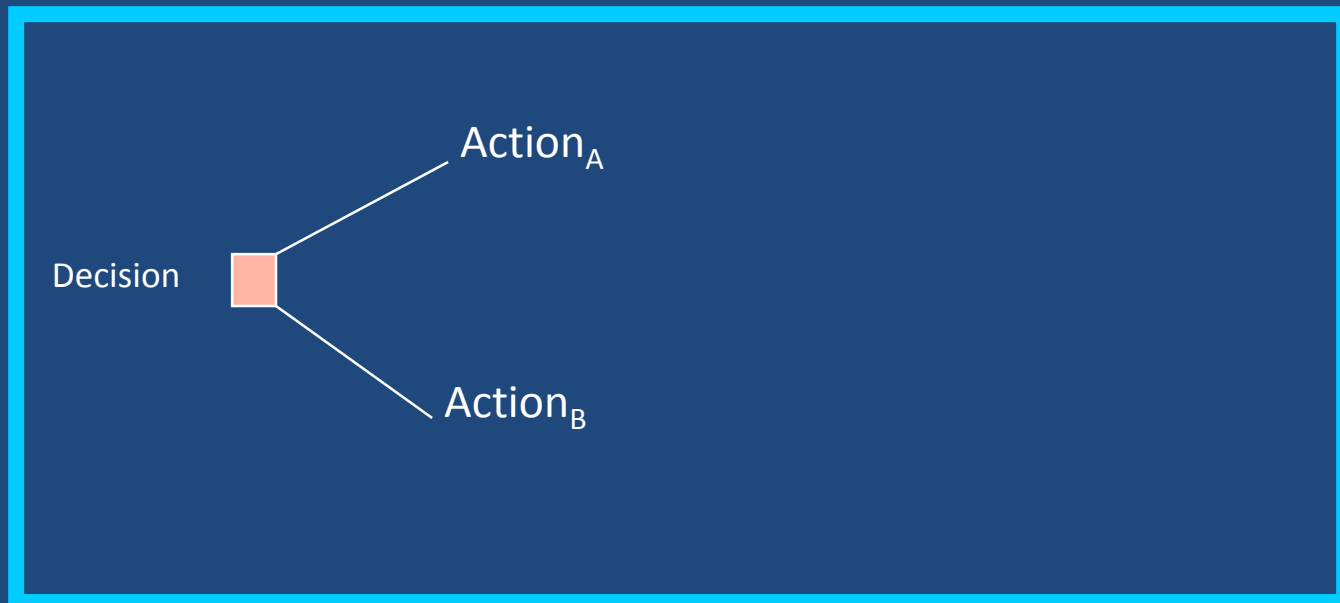
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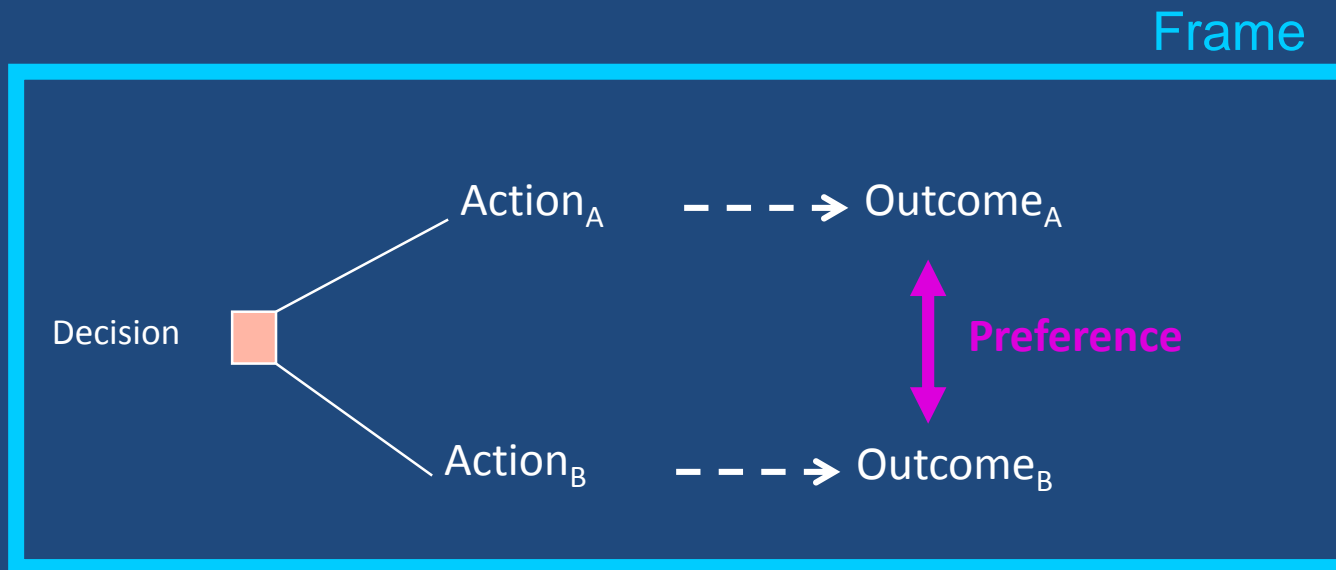
Rational Behavior

- Find the occasion for rational action
- Devise alternative courses of action
- Choose which action to pursue



Subjective Expected Utility Theory

- A Prospective form of Rationality
 - What matters about an action is the **outcome**
 - Evaluates outcomes against **preferences**



The Dominant Normative Theory of Decision
in Contemporary Intellectual Circles

Elements of SEU Theory

- Theory of Action (Ethics)
- Entirely Prospective
 - It doesn't matter how I got to this point
 - Sunk costs
- Usability depends on **action → outcome**
- Justification rests entirely on outcomes
- Judgement is based on preferences

Yum



Uck

Preference

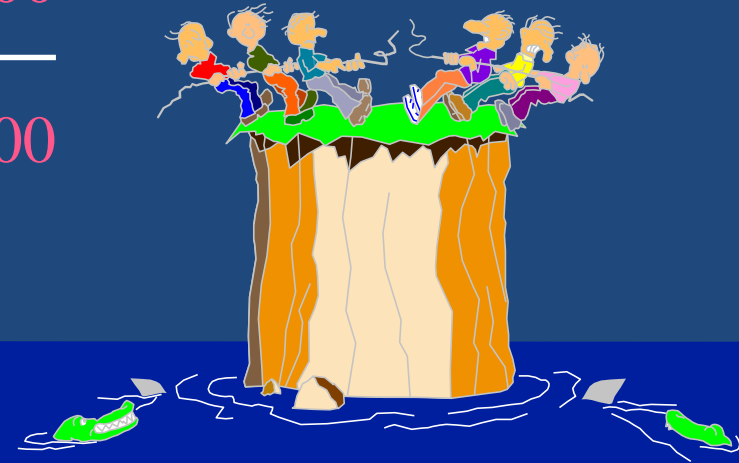


Value is the numerical measure of
preference

Dollars (\$) are the units of value

Preference Conflicts Lead to Loss of Value

Reaction Wheel	+ 3.2 FIT	- \$ 80,000
Power Cond. Unit	- 1.1 FIT	+ \$130,000
<hr/>		
Combined	+ 2.1 FIT	+ \$ 50,000



Differences in revealed values within a design team lead to choices that, taken together, are clearly lose-lose

Framing a Decision

- Recognize a decision situation
- Create alternative actions
- Acquire knowledge of outcomes of actions
- Inform probabilities
- Elicit preferences



Alternatives - Information - Preferences



Terminology - Basic Elements

- Decision
- Alternative
- Possibility
- Probability
- Outcome

Decision

- An (almost) irrevocable commitment of resources
- Commitment is to Action or Well-Considered Inaction
- Action from decision is thoughtful, purposeful action

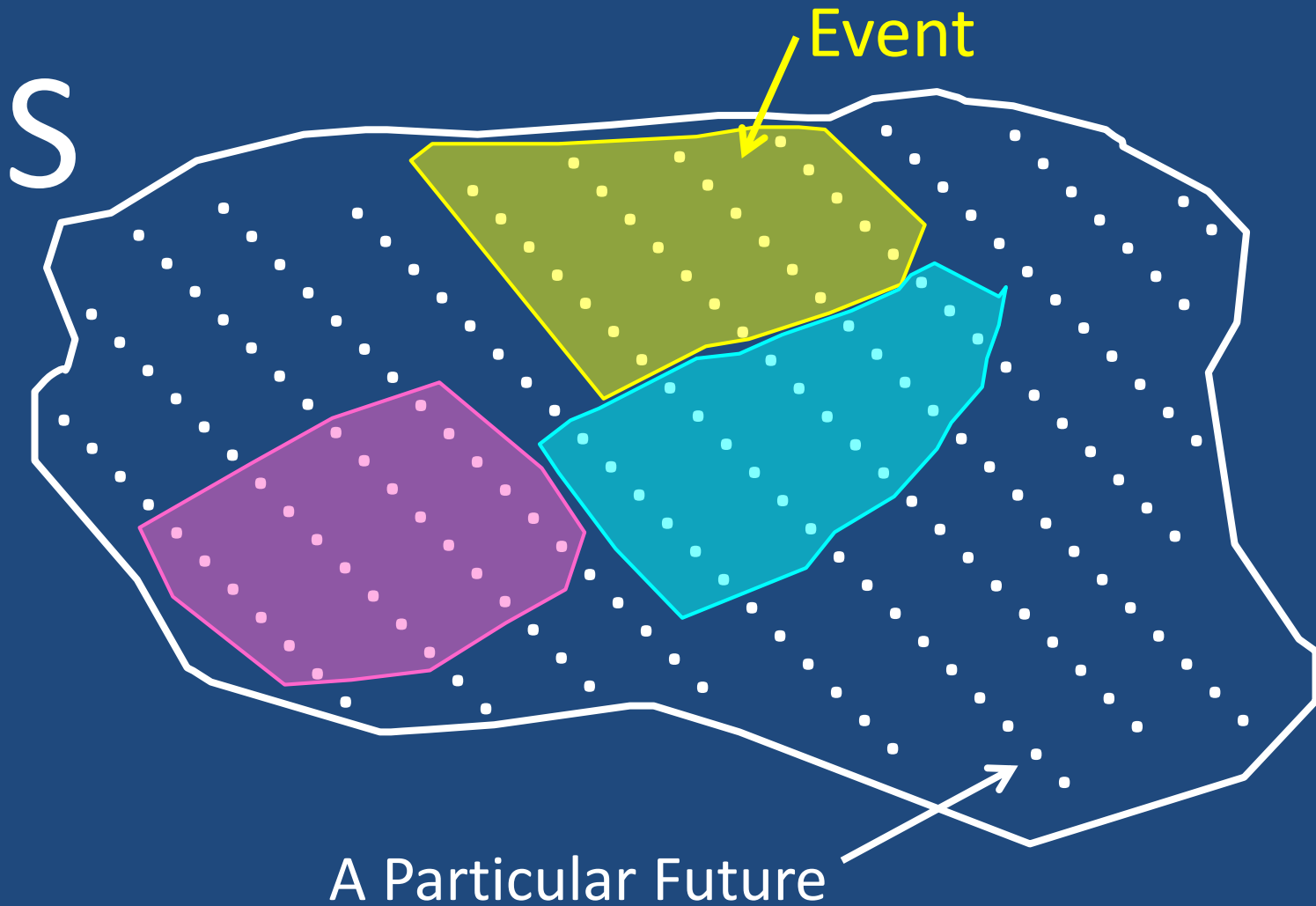
Alternatives

- Alternatives are Alternative Actions
- A decision is a choice among alternative actions
- Decision Theory focuses on decisions that have a finite number of alternatives
 - Optimization is the discipline that studies decisions with infinite alternatives

Possibility

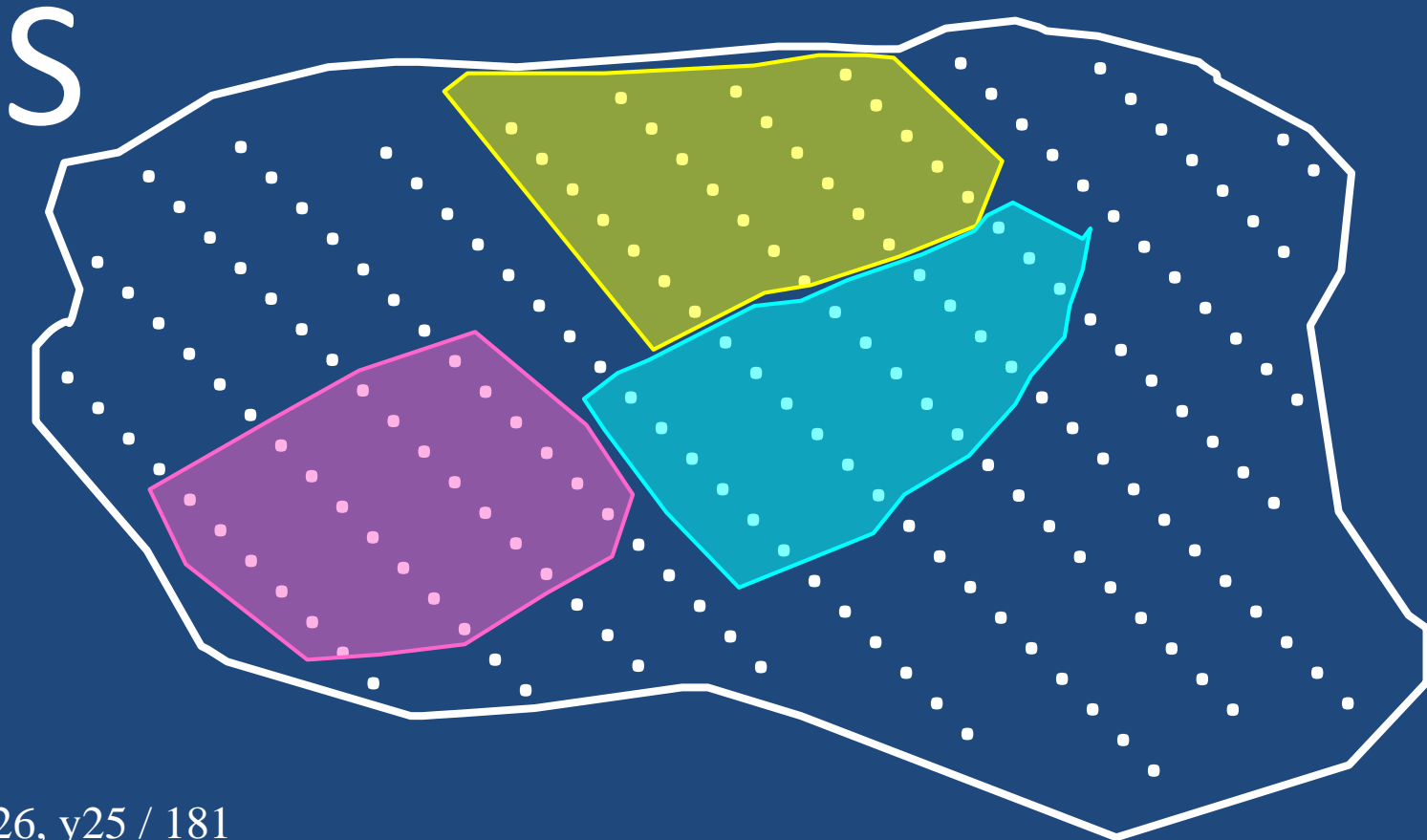
- A possibility is a relevant state of the world that might occur
 - State of the world: Our considerations of effects of our actions are without bound, and include impacts on others and unintended results
 - Might: A possibility is an “event” in probability math

Set Theory and Probability

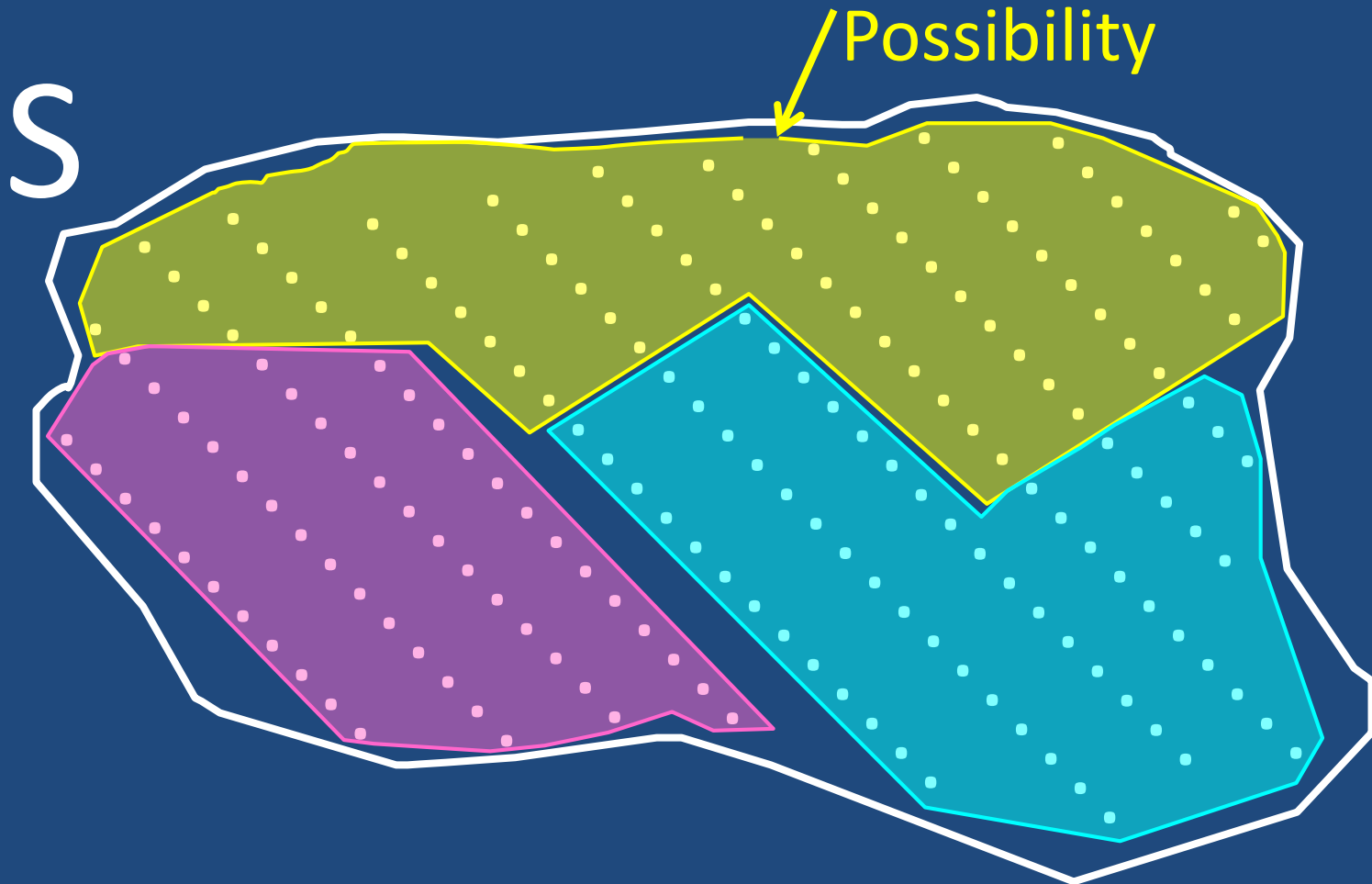


For mutually exclusive events

$$\mathbb{P}\left[\bigcup (E_1, E_2, E_3, E_4, \dots)\right] = \sum_i \mathbb{P}(E_i)$$



Distinctions



Preference and Prospects

- We must be able to elicit preferences for prospects and measure the preferences with value
- The assignment of values to prospects constitutes a value model for a decision

Probability

- Each action or chain of actions brings about a probability with regard to every possibility
- Note that, **under certainty**, an action causes a possibility to occur
- **Under uncertainty**, an action changes the probability of two or more possibilities

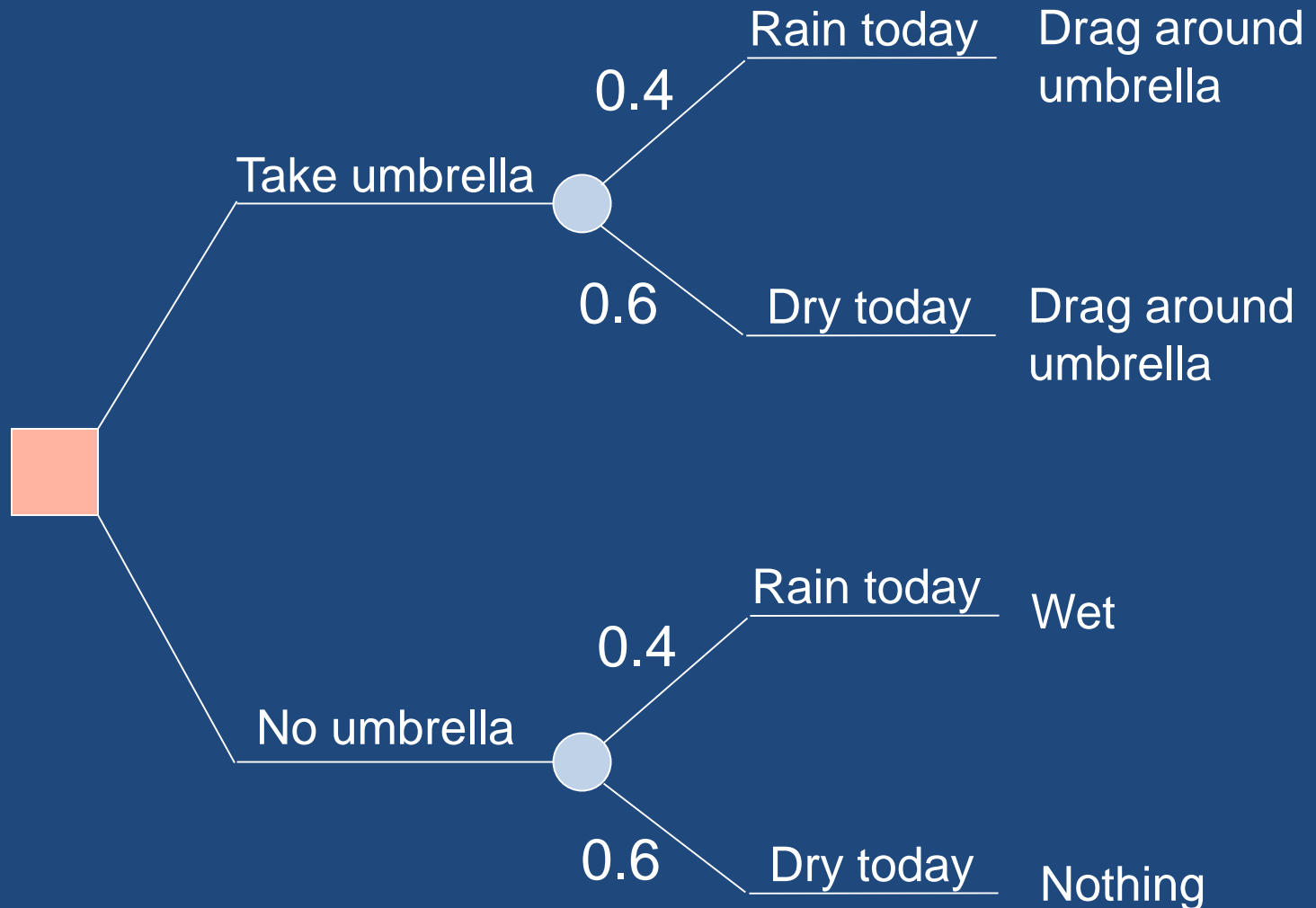
Outcome

- The collection of prospect that might result from an alternative action, including possibilities and their associated probabilities, is the **Outcome** of the alternative
- For parsimony, we do not include possibilities in the outcome of an alternative if the associated probability is zero

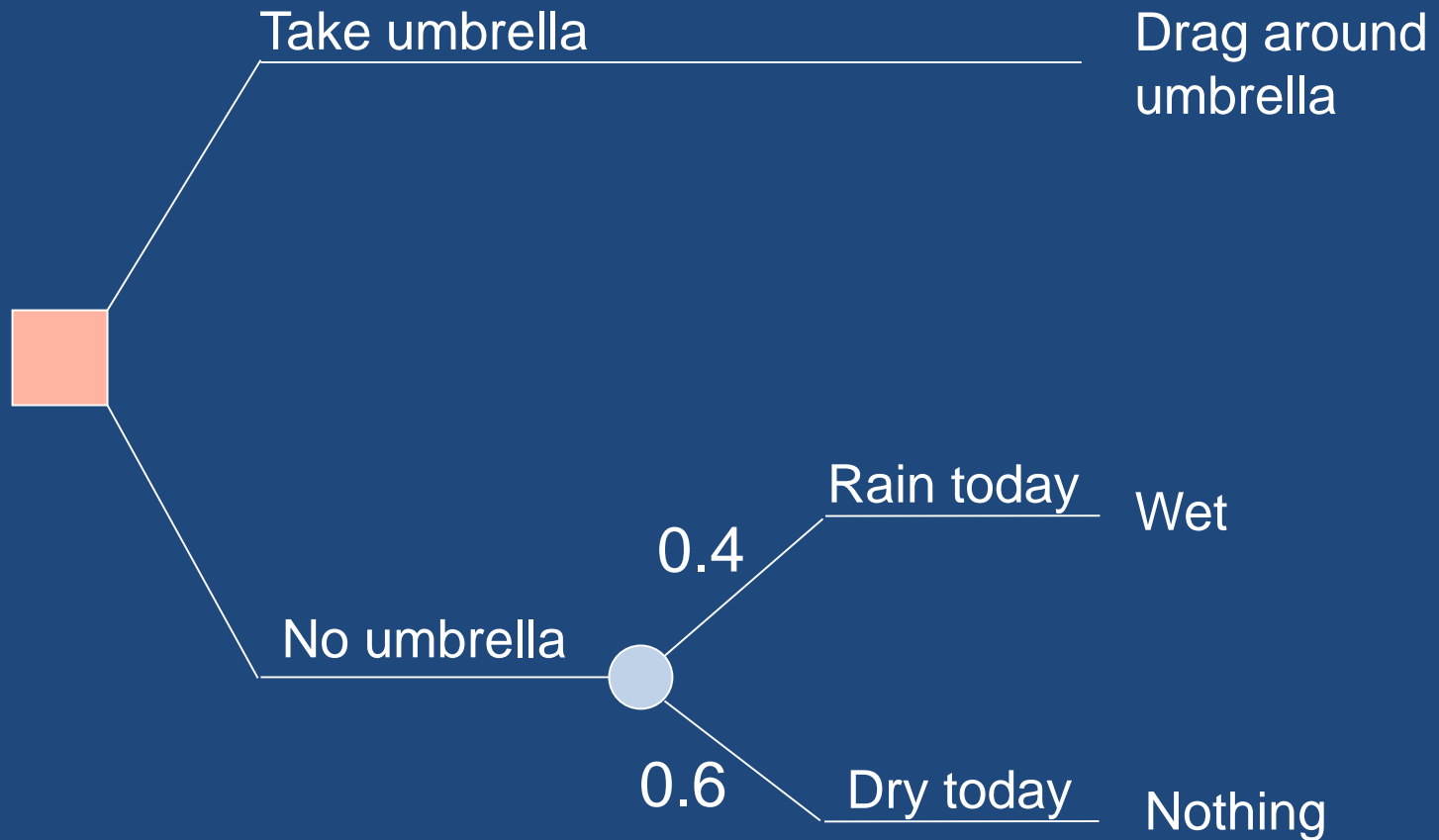
Knowledge and Information

- In this course, knowledge is a body of causal relationships of the form
 - If this is done, then this will occur
 - more subtly and generally, if this action is done, then it increases or decreases the probabilities of these events in these ways
- useful knowledge that causally links actions to outcomes is conditioned on information about the state of the world

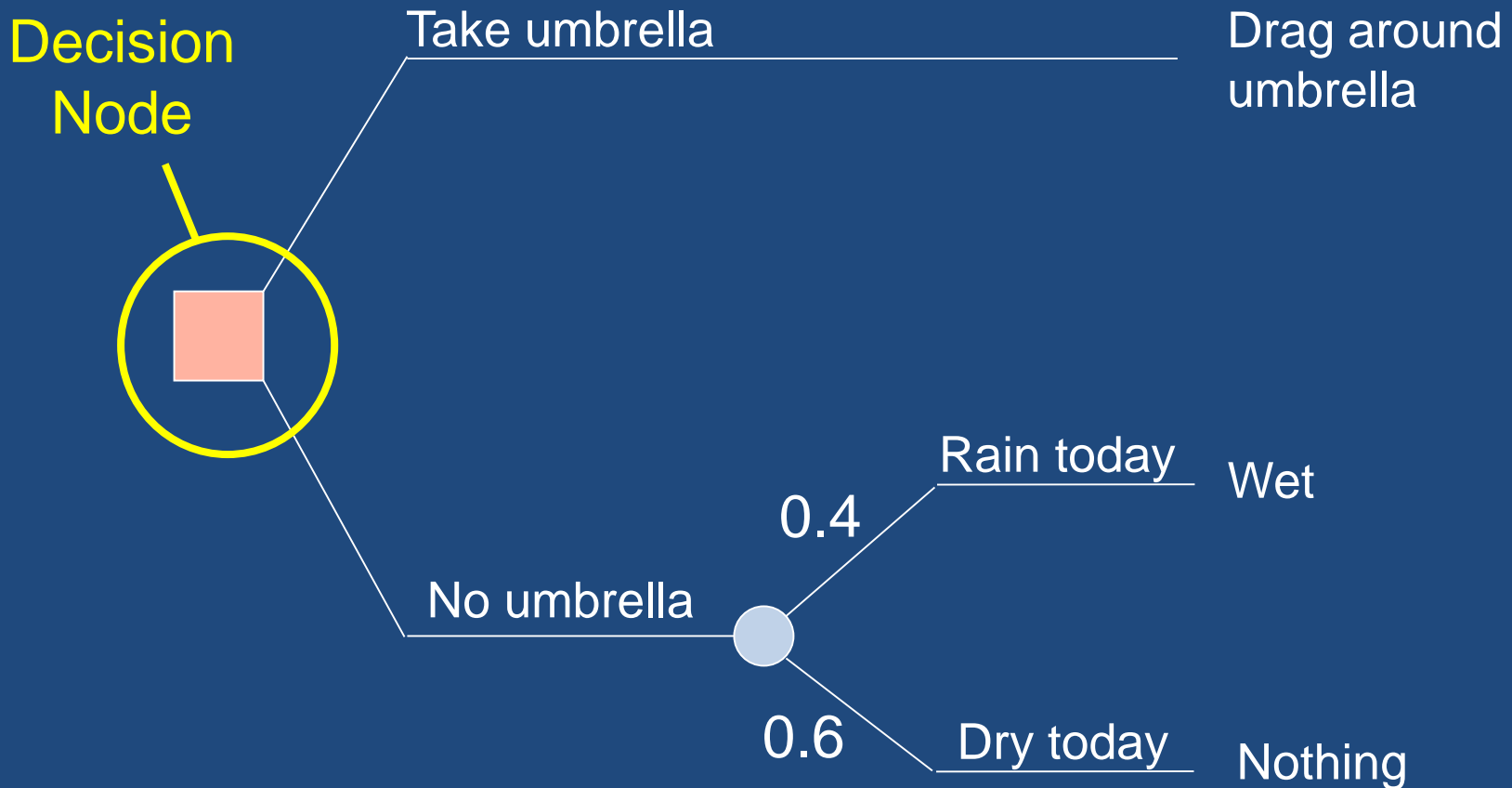
Decision Diagrams



Decision Diagrams

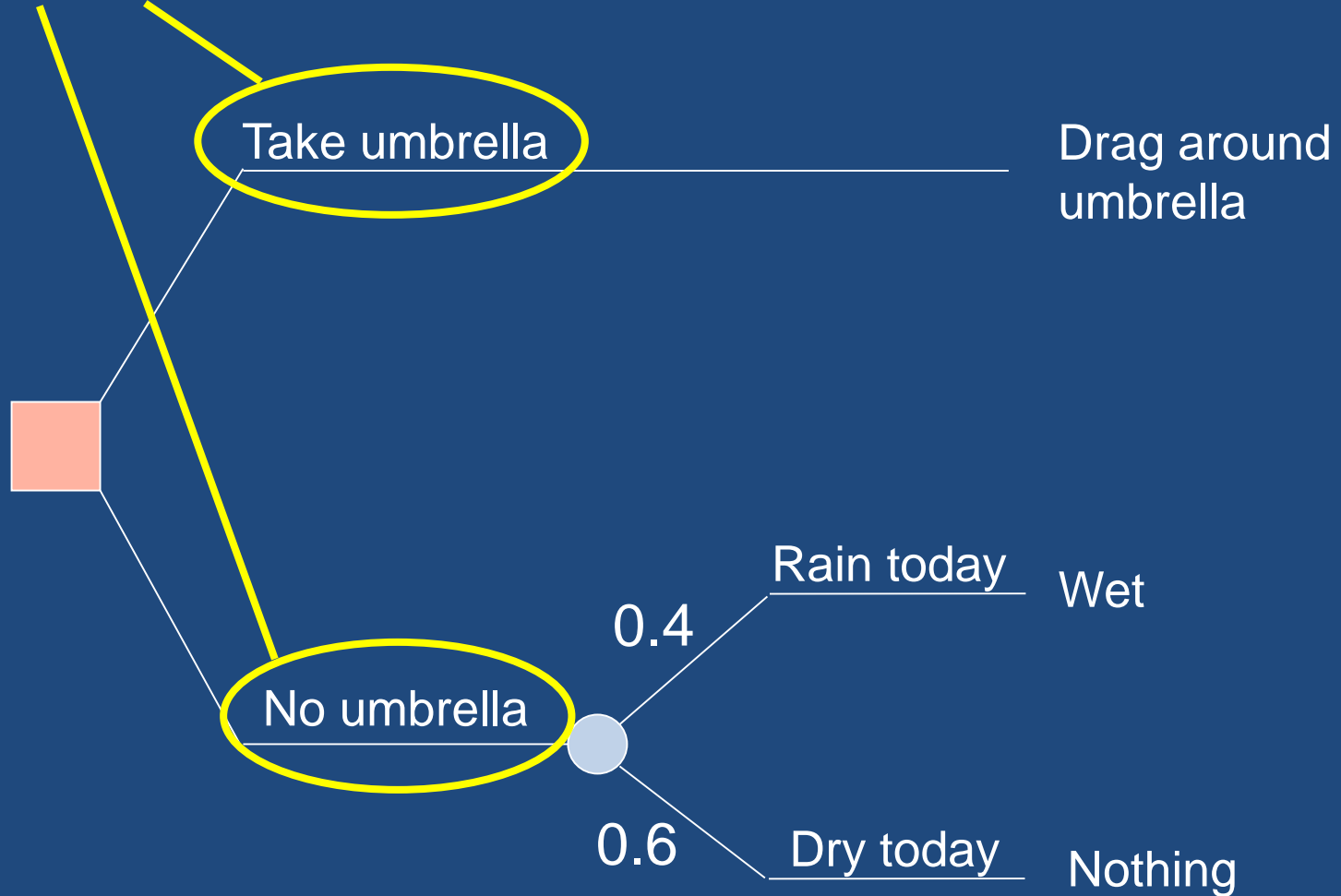


Decision Diagrams

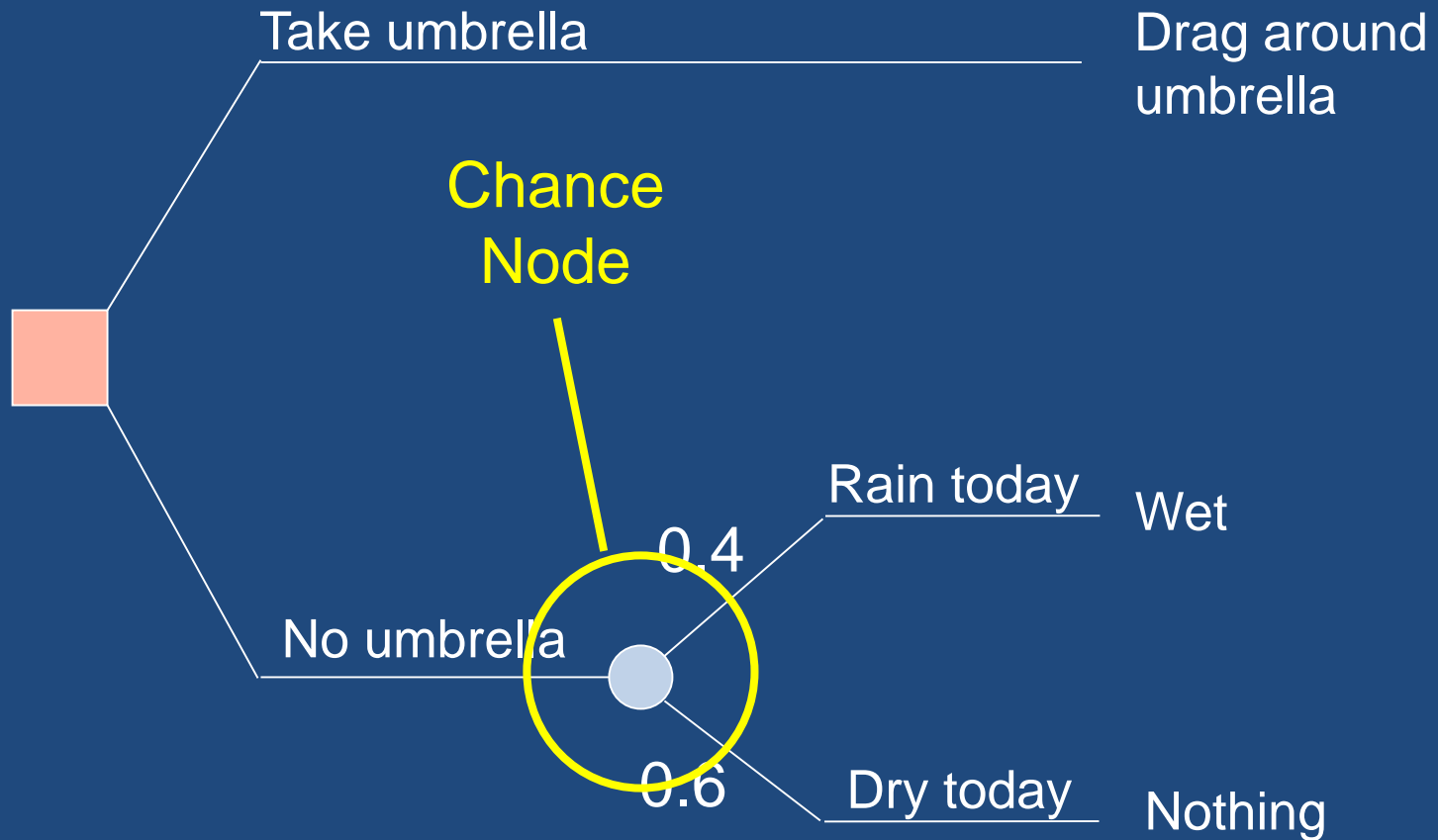


Decision Diagrams

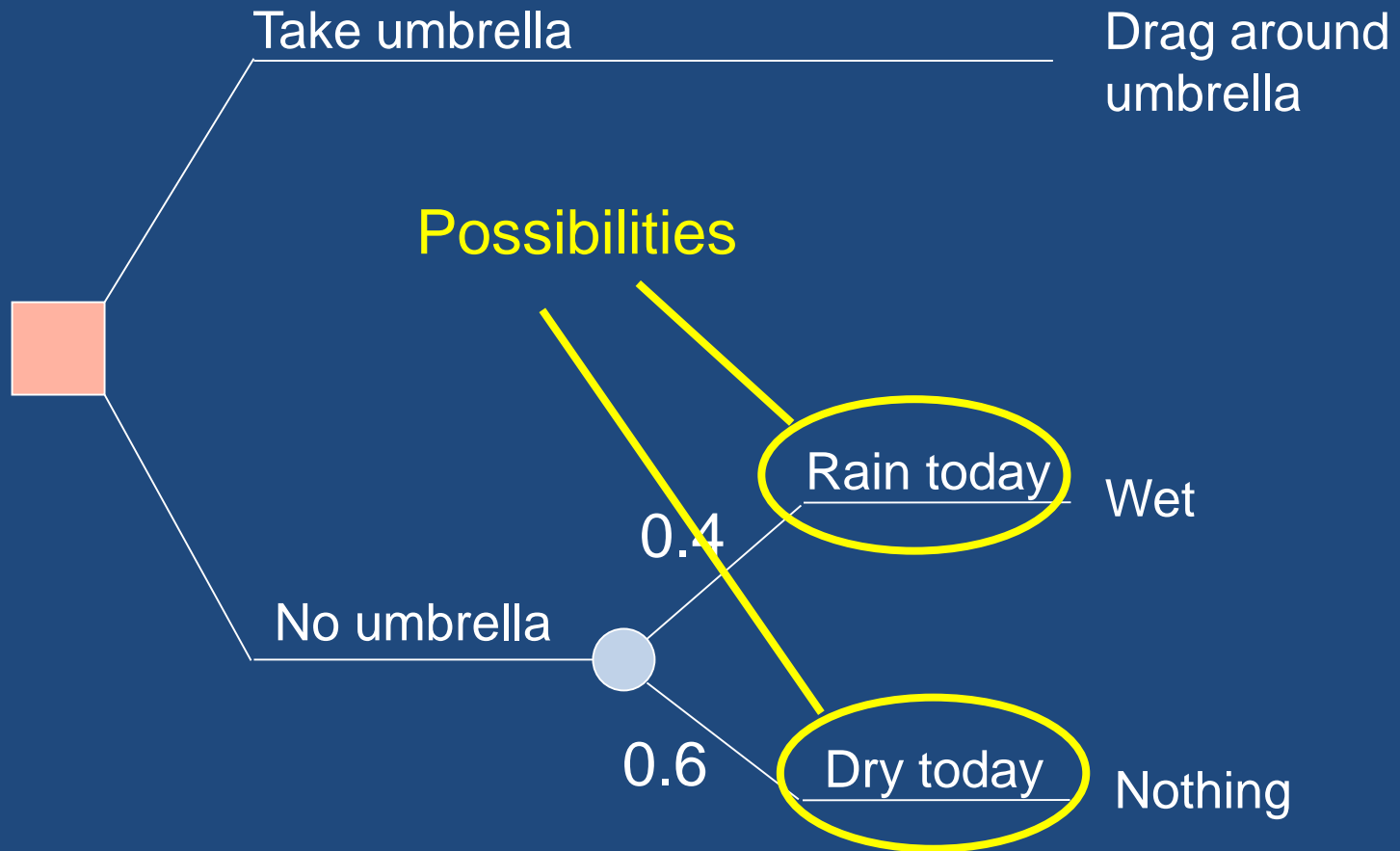
Alternatives



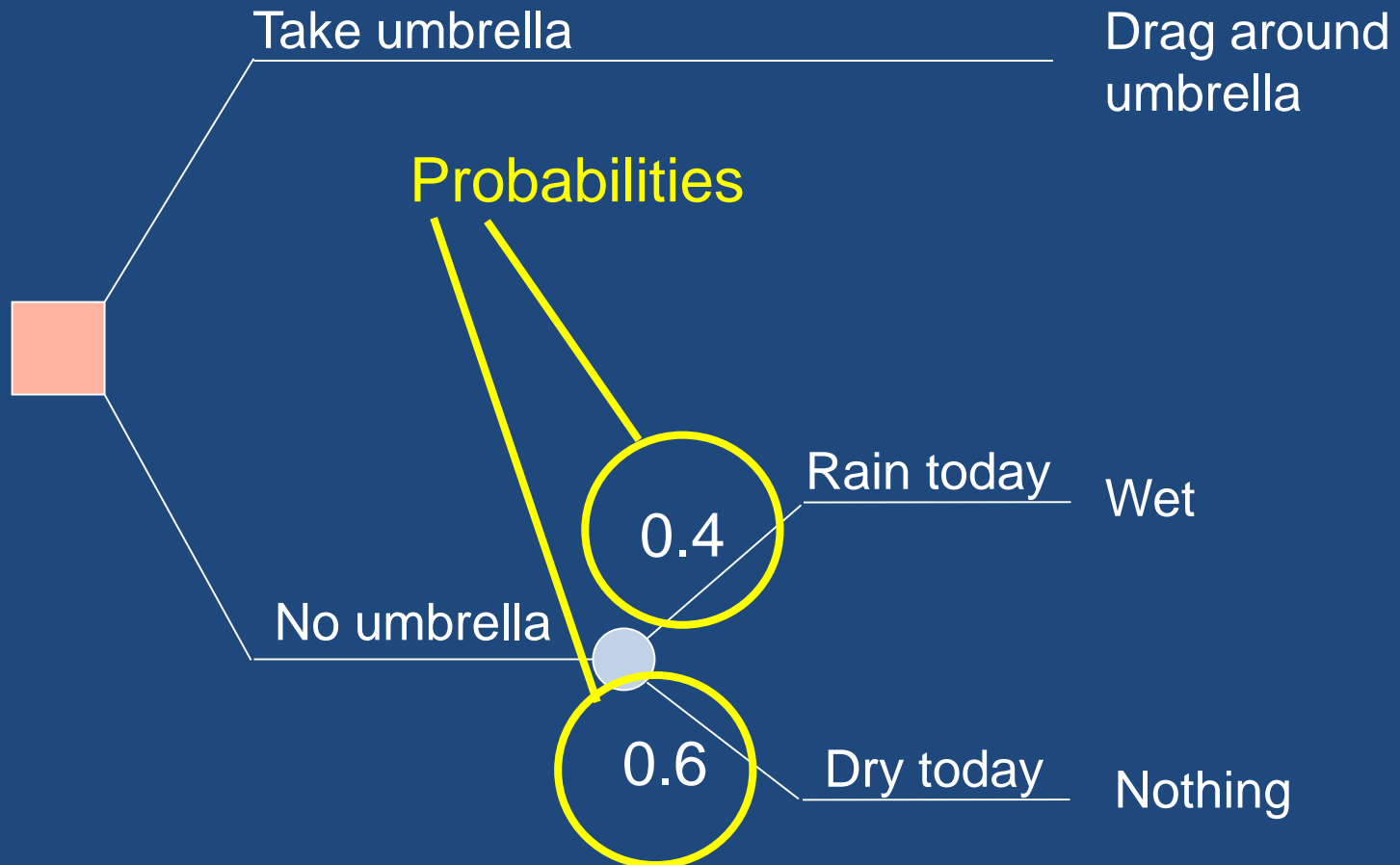
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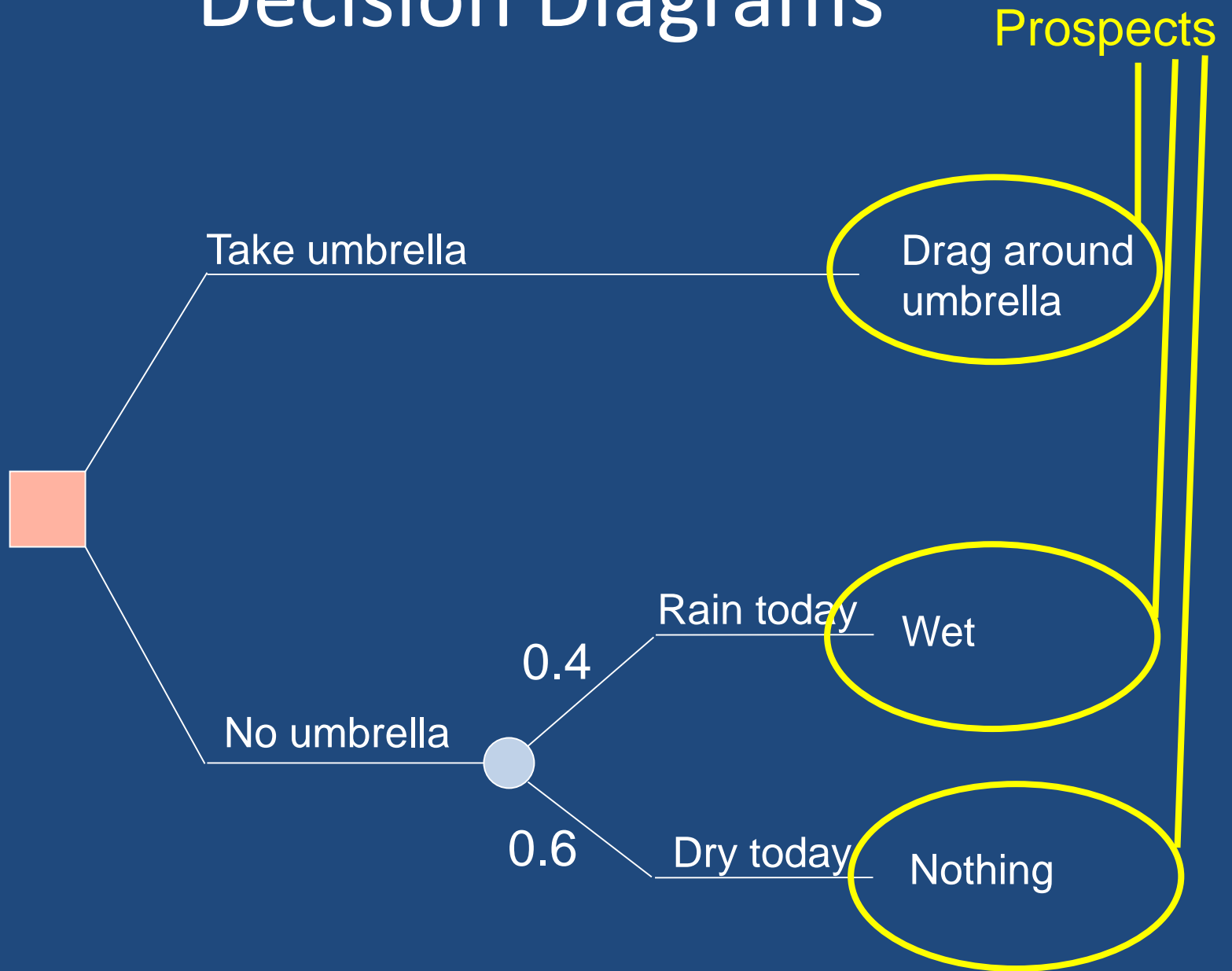
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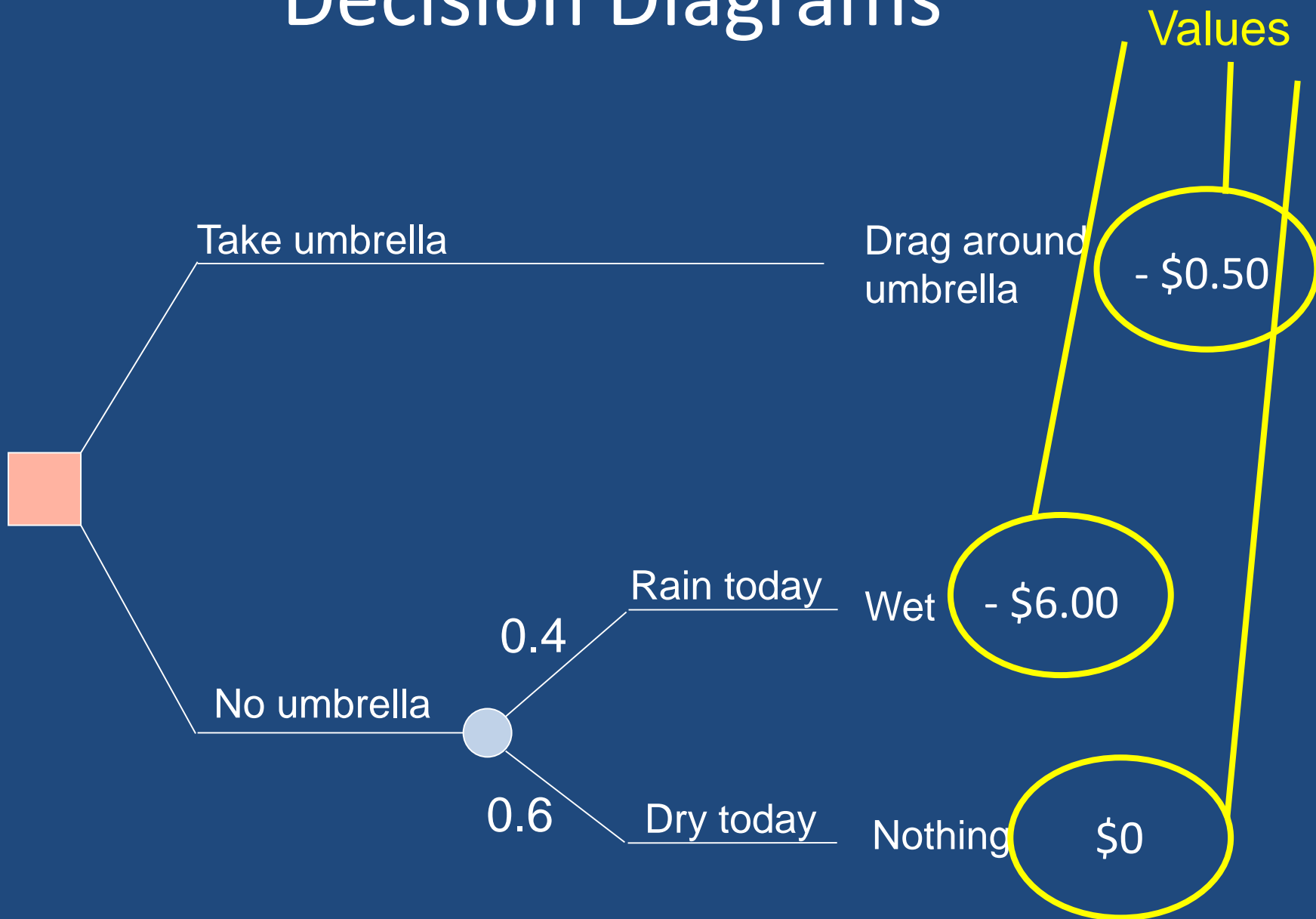
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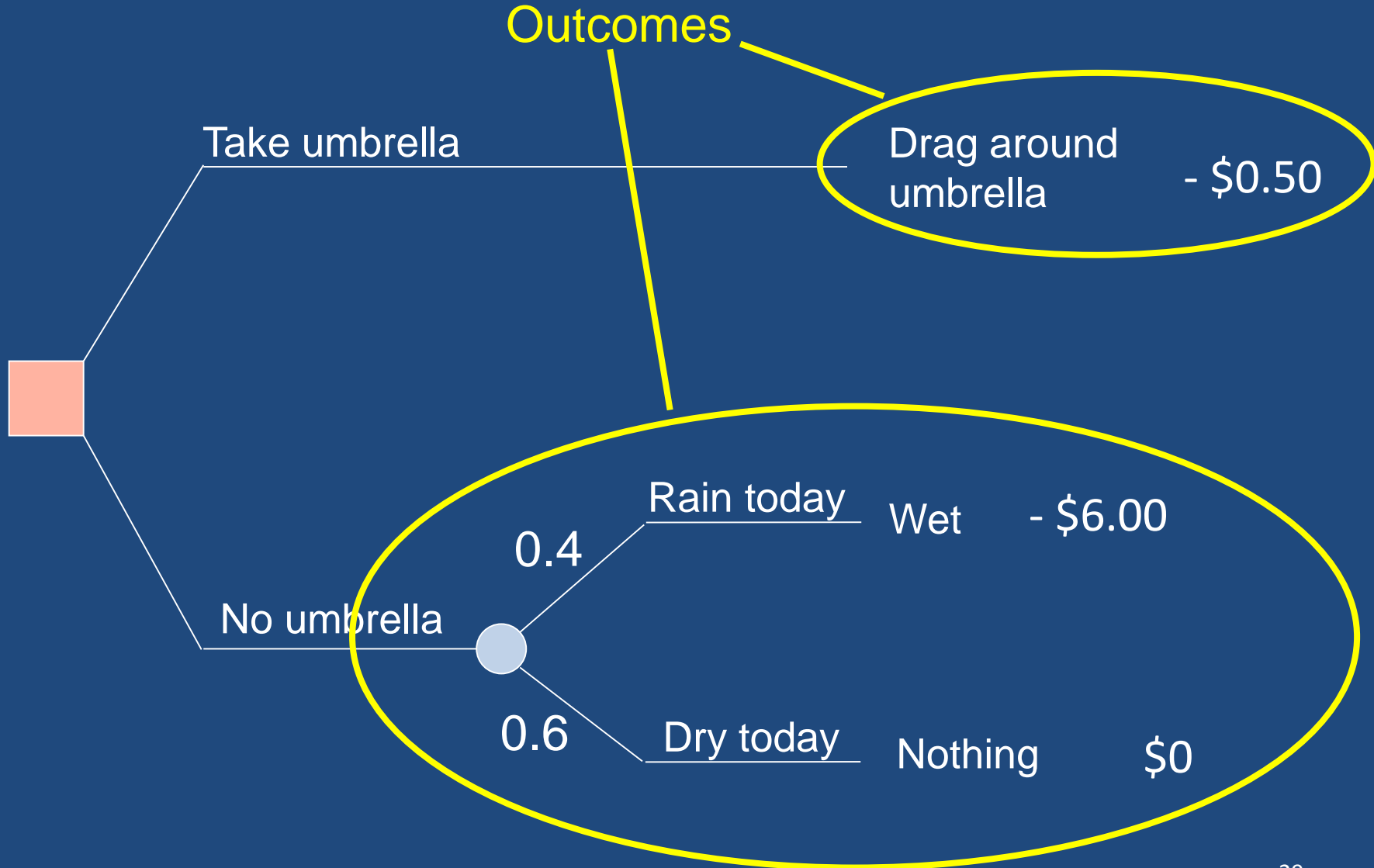
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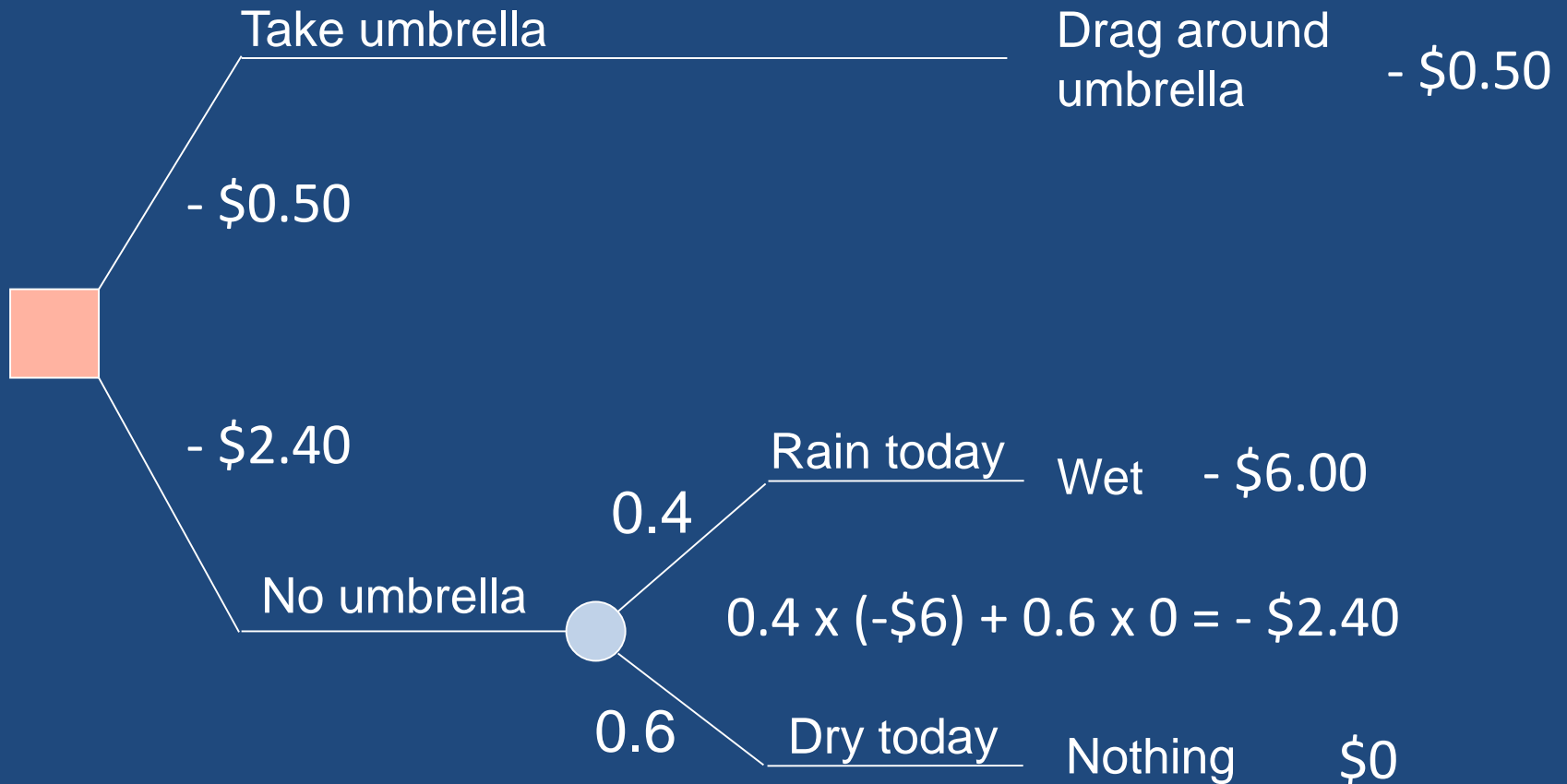
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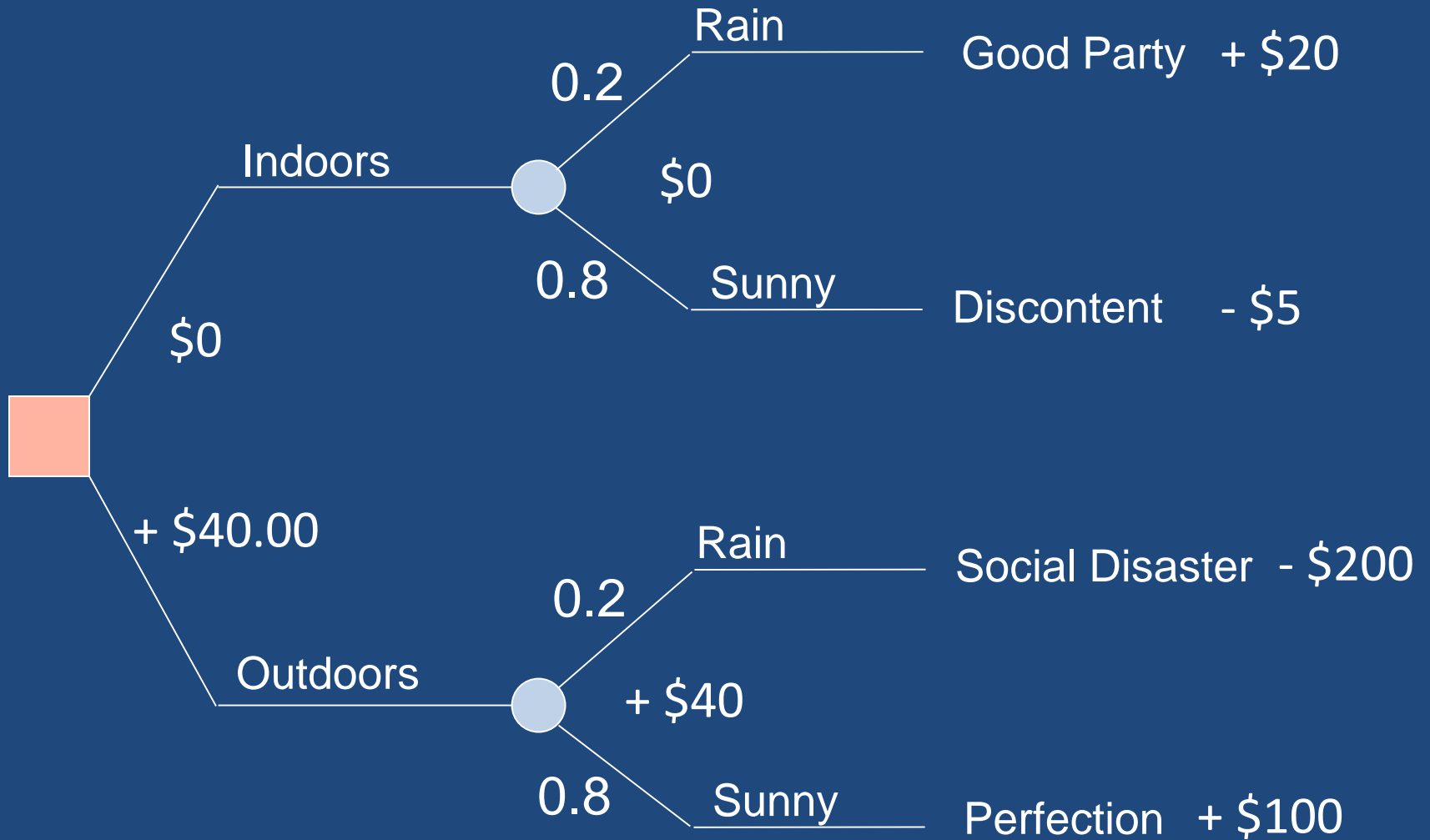
Decision Diagrams



Evaluating a Decision Diagram



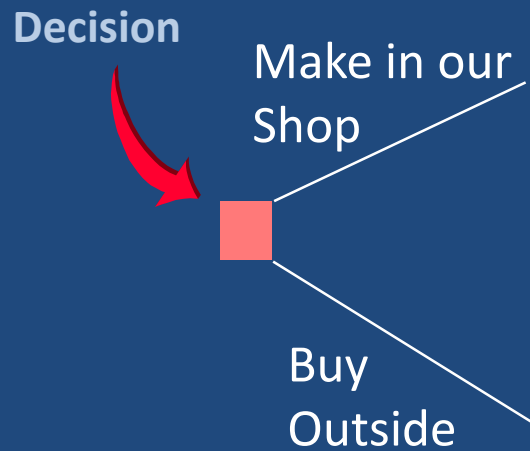
The Party Problem



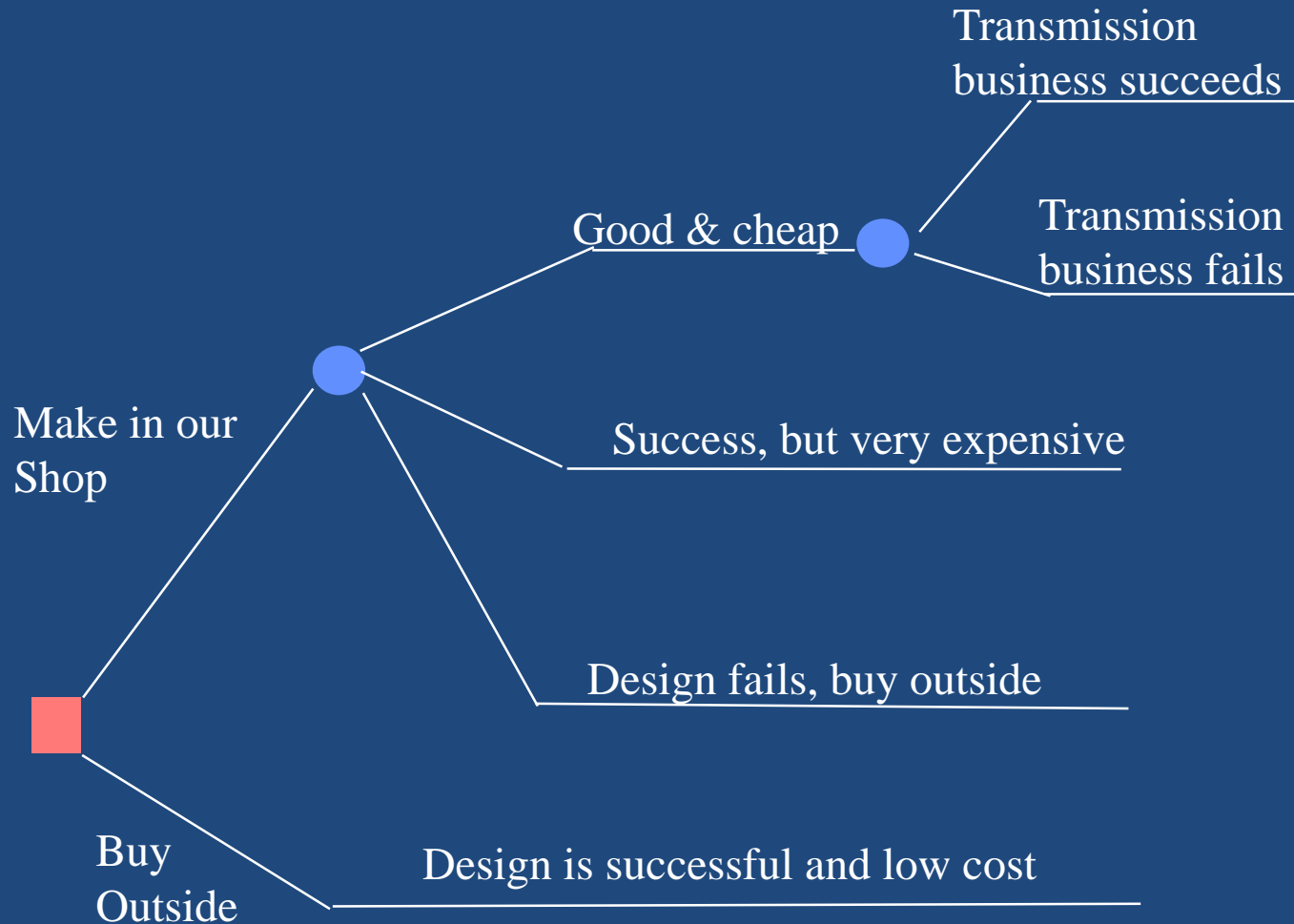
Make or Buy?

You company manufactures rotorcraft. You own a machine shop, but until now, you have not cut gears. A new light helicopter design includes a gearbox to drive an electrical generator, fuel pump, and engine oil pump. Your traditional gearbox supplier can make a higher quality gearbox for less cost, but your company is interested in developing experience with gearboxes to possibly bring transmissions in house as a major project.

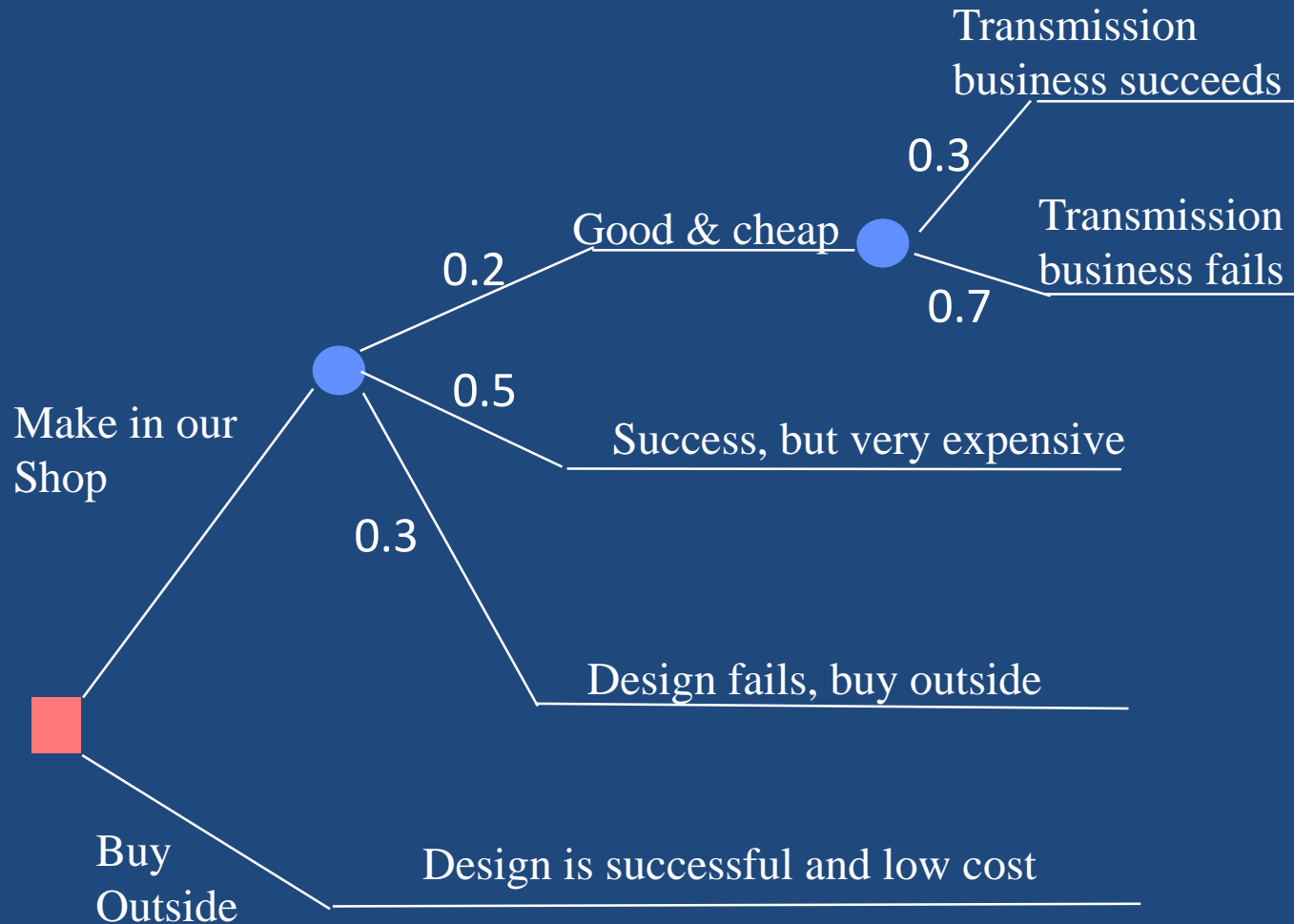
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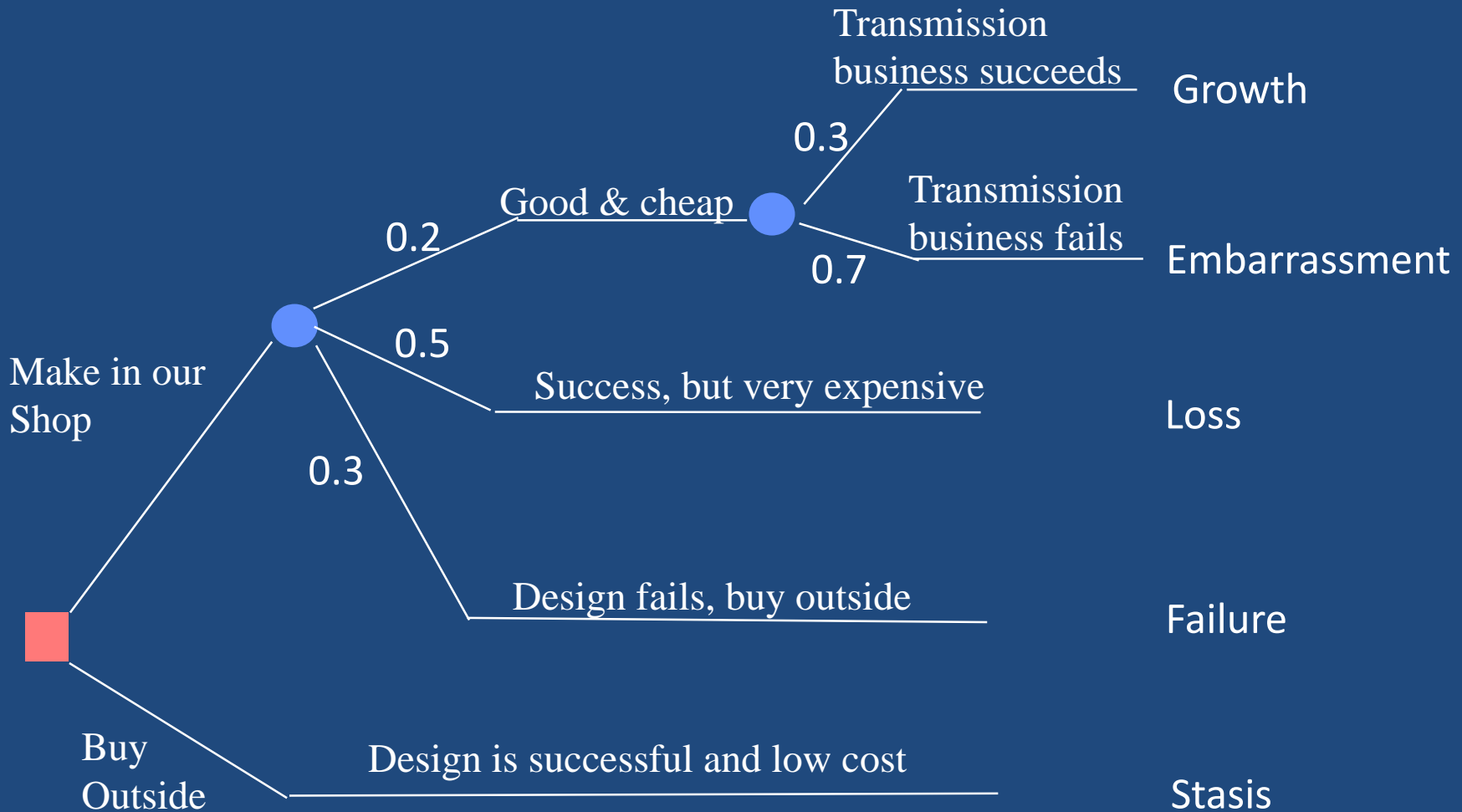
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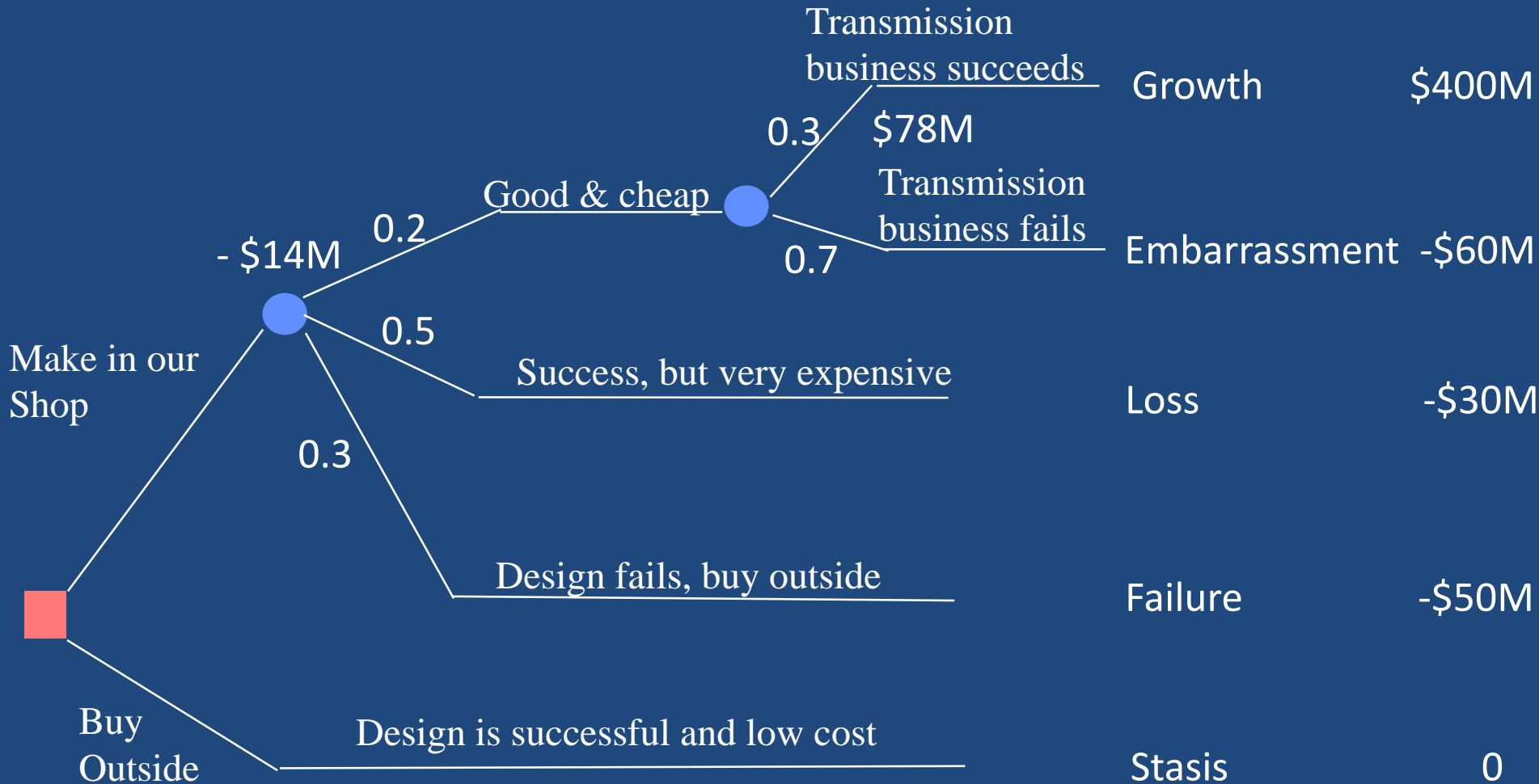
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Make or Buy?



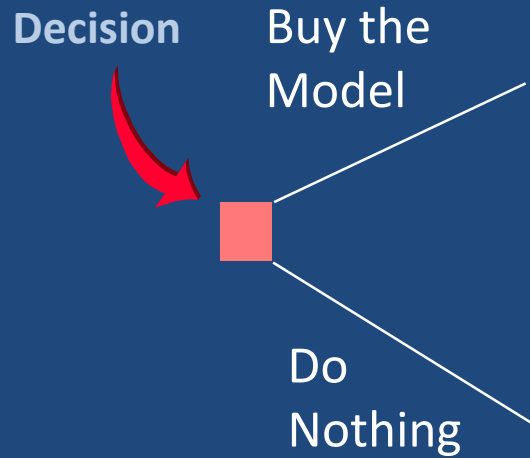
New Finite Element Model

You attend a conference in a very cosmopolitan city where everyone is stylish and vodka comes in flavors.

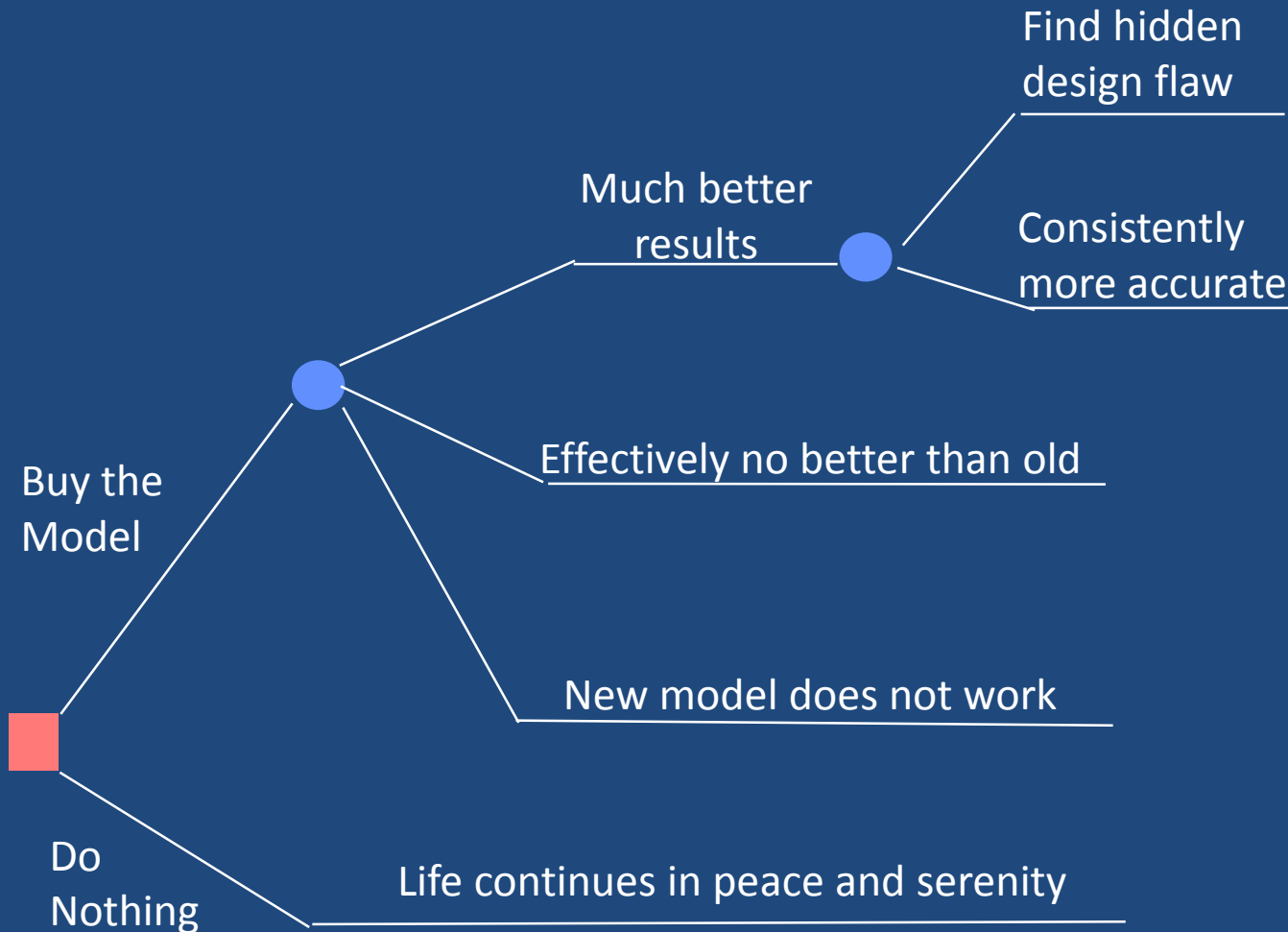
A new finite element model is presented for analyzing the strength and durability of composite materials.

Should you purchase the \$200,000 model for your design group?

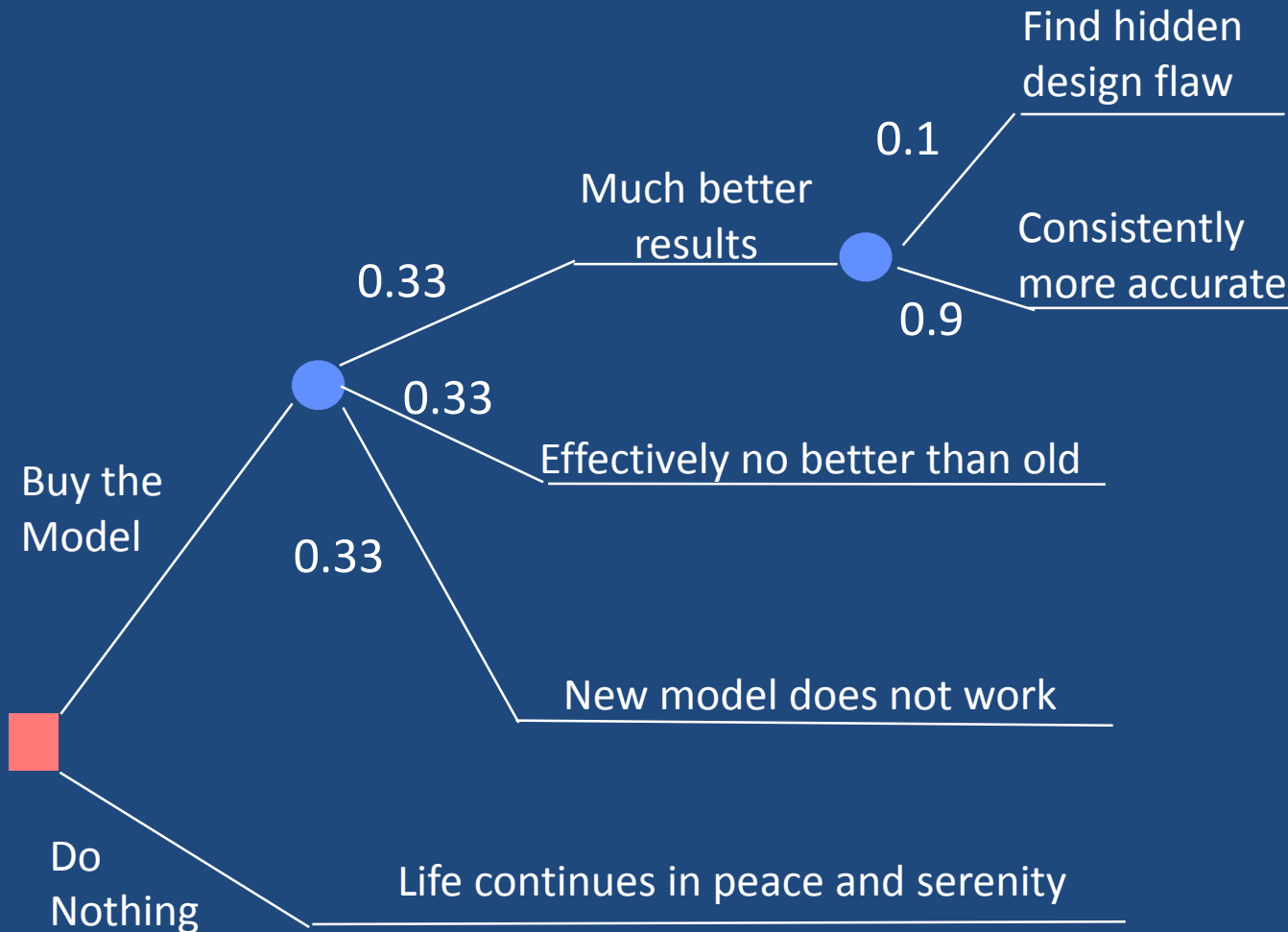
New Finite Element Model



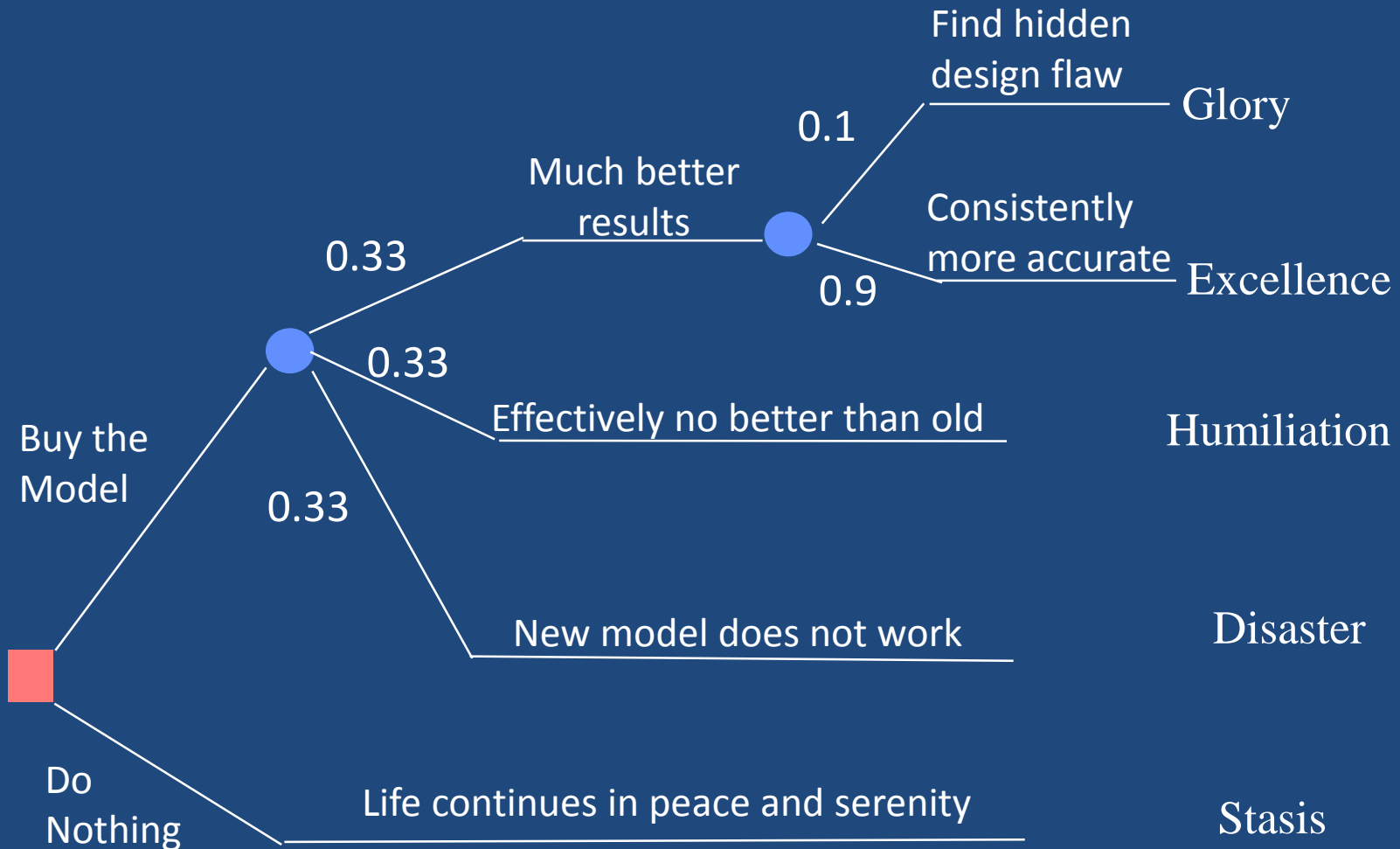
New Finite Element Model



New Finite Element Model



New Finite Element Model



New Finite Element Model

All dollar values are in millions

