Operational Research and Optimisation

AQ052-3-M-ORO and VD1

Decision Analysis

Topic & Structure of the lesson

- **Problem Formulation**
- **Decision Making without Probabilities**
- **Decision Making with Probabilities**

Learning Outcomes

- **A the end of this topic, You should be able to apply appropriate decision technique (without or with probability) to find the best decision of a problem.**

Key Terms you must be able to use

If you have mastered this topic, you should be able to use the following terms correctly in your assignments and exams:

Problem Formulation

- A decision problem is characterized by decision alternatives, states of nature, and resulting payoffs.
- The decision alternatives are the different possible strategies the decision maker can employ.
- The states of nature refer to future events, not under the control of the decision maker, which may occur. States of nature should be defined so that they are mutually exclusive and collectively exhaustive.

Payoff Tables

- The consequence resulting from a specific combination of a decision alternative and a state of nature is a payoff.
- A table showing payoffs for all combinations of decision alternatives and states of nature is a payoff table.
- Payoffs can be expressed in terms of profit, cost, time, distance or any other appropriate measure.

	Good Economic Conditions	Poor Economic Conditions
Apartment Building	$50,000	$30,000
Office Building	$100,000	-$40,000
Warehouse	$30,000	$10,000

Decision Making without Probabilities

- Three commonly used criteria for decision making when probability information regarding the likelihood of the states of nature is unavailable are:
  - the optimistic approach
  - the conservative approach
  - the minimax regret approach.

Example: Burger Prince

Burger Prince Restaurant is contemplating opening a new restaurant on Main Street. It has three different models, each with a different seating capacity. Burger Prince estimates that the average number of customers per hour will be 80, 100, or 120. The payoff table for the three models is on the next slide.

Example: Burger Prince

- Payoff Table

	Average Number of Customers Per Hour		
	$s_1 = 80$	$s_2 = 100$	$s_3 = 120$
Model A	$10,000	$15,000	$14,000
Model B	$ 8,000	$18,000	$12,000
Model C	$ 6,000	$16,000	$21,000

Determine the best decision using:

(i) Optimistic approach (Maximax)

(ii) Conservative approach (Maximin)

(iii) Minimax regret approach

Decision Making with Probabilities

- Expected Value Approach
  - If probabilistic information regarding the states of nature is available, one may use the expected value (EV) approach.
  - Here the expected return for each decision is calculated by summing the products of the payoff under each state of nature and the probability of the respective state of nature occurring.
  - The decision yielding the best expected return is chosen.

Expected Value of a Decision Alternative

- The expected value of a decision alternative is the sum of weighted payoffs for the decision alternative.
- The expected value (EV) of decision alternative d_i is defined as:

$$\mathrm{EV}(d_i) = \sum_{j=1}^{N} P(s_j) V_{ij}$$

where: N = the number of states of nature

$P(s_j)$ = the probability of state of nature s_j

V_{ij} = the payoff corresponding to decision alternative d_i and state of nature s_j

Example: Burger Prince

Burger Prince Restaurant is contemplating opening a new restaurant on Main Street. It has three different models, each with a different seating capacity. Burger Prince estimates that the average number of customers per hour will be 80, 100, or 120. The payoff table for the three models is on the next slide.

Example: Burger Prince

- Payoff Table

	Average Number of Customers Per Hour		
	$s_1 = 80$ (p = 0.4)	$s_2 = 100$ (p = 0.2)	$s_3 = 120$ (p = 0.4)
Model A	$10,000	$15,000	$14,000
Model B	$ 8,000	$18,000	$12,000
Model C	$ 6,000	$16,000	$21,000

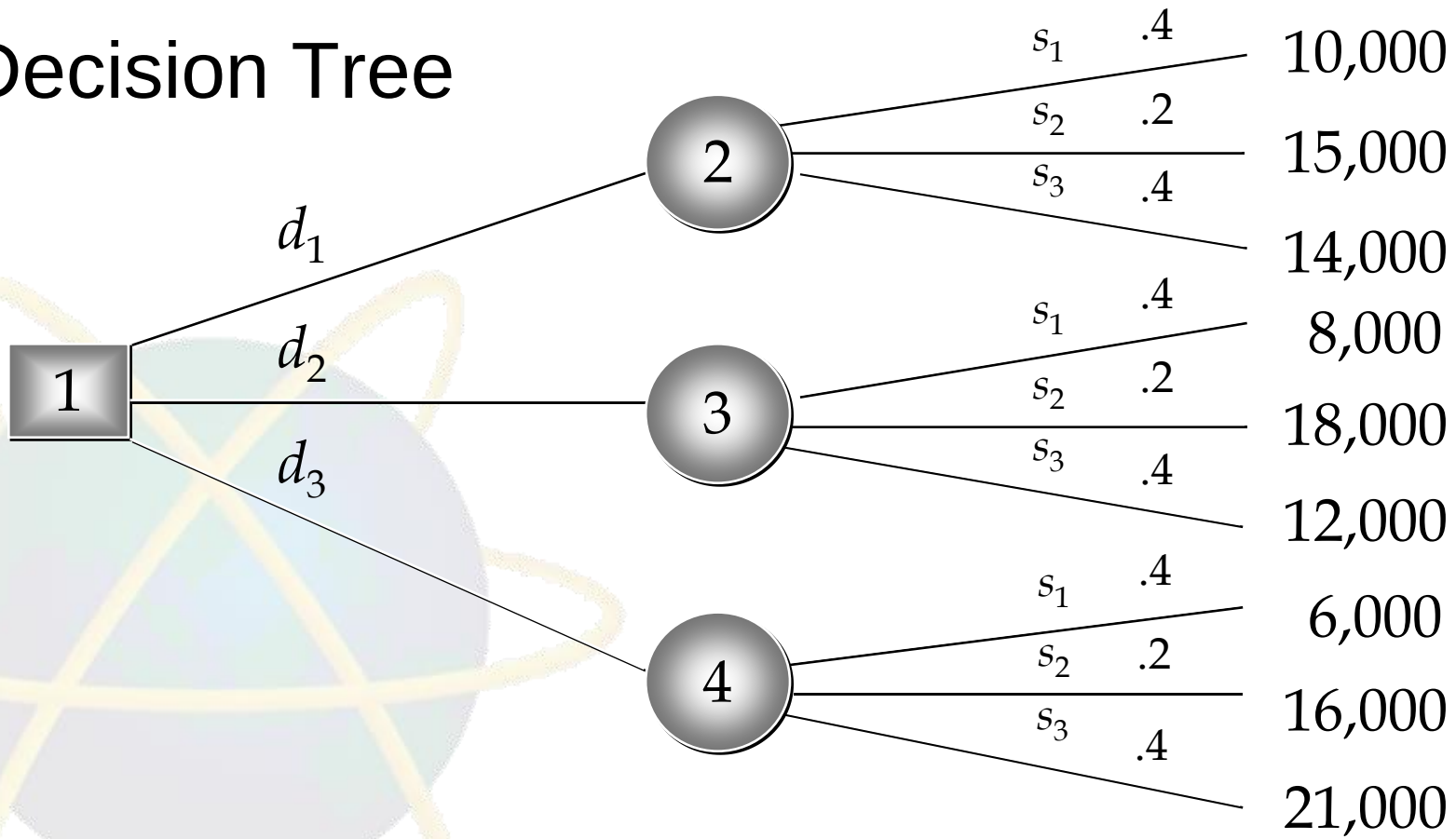
Example: Burger Prince

- Expected Value Approach

  Calculate the expected value for each decision. The decision tree on the next slide can assist in this calculation. Here d_1, d_2, d_3 represent the decision alternatives of models A, B, C, and s_1, s_2, s_3 represent the states of nature of 80, 100, and 120.

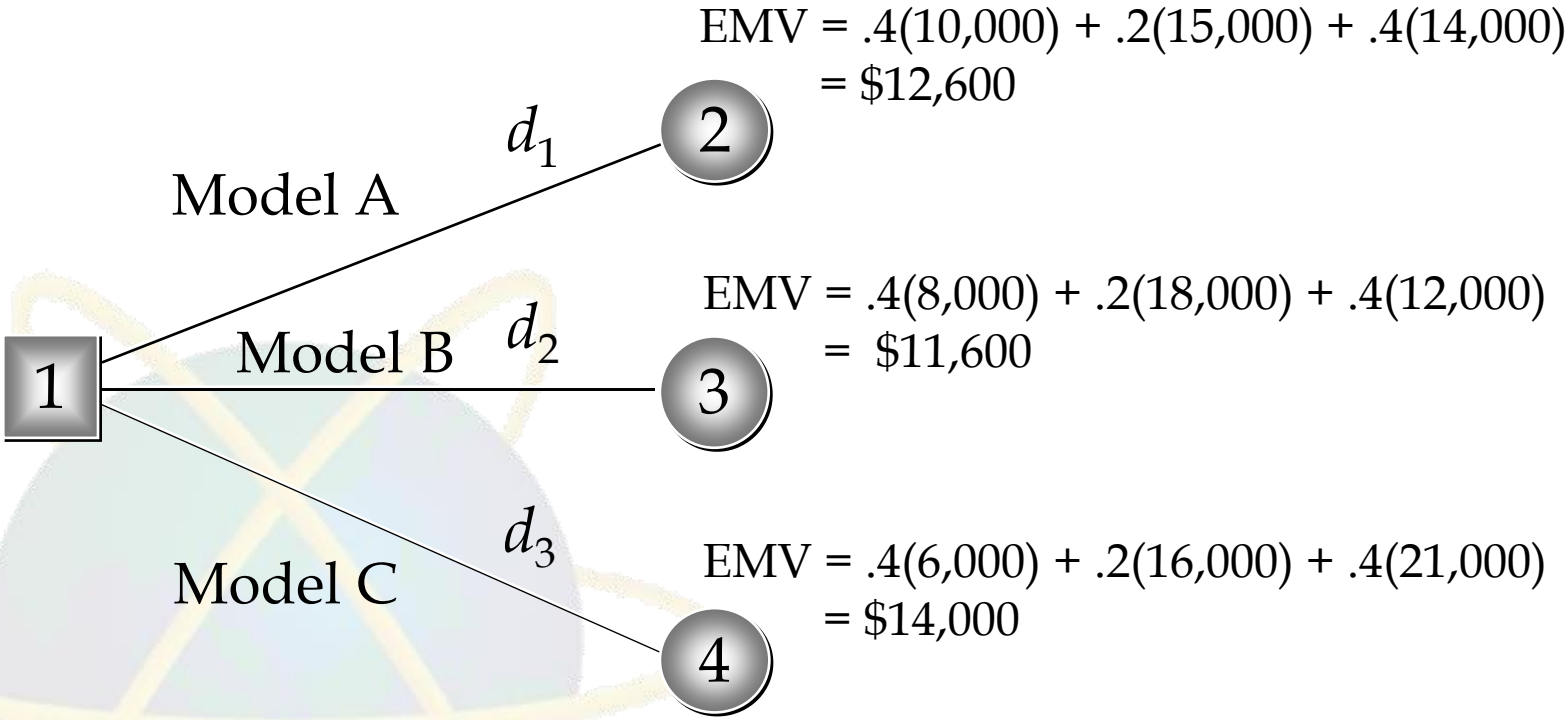
Example: Burger Prince

- Decision Tree



Example: Burger Prince

- Expected Value For Each Decision



Choose the model with largest EV, Model C.

Burger Prince must decide whether or not to purchase a marketing survey from Stanton Marketing for $1,000. The results of the survey are "favorable" or "unfavorable". Should Burger Prince have the survey performed by Stanton Marketing?

P(favorable) = 0.55

If the report is favorable,

Probability to have 80 customers = 0.15

Probability to have 100 customers = 0.19

Probability to have 120 customers = 0.66

P(unfavorable) = 0.45

If the report is unfavorable,

Probability to have 80 customers = 0.70

Probability to have 100 customers = 0.22

Probability to have 120 customers = 0.08

Exercise 1

A company is deciding whether to develop and launch a new product. Research and development costs are expected to be $400,000 and there is a 70% chance that the product will be successful. If it is successful, the expected revenue and the probability of each occurring have been estimated as follows, depending on whether the product's popularity is high, medium or low.

	Probability	Revenue
High	0.2	$1000,000 per annum.
Medium	0.5	$800,000 per annum.
Low	0.3	$600,000 per annum.

If it is a failure, there is a 0.6 probability that the research and development work can be sold for $50,000 and a 0.4 probability that it will be worth nothing at all.

(a) Draw a decision tree to represent the problem above.

(b) Determine the expected value for each possible action and hence estimate the net profit for the company.

Quick Review Question

Follow Up Assignment

Summary of Main Teaching Points

Question and Answer Session

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Next Lesson

Markov Process