TIE4203 Decision Analysis in Industrial & Operations Management
Tutorial 5 (DPL Lab)
Decision Modeling and Analysis using DPL 9

Overview of DPL

1. Introduction

- DPL stands for **Decision Programming Language** and is one of the best software designed for professional decision analysts/consultants.

- In DPL, decision models are built using both influence diagrams and decision trees.

  1. The influence diagram defines the *elements* of the problem and the *probabilistic relationships* among them. However, it does not follow the standard influence diagrams as defined in Chapter 5 or as in Howard and Matheson (1981).

  2. The decision tree shows the *chronology* of events and the asymmetric structure of the problem that is defined in the influence diagram and it may be displaced in compact or generic form.

- DPL 9 supports

  1. Graphical user interface (GUI) for creating and modifying influence diagrams and decision trees.
  2. Generation of optimal decision policy tree.
  3. Risk profile generation in CDF and EPF formats.
  4. Sensitivity tools for generating tornado diagrams.
  5. Sensitivity tools for generating one-way and two-way rainbow diagrams.
  6. Automatic flipping of probability trees if needed at solution time.
  7. Automatic expected value of perfect information and value of control computations.
  8. Built-in exponential utility function (risk averse only).
  9. User-defined utility functions for any risk preference.
  10. Automatic discrete approximation of continuous probability distributions.
  11. Option value analysis using control on decision nodes.
  12. Strategies generation table for problems with a large number of decision nodes.
  13. Value nodes and slots can be linked to Excel.
  14. A programming language: Create decision models without using the user interface.

2. Main Differences between DPL and Standard Influence Diagram

- DPL does not follow the standard influence diagrams as defined in Chapter 5 of Lecture Notes or as in Howard and Matheson (1981).

- We provide here only the major differences between DPL Influence Diagram and Standard Influence Diagram. See DPL documentation for more details.

DPL Chance Nodes

- In a DPL influence diagram, every chance node has a set of states (or outcomes), and associated with each state is a (conditional) probability and an optional numeric value. A global variable with the same name as the node will be created and the values used in computations of other values.

Example:

Chance Node: Stock Price		
State name	**Probability**	**Value**
High	0.5	12
Medium	0.3	0.5*Profit
Low	0.2	2 + @exp(Profit/12)

- The value slot may contain:
  1. A number (constant).
  2. An expression containing other variables and/or built-in DPL function that evaluates to number.
  3. Linked to a spreadsheet cell.

DPL Decision Nodes

- In a DPL influence diagram, every decision node has a set of alternative and associate with it is an optional numeric value. A global variable with the same name as the node will be created and the values used in computations of other values.

Example:

Decision Node: Stock to buy	
Alternative	**Value**
IBM	100
SingTel	88
DBS	35
None	0

- The value slot may contain:
  1. A number (constant).
  2. An expression containing other variables and/or built-in DPL function that evaluates to number.
  3. Linked to a spreadsheet cell.

Value Nodes

- A DPL value node is not to be confused with the value (utility) node in a standard influence diagram.

- A value node in a DPL influence diagram is a global variable that is assigned a numerical value which can be used in computations of other values.

Example:

Value node: Cost of Production
Value = 100@UnitCost

- The value slot may contain:
  1. A number (constant).
  2. An expression containing other variables and/or built-in DPL function that evaluates to number.
  3. Linked to a spreadsheet cell.

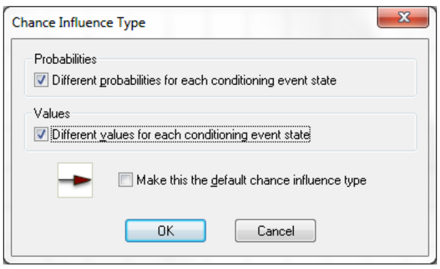
- A DPL influence diagram may have multiple value nodes each representing a global variable or constant.

The COLORFUL World of DPL Arcs

- Since each node in a DPL influence diagram may contain additional numerical values, there are four possible dependent and independent relations. DPL uses colors to denote the four different relationships.

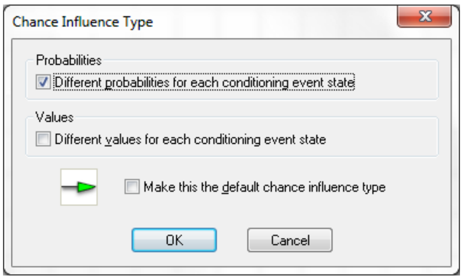
Case 1: Probabilistic and Value Dependent

- Each outcome of the chance node has a different probability distribution and a different value set for each state of the conditioning node. Such a relationship is denoted by a **burgundy** arrowhead.



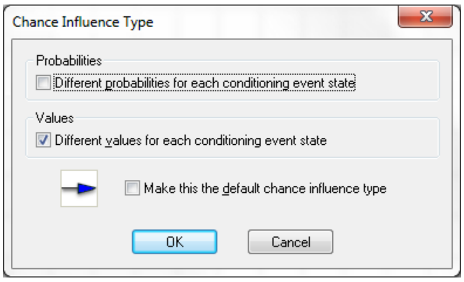
Case 2: Probabilistic Dependent, but Value Independent

- Each outcome of the chance node has a different probability distribution for each state of the conditioning event, but the same value set for each state of the conditioning event. Such a relation is represented by a **green** arrowhead.



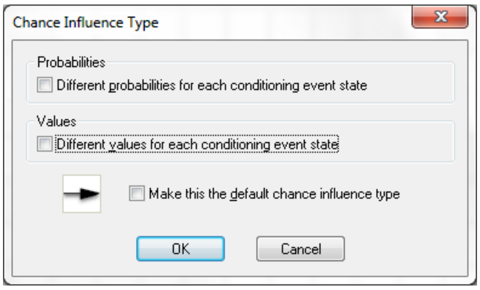
Case 3: Probabilistic Independent, but Value Dependent

- Each outcome of the chance node has the same probability distribution for each state of the conditioning event, but a different value set for each state of the conditioning event. Such a relation is represented by a **blue** arrowhead.



Case 4: Probabilistic and Value Independent

- Such arcs are used for chronological and information arcs. An optional **black** arrowhead arc may be used to indicate such an arc.



Objectives and Learning Outcomes of the Lab Session

- This lab exercise aims to get you familiarized with the basic functions of the DPL software.
- At the end of the lab session, you will be able to:

    1. Build decision models using the graphical model editor and input the relevant data such as probabilities and utility functions.
    2. Solve the decision models to find optimal decision policies
    3. Generate and interpret risk profiles
    4. Perform and interpret the expected value of information and control on uncertain variables.
    5. Perform one-way sensitivity analysis and generate rainbow diagrams.
    6. Build sequential decision models with asymmetric structures.
    7. Reorder and modify the decision tree structure generated by DPL.
    8. Perform the expected value of imperfect information analysis.
    9. Perform two-way sensitivity analysis and generate two-way rainbow diagrams.

DPL 9 Lab Exercises

1. Creating Decision Models

Use DPL to model Kim's Party Problem as described in Chapter 4 of the Lecture Notes.

Kim wants to decide on the location to hold a party tomorrow. Ideally, she would like to hold the party outdoors in the garden but is concerned about the weather. If the party is held outdoors, it would be a disaster if it rains. On the other hand, if she holds the party indoors, it would be weather-proof, but she would not enjoy the party as much as she would if the party was outdoors. She could also "compromise" by holding the party partially outdoors under the porch. Where should she hold the party?

Kim believes that the probability that the weather will be sunny tomorrow is 0.4. Her utility function is $u(x) = \frac{4}{3}(1 - 2^{-x/50})$ where x is in dollars. Her equivalent dollar values for various outcomes are:

Decision-Outcome	Equivalent Dollar Value
Outdoors-Sunny	$100
Porch-Sunny	$90
Indoors-Rainy	$50
Indoors-Sunny	$40
Porch-Rainy	$20
Outdoors-Rainy	$0

2. Base Model Analysis

***Question* 2.1**: What is Kim's best party location and certainty equivalent?

Answers: Kim should hold her party at ______________________

Her optimal certainty equivalent is _________________

***Question* 2.2:** What is Kim's *value of clairvoyance* on the weather?

Answer: Value of Clairvoyance on the Weather = ___________________________

***Question* 2.3:** If Kim is offered a magic weather control machine that can precisely set the weather anywhere anytime, how much would Kim be willing to pay to use the machine once?

Answer: Value of Control on the Weather = _________________________________

***Question* 2.4:** Generate the Risk Profiles for Kim's decision alternatives. Is there any stochastic dominance?

Answers: First Order Stochastic Dominance _____Yes/No_____
Second Order Stochastic Dominance _____Yes/No_____

3. One-Way Sensitivity Analysis (Rainbow Diagram)

***Question* 3.1:** Investigate the impact on the optimal party location if the probability of sunshine is varied from 0 to 100% by generating a *rainbow diagram*.

Where should Kim hold her party if the probability of sunny = 0.35?

Answer: ______________________________

***Question* 3.2:** Investigate the impact on the optimal party location if Kim's risk tolerance is varied from $10 to $1,000 by generating a *rainbow diagram*.

Where should Kim hold her party if her risk tolerance is $500?

Answer: ______________________________

4. Sequential Decisions (Asymmetric) and Value of Imperfect Information Analysis

***Question* 4.1:** A rain detector is available and the true-sunny detection rate and the true-rainy detection rate are both equal to 0.8. If the fee for the use of the detector is $12, create a model to help Kim decides if she should use the detector or not. What is her certainty equivalent?

Answers: Kim should / should not use the rain detector at a cost of $12

Optimal certainty equivalent = __________________

***Question* 4.2:** Plot a rainbow diagram for Kim's certainty equivalents if the cost for using the detector is varied from $0 to $25.

Answers: Kim should / should not use the rain detector at a cost of $6

Optimal certainty equivalent = __________________

***Question* 4.3:** What is the maximum Kim should pay for using the detector?

Answer: __________________________________

5. Sensitivity Analysis on True-Detection Rates

Question **5.1:** Assuming that the detector is free to use, and the true sunny detection rate is equal to the true rainy detection rate, plot a rainbow diagram for Kim's certainty equivalent by varying the true detection rate from 0 to 100%.

Answer: Kim should / should not use the rain detector when the true-detection rates are 0.5

6. Two-Way Sensitivity Analysis on True-Detection Rates

Question **6.1:** Assuming again that the detector is free to use, perform a two-way sensitivity analysis by varying simultaneously from 0 to 100%, the true sunny detection and true rainy detection rates of the detector.

Answer: Kim should / should not use the rain detector when the true-sunny detection rate is 0.25 and the true-rainy detection rate is 0.25.