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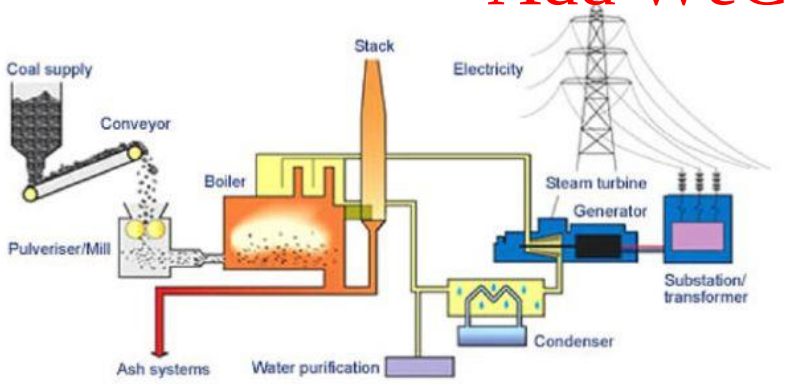
Business problems involve uncertainty: the NEES example

NEES is a company that produces po ding how much to bid for the salvage rights to a grounded ship, the *SS Kuniang*.

If successful, the ship could be repaired to haul coal for the company's power stations. If the bid fails, NEES could purchase a new ship or a tug/barge combination.

The higher the bid th in.



NEES decision is complicated by further uncertainty

U.S. Coast Guard (USCG) judgment about the **Marine salvage value** of the ship involves an obscure law on shipping in coastal waters. **Marine salvage** is the process of recovering a ship and its cargo after a shipwreck or other maritime casualty. USCG's judgment will not be known until after the winning bid.

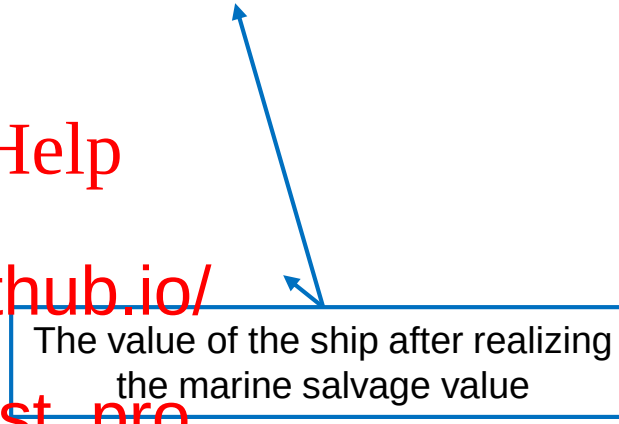
- If the judgment i *en NEES* could use the ship for its shipping needs.

- *High salvage value means that the ship is considered* ineligible of use in domestic shipping unless expensive equipment is installed, i.e. greater expenses for NEES.

How much should NEES bid?

Decision tree diagrams timing of decisions and revelations of rel certainties

To complete the tree need to assign $ values (or utilities) to decis outcomes



When all the cash flows are given we can assign terminal values to each branch by adding up along the branch

Decision criteria: minimize worst case

Consider bidding $10M

We assign values to the nodes working from the end branches toward the r ee

The value of an *event* node is the value corresponding to the worst-case s

The value of a *decision node* here comes from making the decision that maximiz ofit

What should be our maximum bid?

If we just want to minimize the worst case it does not make sense to bid anything over ($ M = $8.3M

If two strategies result in the same "worst case" we might think about another criteria for s ong the strategies

What should do – bid or purchase the alternative?

Another possible criteria: Maximizing the cash flow

- Expected Utility = EU = Weighted utility

- For example: you can buy a lottery ticket for 10 dollars. If you win you get 100 dollars. If you lose you get 0 dollars. The probability of winning is 8%. Would you buy the ticket?

- We answer by calc

$$EU = \Pr(\text{winning}) \cdot 100 + \Pr(\text{losing}) \cdot 0 - 10$$

$$= 8\% \cdot 100 + 92\% \cdot 0 = 8 - 2 < 0$$

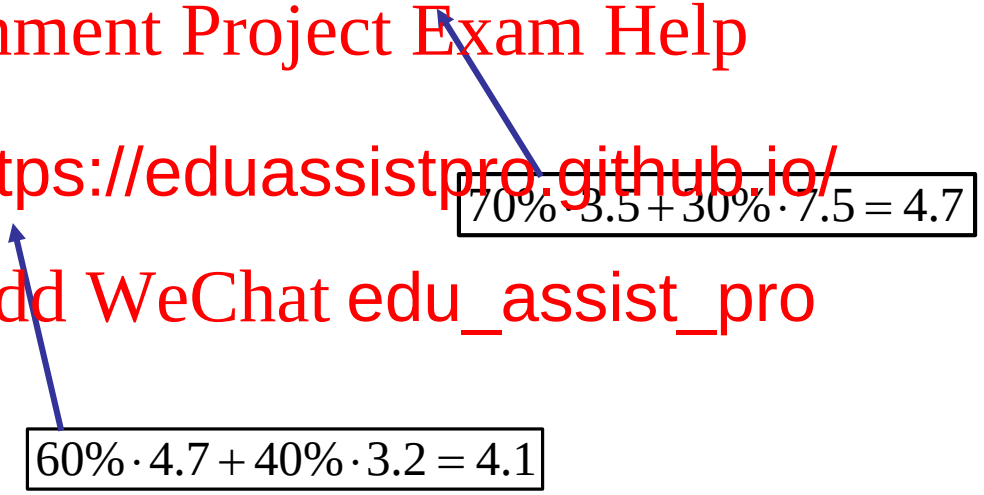
- Buy the ticket only if: $EU \geq 0$

Another possible criteria: Maximizing the cash flow

Event node values are calculated based on expected values

Decision node values are calculated by selecting the decision that maximizes the node

Calculating the Expected Utility



We could also assume an analytical relationship between bid size and the probability of win, a the optimal bid size

The problem statement reads:

The higher the bid, the more likely the company will win. They expect that a bid of

- $2M would definitely not win
- $12M would definitely win
- $8M has 60% cha

We can write a formula for calculating the probability to win as a function of the bid amount:

$$\text{Prob\_Of\_Win} = (\text{Bid} - 2)/10$$

Sensitivity analysis

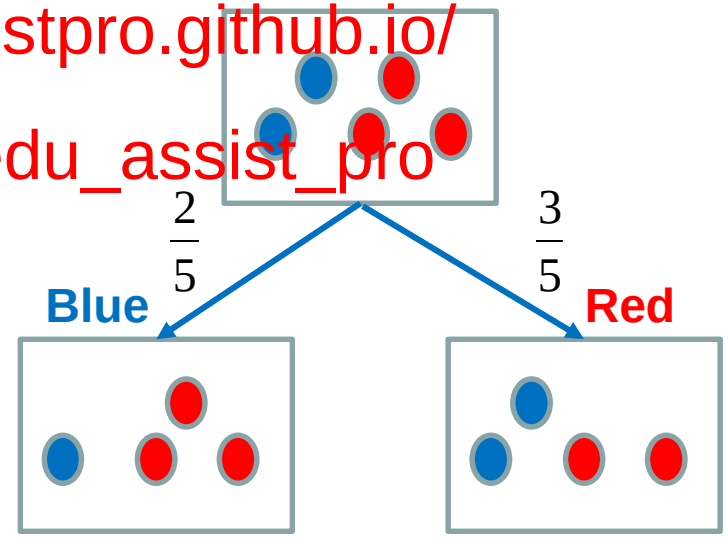
We use sensitivity analysis to calculat the profit under different bids.

We set the bid price to be our sensitivity parameter (and not as optimization parameter, because we do not use optimization model to find the bid price).

Let's take a break to talk about Probability

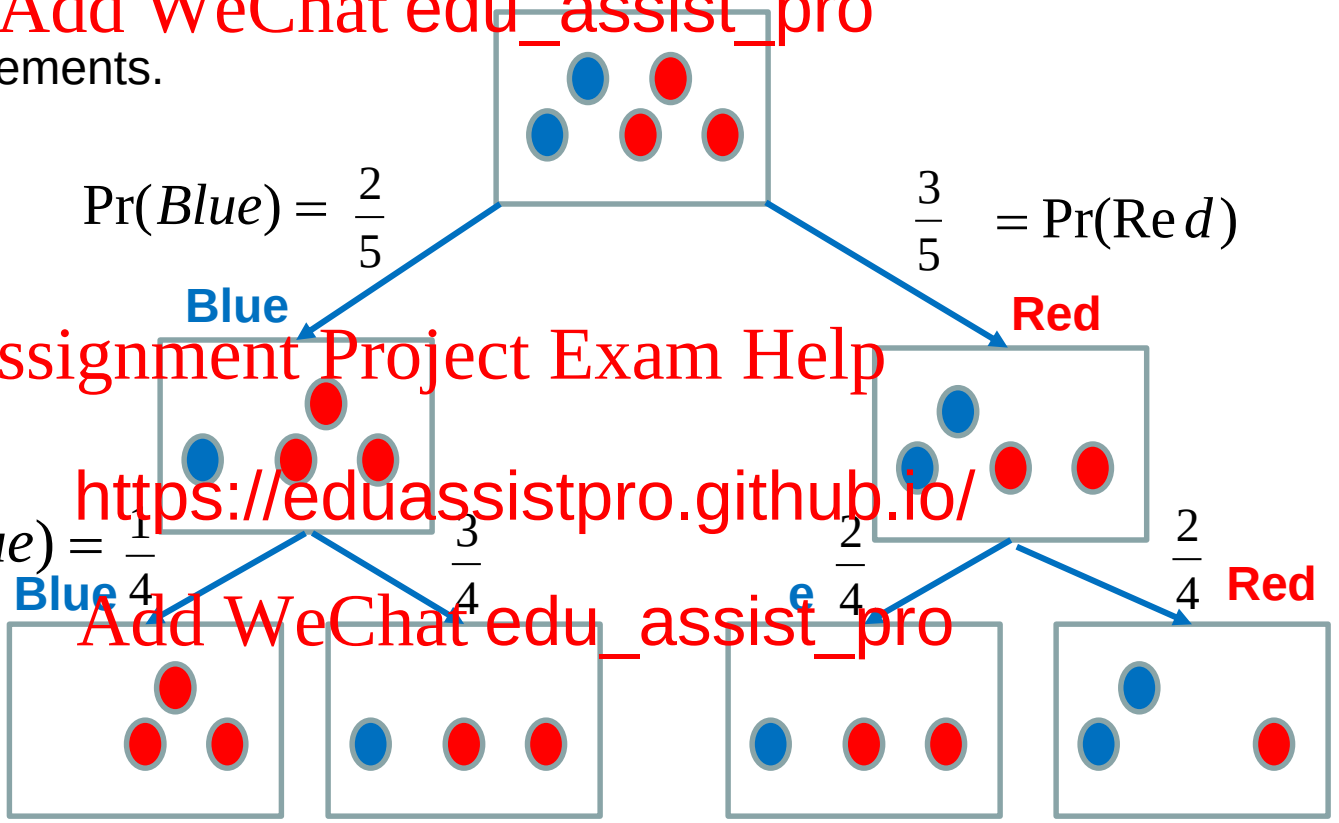
Probability = chance.
We use probability to measure uncertainty.
Probability measurements: 0 to 1 or 0% to 100%.

For example: From a box that contains 2 blue and 3 red balls, we randomly eyes closed).
What are the chances of



What are the chances of drawing two blues?

Assumption: no replacements.

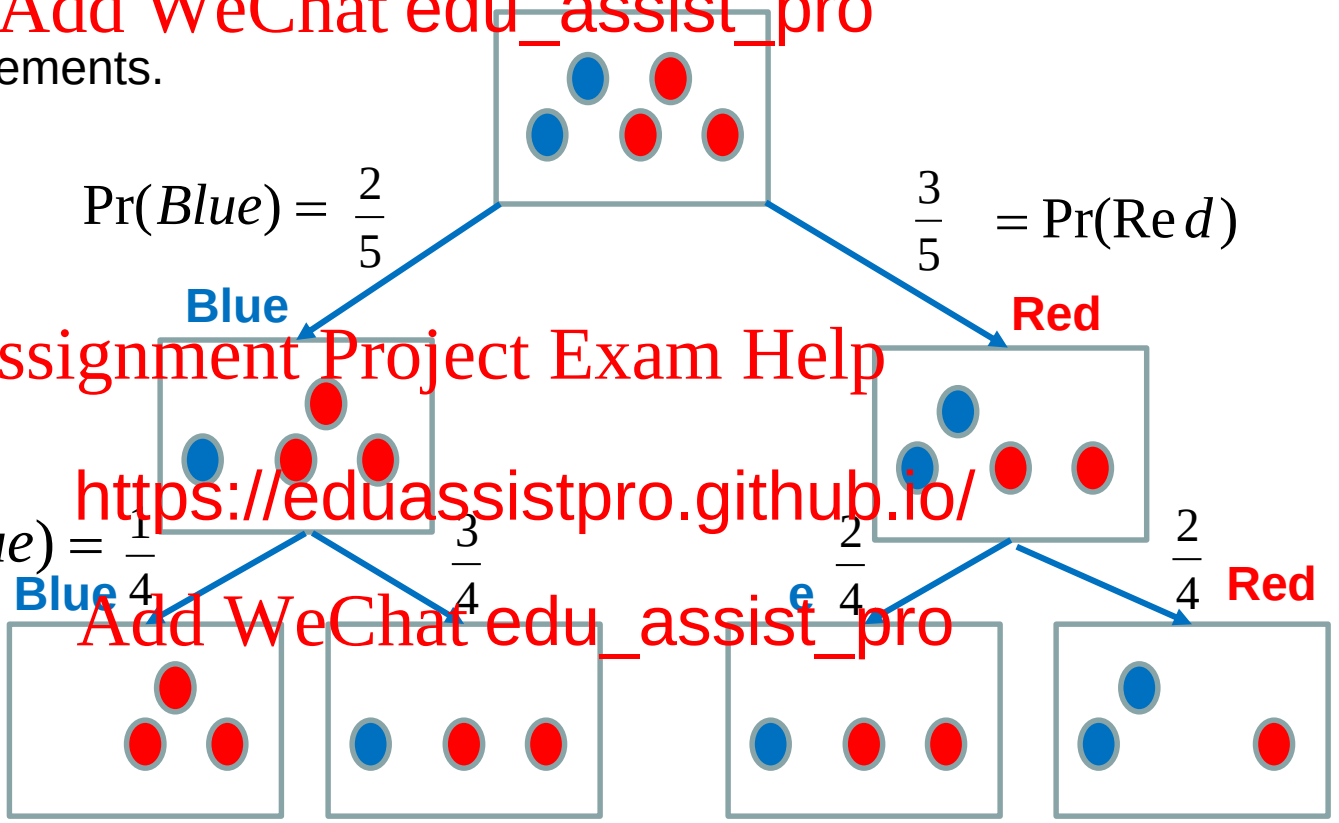


$$\Pr(Blue, Blue) = \frac{2}{5} \cdot \frac{1}{4} = \frac{1}{10}$$

$$\Pr(Blue, Blue) = \Pr(Blue) \cdot \Pr(Blue|Blue)$$

What are the chances of drawing red and then blue?

Assumption: no replacements.



$$\Pr(red, Blue) = \frac{3}{5} \cdot \frac{2}{4} = \frac{3}{10}$$

$$\Pr(\text{Red,Blue}) = \Pr(\text{Red}) \cdot \Pr(\text{Blue}|\text{Red})$$

Conditional probability

$$\Pr(A|B) = \Pr(\text{Event A would happen if we know th happened})$$

$$\Pr(\text{A and B}) = \Pr(B) \cdot \Pr(A|B) = \Pr(A) \cdot \Pr(B|A)$$

Bayes' rule:

$$\Pr(A|B) = \frac{\Pr(\text{A and B})}{\Pr(B)}$$

$$\Pr(B|A) = \frac{\Pr(\text{A and B})}{\Pr(A)}$$

Interesting video regarding Bayes' rule:
https://www.youtube.com/watch?v=R13BD8qKeTg

Total Probability Theorem

Recall that the probability that the first draw would be of a blue ball is $\frac{2}{5}$.

What are the chances that the second draw would be of a blue ball?

Answer: Total probability theorem:

$$\Pr(\text{2nd is blue}) = \Pr(\text{2nd is blue} \mid \text{1st is blue}) \cdot \Pr(\text{1st is blue}) + \Pr(\text{2nd is blue} \mid \text{1st is red}) \cdot \Pr(\text{1st is red})$$

Meaning:

$$\Pr(\text{2nd is blue}) = \frac{2}{5} \cdot \frac{1}{4} + \frac{3}{5} \cdot \frac{2}{4} = \frac{2}{5}$$

A Mobile Oil Company has recently acquired rights to a new potential source of n Alaska.

- The current market value of these rights is $90,000. The company could sell these rights now.

- However, if there is natural oil at the site, it is estimated to be worth $800,000; although the company would have to pay $100,000 in drilling costs to extract the oil.

- The company belie that the proposed drilling site actually would hit the natural oil r

- Alternatively, the company can pay $30,000 to first carry out a seismic survey at the proposed drilling site.

- The survey is not totally accurate: there is a 20% chance that the survey is favorable when oil is not present (false positive, type I error); and a 40% chance that the survey result is unfavorable when there is oil at the site (false negative, type II error).

Model formulation

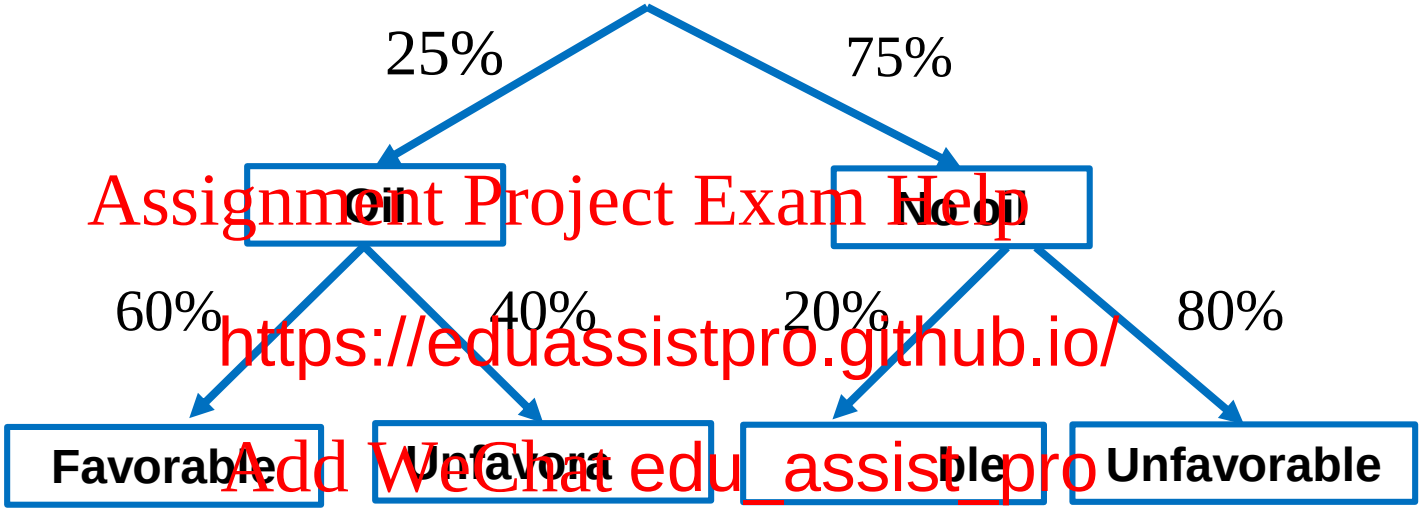
- What is the company objective?
  - Maximize profit

- What decisions does the Mobile Oil Company face?
  - Drill
  - Sell
  - Survey

- How to calculate the expected value of each action?

- **Go to the excel file "Mobile oil company"**

What is the probability of a favorable survey?

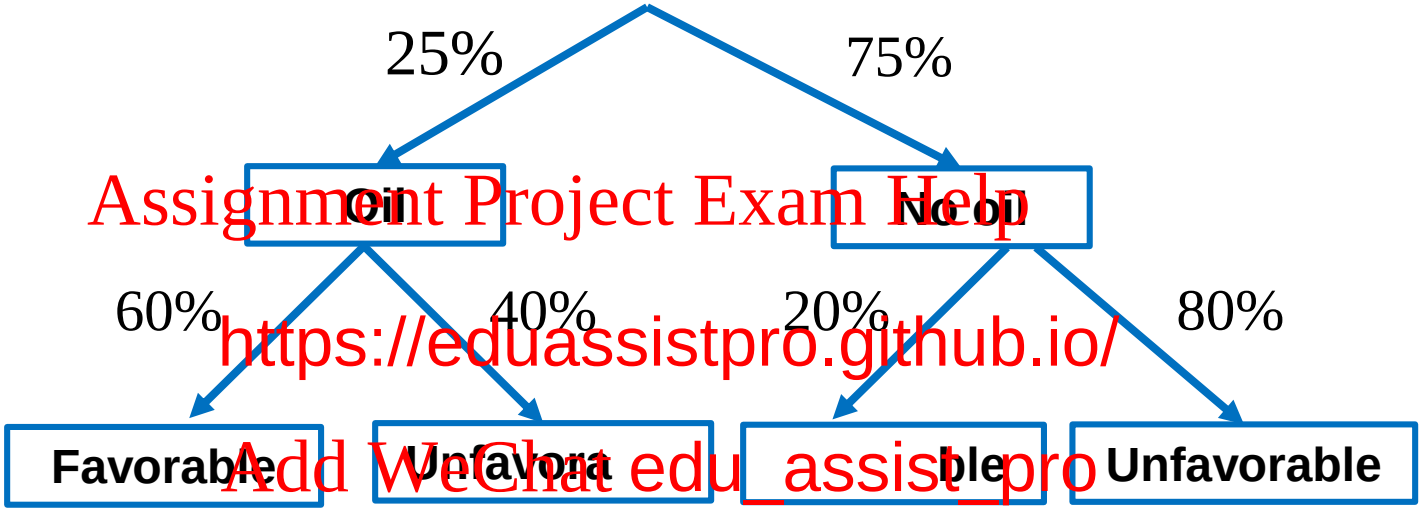


What is the probability of a favorable survey?

$$\Pr(\text{Favorable}) = 0.25 \cdot 0.60 + 0.75 \cdot 0.20 = 0.30 = 30\%$$

$$\Pr(\text{unfavorable}) = 1 - \Pr(\text{Favorable}) = 0.70 = 70\%$$

What is the probability of finding oil given a favo vey?

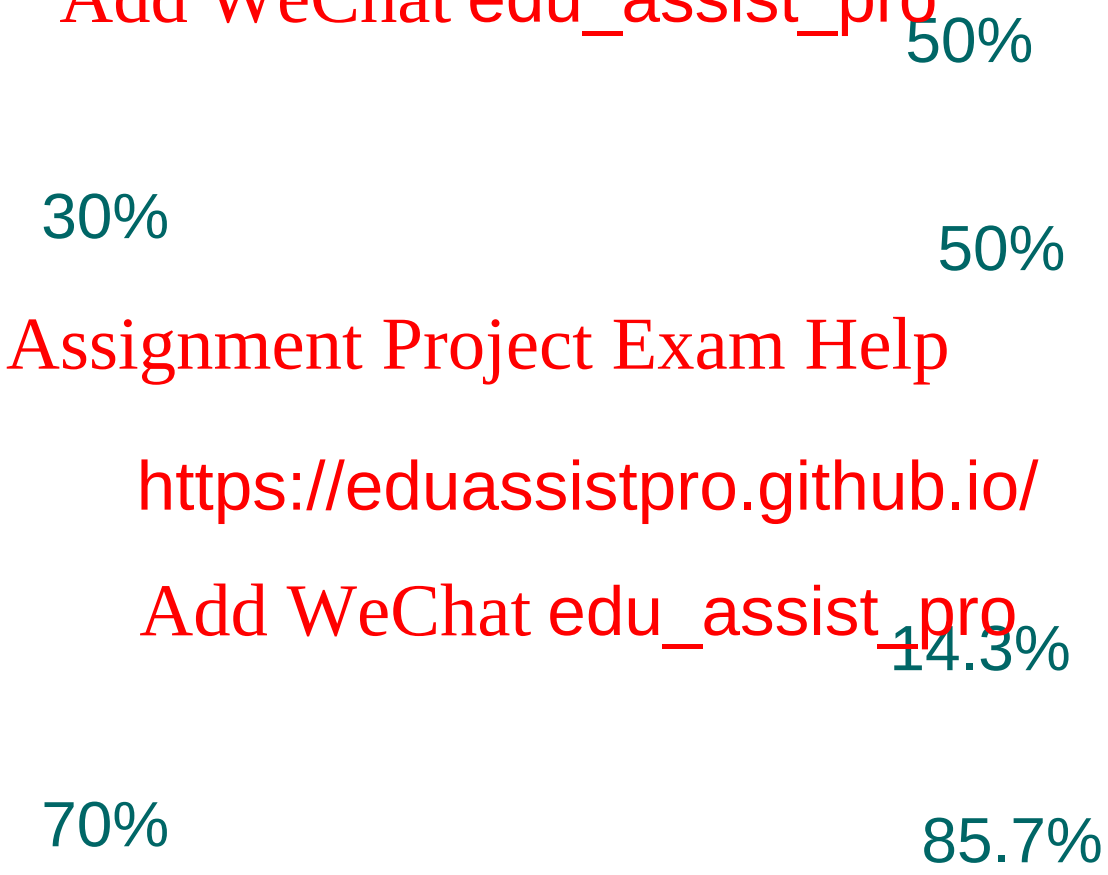


$$\Pr(\text{Oil}\,|\,\text{Favorable}) = \frac{\Pr(\text{Oil and Favorable})}{\Pr(\text{Favorable})} = \frac{0.25 \cdot 0.6}{0.3} = 0.5 \quad \Rightarrow \quad \Pr(\text{No Oil}\,|\,\text{Favorable}) = 1 - 0.5 = 0.5$$

$$\Pr(\text{Oil}\,|\,\text{Unfavorable}) = \frac{\Pr(\text{Oil and Unavorable})}{\Pr(\text{Unfavorable})} = \frac{0.25 \cdot 0.4}{0.7} = 0.143 \quad \Rightarrow \quad \Pr(\text{No Oil}\,|\,\text{Unfavorable}) = 1 - 0.143 = 0.857$$

What probabilities do we need for the decision tree?

What is the probability of finding oil if the survey is favo



Would choose to drill, no matter what the survey results

Que

1. Would the decision be different if the survey would cost less?
2. If the accuracy of the survey was different, would that affect the decision?