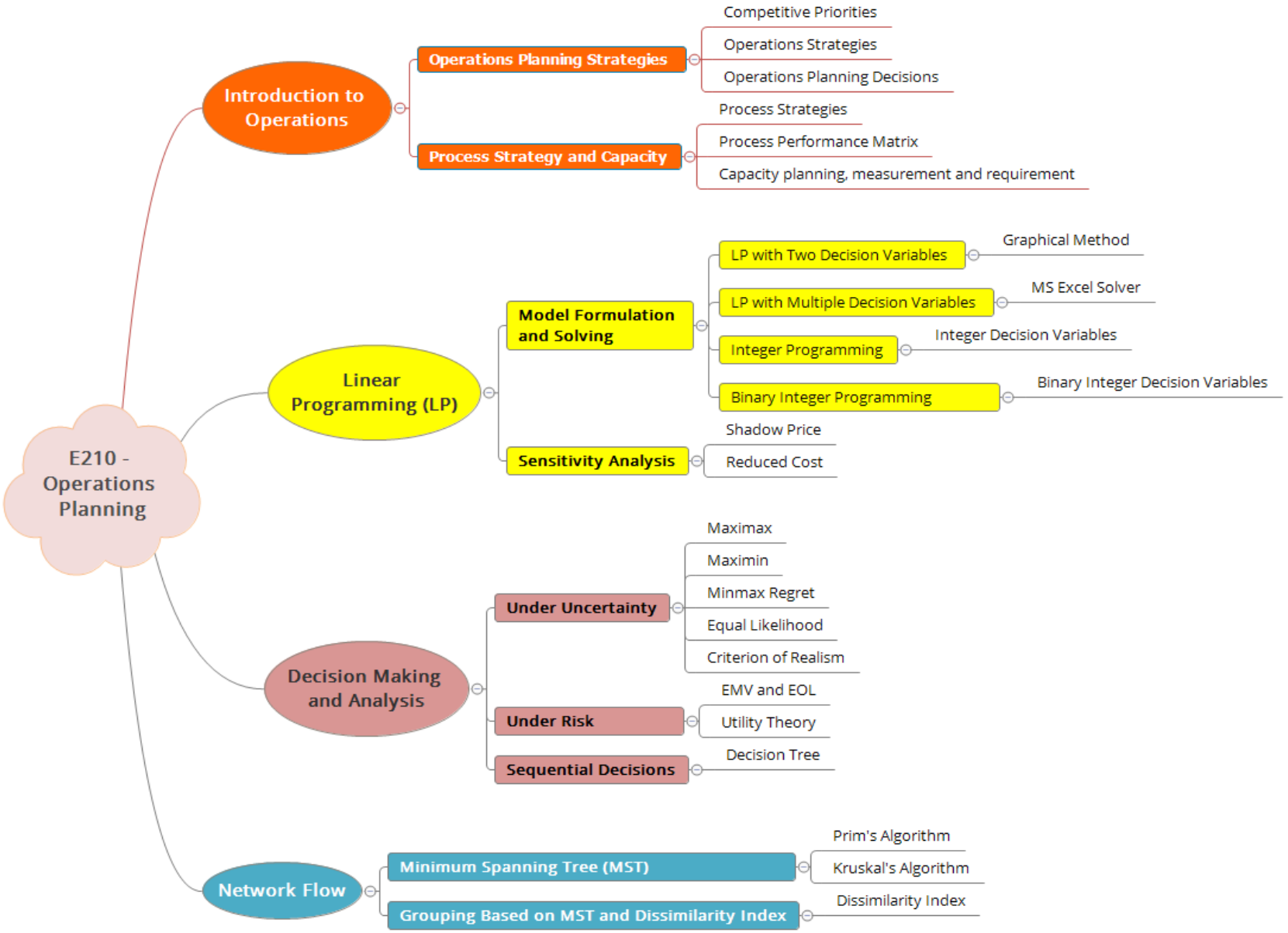
Problem 10

Sequential Decisions

E210 – Operations Planning

SCHOOL OF ENGINEERING

E210 Operations Planning Topic Tree



Decision Tree

- Payoff applicability limited to situations involving single decision.
- Many real-world decisions consist of a sequence of dependent decisions.
- Decision Tree is a chronological network representation of decision making process using three types of nodes:
  - Decision nodes (□)
  - Event or chance nodes (○).
  - Terminal node (◁)

Decision Tree

- Branches from decision node
  - Represent different alternatives
  - Include cost/benefit value associated with that decision.
- Branches from event node
  - Represent possible outcomes of uncertain event
  - Associated with probabilities, given all previous occurrences (decisions and events) have occurred.
- Leaves are the end-points (terminal nodes) of branches
  - Corresponds to an entry in the payoff table.
  - Payoff at each leaf is computed by summing the cash flows along the set of branches leading to each leaf.

Benefits of Decision Tree

- Choices are set out in a logical way.
- Potential options & choices are considered at the same time.
- Use of probabilities enables the “risk” of the options to be addressed.
- Likely costs are considered as well as potential benefits.
- Easy to understand & tangible results.

Disadvantages of Decision Tree

- Probabilities are just estimates – always prone to error.
- Uses quantitative data only – ignores qualitative aspects of decisions.
- Assignment of probabilities and expected values prone to bias.
- Decision-making technique doesn’t necessarily reduce the amount of risk.

Problem 10
Suggested Solution

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Today's Problem: Information Provided

- There are **16 possible scenarios** in this problem. The **payoff** for each scenario could be calculated using the decision tree.
- Given:
  - Unit Cost of the New Process: $150
  - Unit Cost of the Existing Process: $180
  - Unit Price: $200
  - High customer demand: 30K units
  - Low customer demand: 10K units
  - Cost of developing a New Process (Year 1): $800K
  - Cost of modifying the Existing Process (Year 1): $120K
  - Production capacity of New Process: 35K units
  - Production capacity of Existing Process: 25K units
  - Cost of On-line Advertisement (Year 2): = $150K
  - Cost of Newspaper Advertisement (Year 2): = $80K

Today's Problem: Formulation

- In today's problem, payoff is a summation of: cost of developing/modifying production process (negative value), advertisement cost (negative value), profit from selling e-book readers (positive value) for both years.
- Example: Modify the Existing Process (year 1) -> High Demand (year 1) -> Newspaper Advertisement (year 2) -> Low Demand (year 2)
- Payoff = (Cost of modifying the Existing Process year 1)+(High Demand, year1 profit)+(Cost of Newspaper Advertisement year 2) +(Low demand year 2 profit)

= (- $120k) + ($200-$180)*25k + (-$80k) + ($200-$180)*10k

= $500

Cost of modifying existing process (-value)

Year 1 Profit (+value)

Newspaper Advertisement Cost(-value)

Year 2 Profit (+value)

Today's Problem: Calculating Payoffs

Example 1:

- Consider the New Process with Low Demand in the 1st year and adopt On-line Advertisement with Low Demand in the 2nd year.
- Payoff = - Cost of developing a New Process in Year 1 - Cost of On-line Advertisement in Year 2 + Sales revenues (Low Demand) in Year 1 + Sales revenues(Low Demand) in Year 2
- Payoff = (-800K) + (-150K) +(200-150)*(10K) + (200-150)*(10K) = **$50K**

Today's Problem: Calculating Payoffs

Practice Calculations

- Consider the Existing Process with High Demand in the 1st year and On-line Advertisement with High Demand in the 2nd year.

  Answer: Payoff = $730K

- Consider the New Process with High Demand in the 1st year and adopt Newspaper Advertisement with Low Demand in the 2nd year.

  Answer: Payoff = $1,120K

- Consider the Existing Process with Low Demand in the 1st year and adopt On-line Advertisement with High Demand in the 2nd year.

  Answer: Payoff = $430K

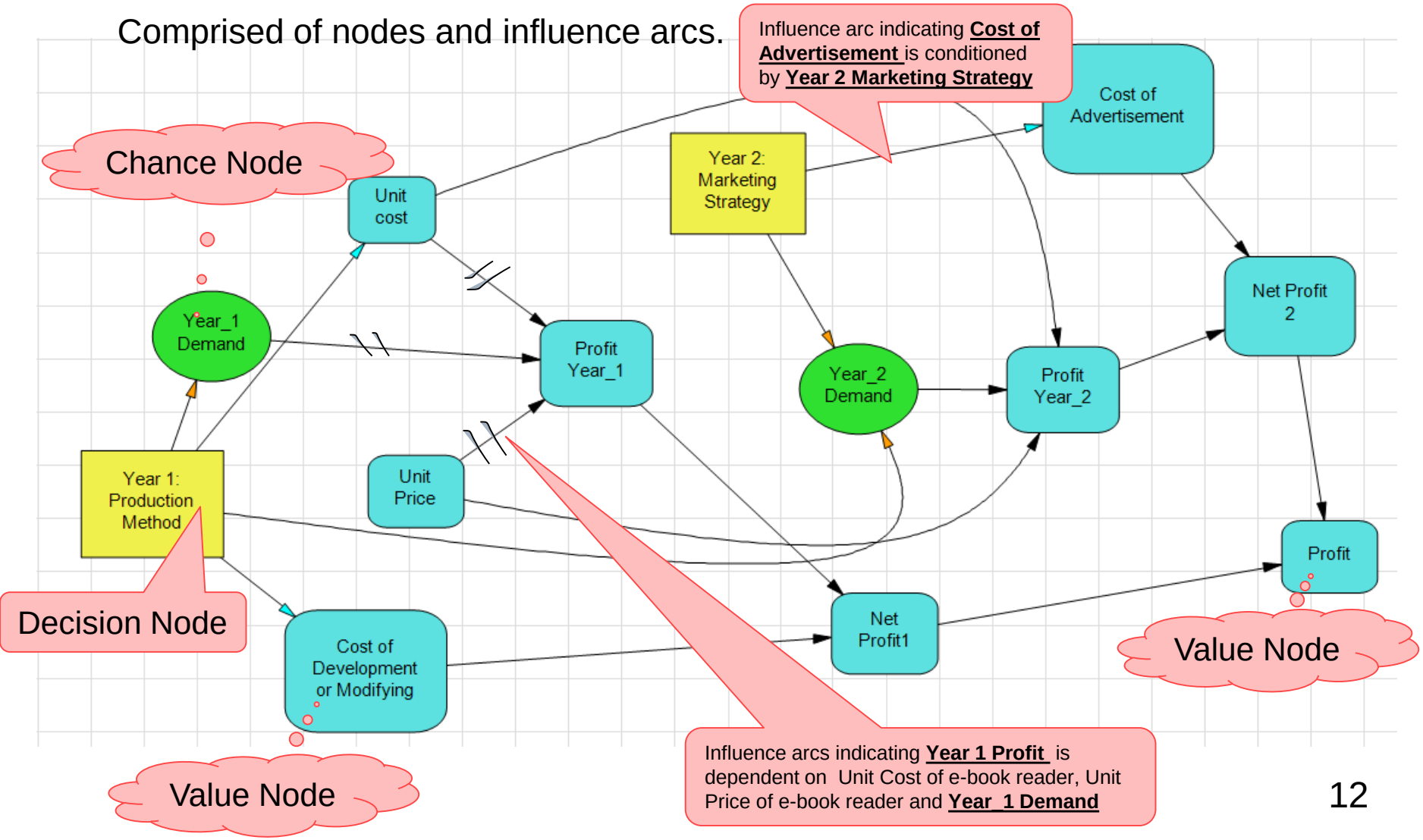
- Consider the Existing Process with Low Demand in the 1st year and adopt Newspaper Advertisement with Low Demand in the 2nd year.

  Answer: Payoff = $200K

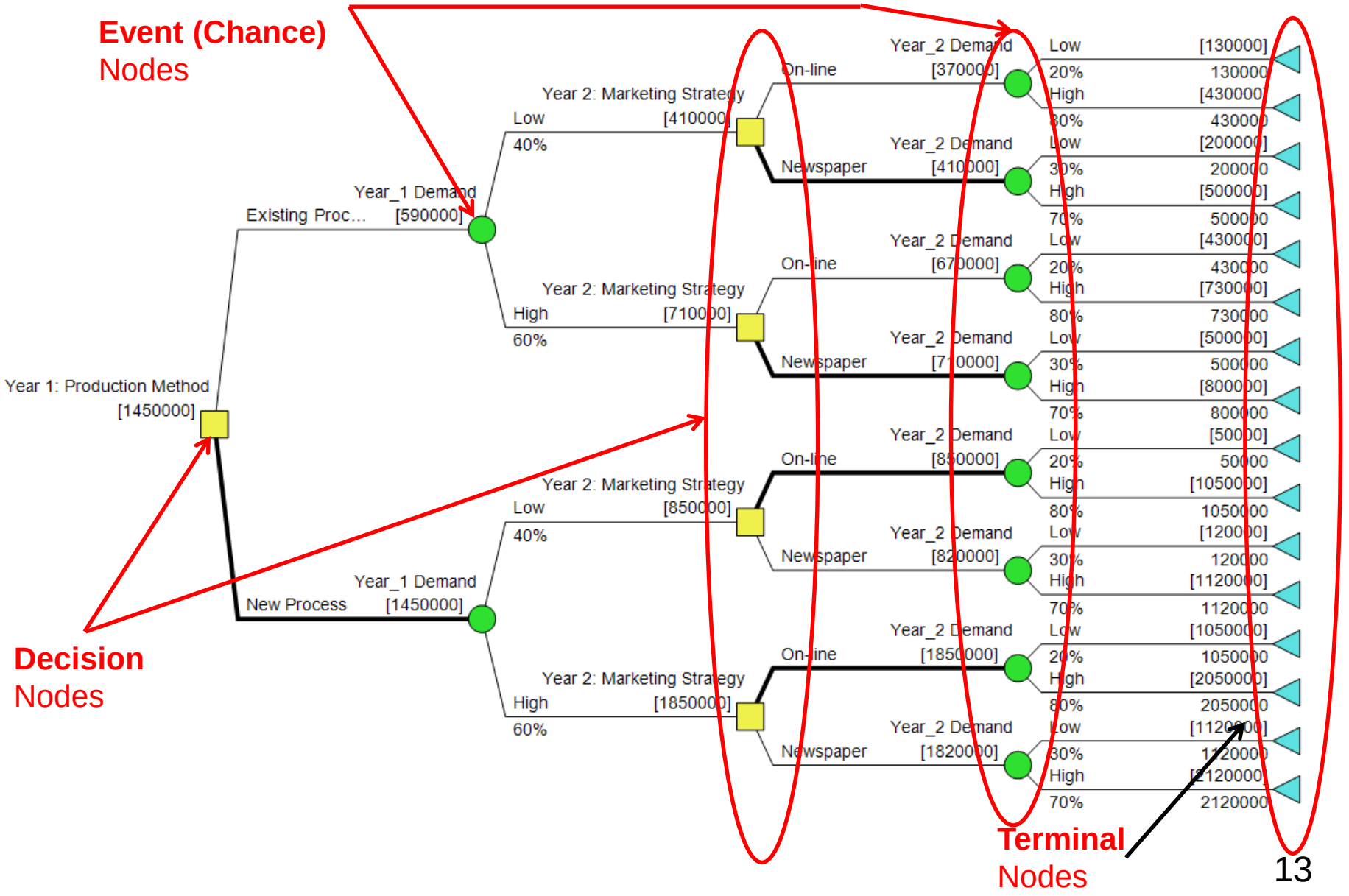
DPL– Influence Diagram

A graphical representation of the components of a decision problem — decisions, uncertainties, and values — and the relationships among them.

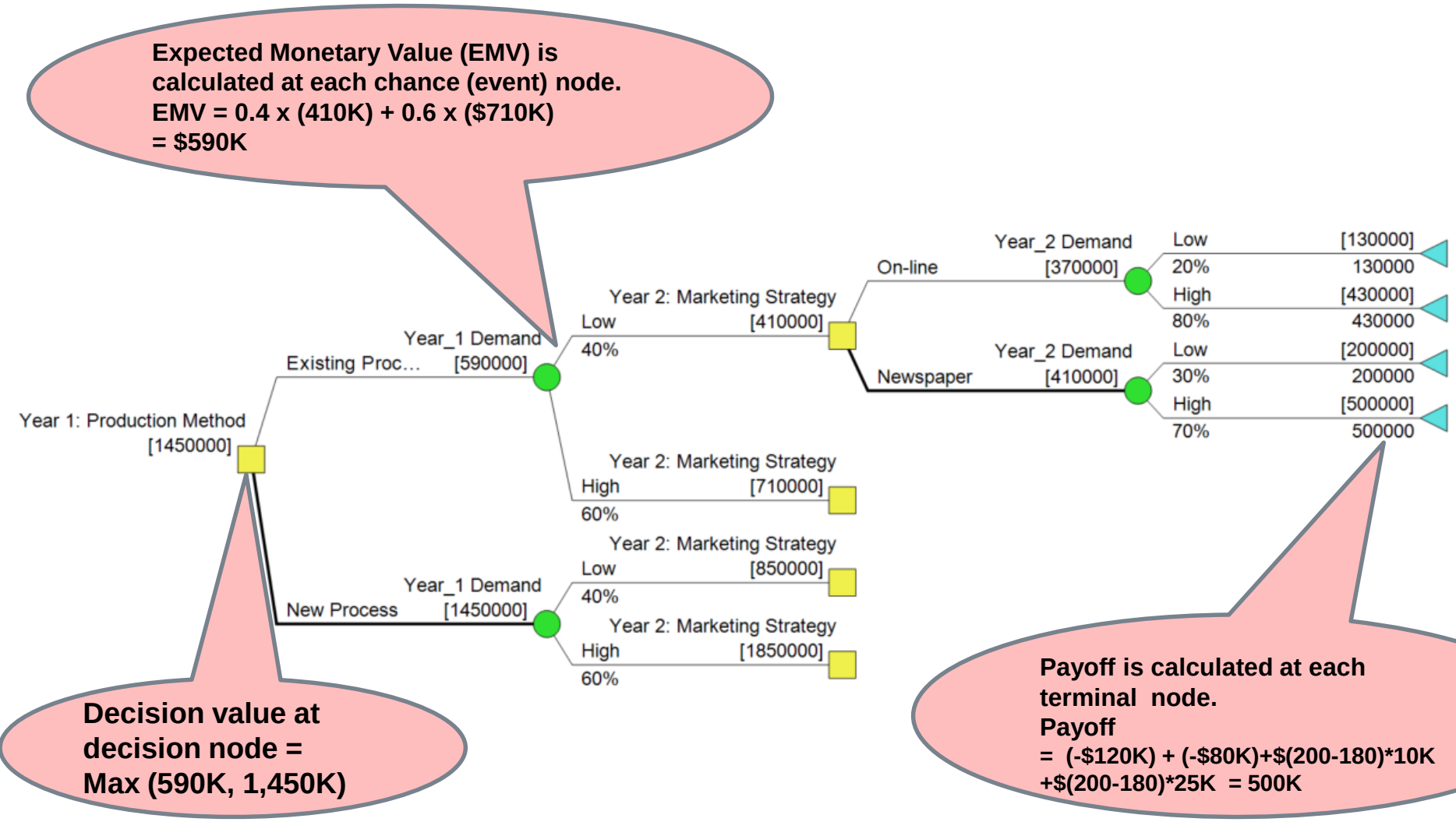
Comprised of nodes and influence arcs.



Decision Tree – Nodes

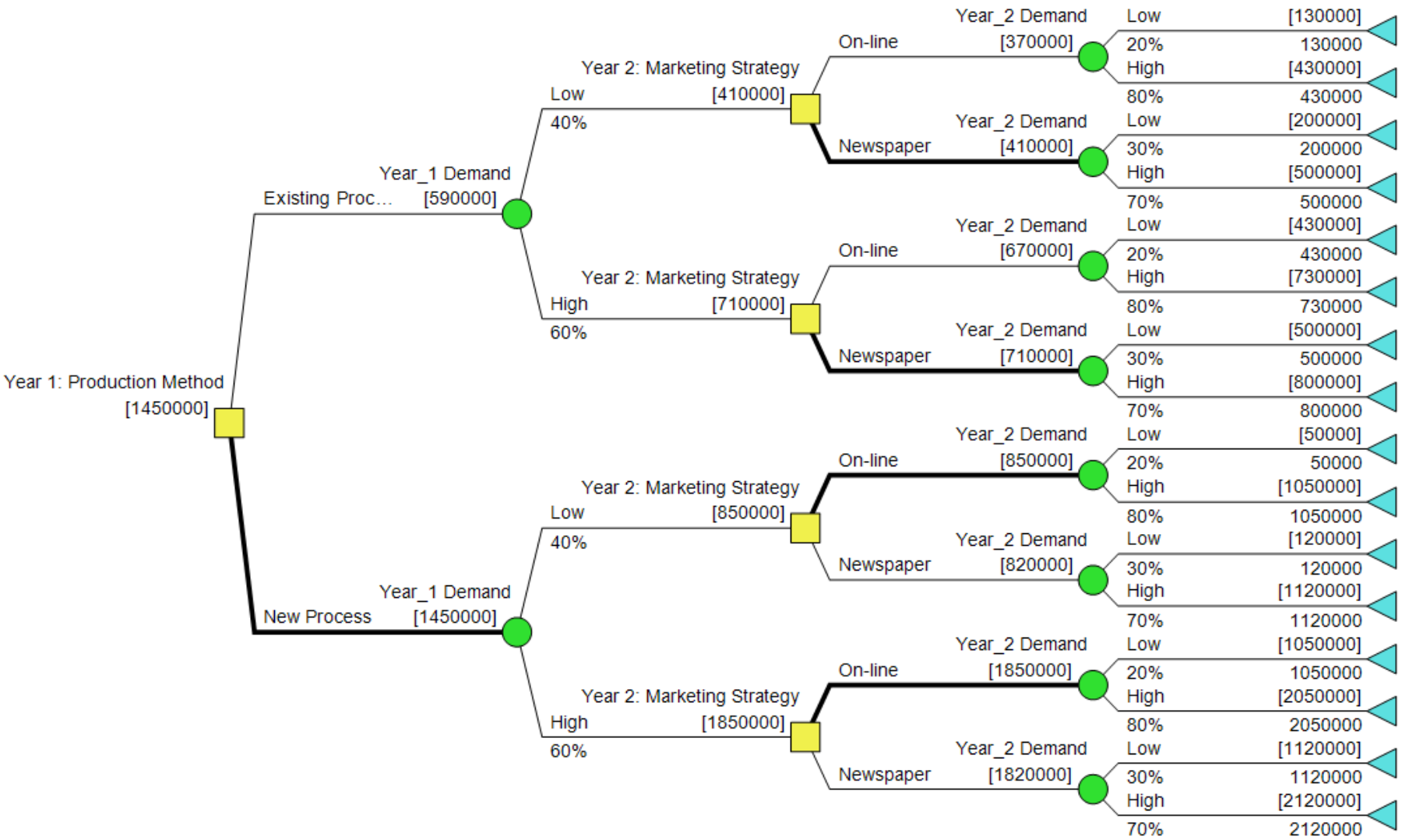


Decision Tree – EMVs and Payoffs



Best decision to make at any decision node is the decision that gives the **maximum** EMV.

Summary of Decisions



It is recommended that EasyReader to opt for developing New Process in Year 1. Regardless of year 1 sales, employ On-line advertisement in Year 2 to reap the maximum profit.

Conclusion

- Decision making is complicated when numerous scenarios are possible.
- Based on decision tree, EasyReader should consider developing New Process in the first year (EMV_New Process = $1,450K vs EMV_Existing Process = $590K).
  - With New Process developed in year 1, the company needs to engage On-line Advertisement regardless of year 1 sales.
  - With Existing Process modified in year 1, the company needs to engage Newspaper Advertisement regardless of year 1 sales.

Conclusion

- A decision tree can be used to represent a series of sequence-dependent decisions that may be influenced by uncertain events or other decisions.
- The payoff for each possible outcome is calculated in the decision tree and ‘rolled back’ to determine the EMVs at each event node.
- The alternative to choose at a decision node is based on the maximum EMV (or minimum cost).
- Use of a decision tree software like DPL makes it easier to carry out scenario studies where change in input parameters can be analyzed.

  E.g. change in probabilities of uncertain events, change in cost/profit.

Learning Objectives

- Construct a basic decision tree.
- Model and present sequential & dependent decision problem using decision tree.
- Evaluate sequential decision making in real-world situations.
- Calculate payoff at each terminal node.
- Calculate EMV at each event node.
- Perform decision making at each decision node.
- Use of software DPL to perform Decision Analysis

Overview of E210 Operation Planning Module