

# ***Making Hard Decisions***

R. T. Clemen, T. Reilly

*Draft: Version 1*

## **Chapter 2**

# **Elements of Decision Problems**

# Introduction

Given a complicated problem, how should one begin?

Critical Step – Identify the elements:

1. Values and objectives
2. Decisions to make
3. Uncertain Events
4. Consequences

**All four will be addressed in more detail separately.**

# Values and Objectives

## 1.OBJECTIVES:

A specific thing one wants to achieve:

- To harvest successfully – Farmer.
- To resolve a specific scientific problem – Scientist.
- To make a lot of money – Investor.

**Person's Values:** Collection of objectives

No values → No objectives → No Decisions

**Special Objective:** Making Money; often a surrogate objective (or means objective) for other objectives e.g. eating, traveling, afford clothing, etc

# Values and Objectives

**Underlying Objectives:** Understanding the underlying Objectives (or fundamental objectives) is crucial to formulating the decision problem and list alternatives.

**Example:**

**Objective:** Travel comfortably from Point A to B

**Alternatives:** Public Transportation, Lease a Car,  
Buy a Car, Buy a Motorcycle

**Really two objectives:** Traveling from A to B and  
Traveling Comfortably

# Values and Objectives

Often **a trade off** has to be made between “money making” objective and other fundamental objectives:

1. How much more money are you willing to spend on air conditioning for your car?
2. How much more money are you willing to spend on a different color?
3. How much more money are you willing to spend to buy a reliable brand?

# Values and the Current Decision Context

## DECISION CONTEXT =

The setting in which a decision occurs

**Person Value's** = Collection of All Objectives

Decision Context **activates** only subset of objectives.

### Example: Travel comfortably from Point A to B

If decision context changes from solely **personal use** to also **business use** other objectives or alternatives may have to be activated.

- The type of car may need to be representative of the position you hold in the company (perhaps we need to consider the Lincoln Town Car with chauffeur in that case)
- Instead of buying a car we may want to lease a car for a three year term (better for tax write-off?)

# Boeing's Supercomputer

As a **large-scale manufacturer** of sophisticated aircraft, **Boeing** needs computing power for tasks ranging from accounting and word processing to computer-aided design, inventory control and tracking, and manufacturing support. When the company's engineering department needed to expand its computing capacity by purchasing **a supercomputer**, the managers faced a huge task of **assembling and evaluation** massive amounts of information. There were system requirements and legal issues to consider, as well as price and variety of management issues

Source: D. Barnhart (1993) "Decision Analysis Software Helps Boeing Select Supercomputer." *OR/MS Today*, 62-63

# Boeing's Supercomputer

## Super Computer Objectives

### Price

- Five-Year Costs
- Cost of Improved performance

### Performance

- Speed
- Throughput
- Memory Size
- Disk Size
- On-Site performance

### User Needs

- Installation Date
- Rollin/Roll out
- Ease of Use
- Software Compatibility
- Mean Time to Failure

### Operational Needs

- Square Footage
- Water Cooling
- Operator Tools
- Telecommunications
- Vendor Support

### Management Issues

- Vendor Health
- US Ownership
- Commitment to supercomputer

# Decisions to Make

Most decisions call for: **The Immediate Decision**

- Go, No Go
- Accept bet or not
- Invest amount of money – may vary in range of values

Look at all possible decision alternatives: **Be Creative!**

- Do nothing
- Wait for information and decide later on
- Execute Hedging

**Decision may be of a sequential nature:**

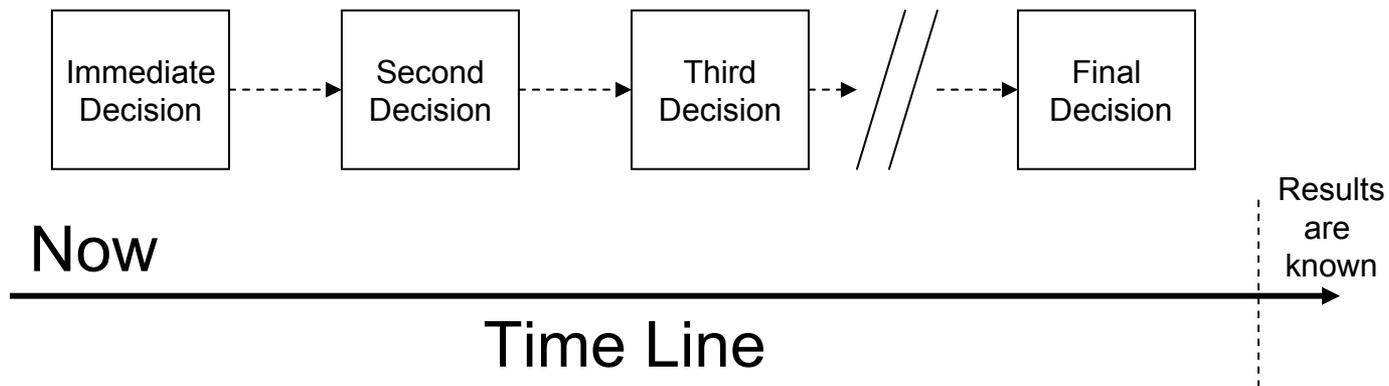
Future decisions may need to be taken into account when making immediate decision

# Decisions to Make

## Future decisions may depend on:

- Past Decisions
- Past Events
- Both

**List of possible decisions** is important, but more important is **the order** in which they occur.



**Consecutive decisions** can be the same, but may differ.

# Uncertain Events

**Many decisions (if not all) are made under the presence of uncertainty:**

- Investment decision: Will stock of company go up or not?
- Camping decision: Will the weather be good or not?
- Mutual fund decision: Will entire stock market go up?

**A decisions problem becomes more complicated when the number of relevant uncertain events increases.**

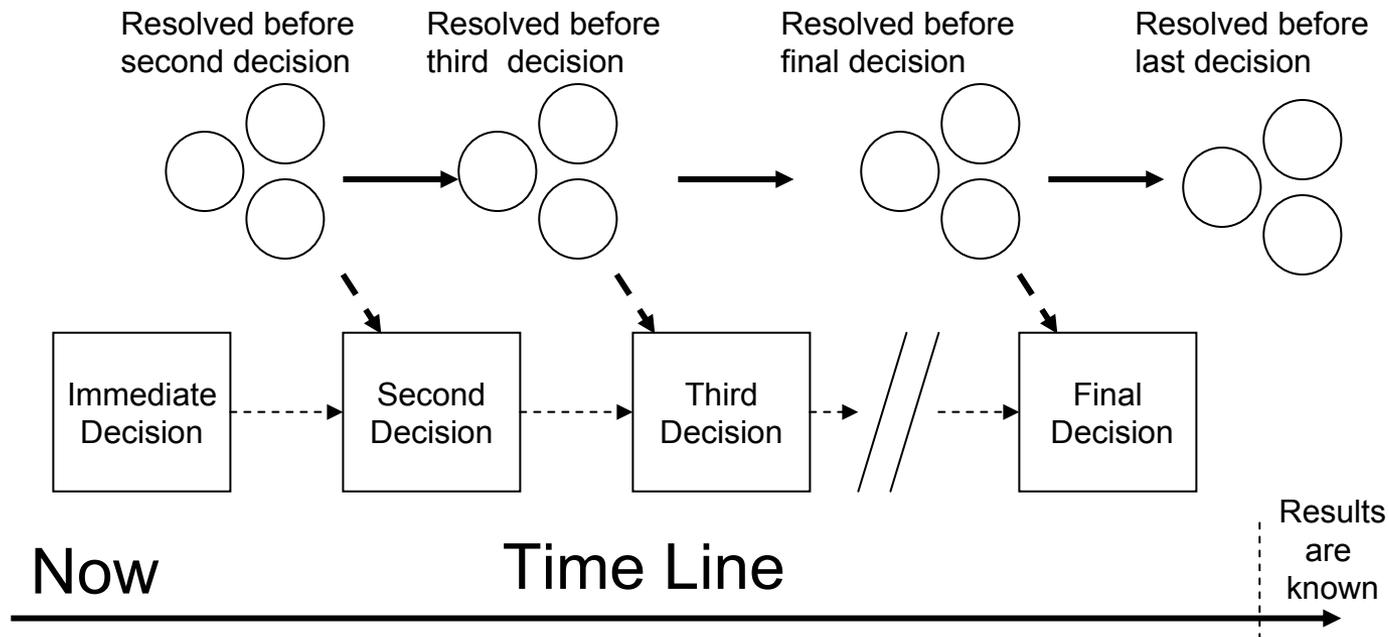
## **Nature of Uncertain Events:**

- Outcomes are measured in distinct classes (Discrete)
- Outcomes may fall in a range of values (Continuous)
- Interdependence between different uncertain events

# Uncertain Events

The time sequence of uncertain events related to the sequence of decision is important. Why?

- Tells you what information becomes known **before** a decision has to be made
- Uncertain events may be **unknown** at the time of the immediate decision, but may be **known** by subsequent decisions



Draft: Version 1

# Consequences

## Evaluation of Outcomes:

- Profit – Measured in # Dollars
- Casualties – Measured in # Deaths
- Environmental Damage – Measured in # Polluted Soil
- Health Risk – Measured in # Infected People

**Trade off between has to be made  
in almost any decision problem**

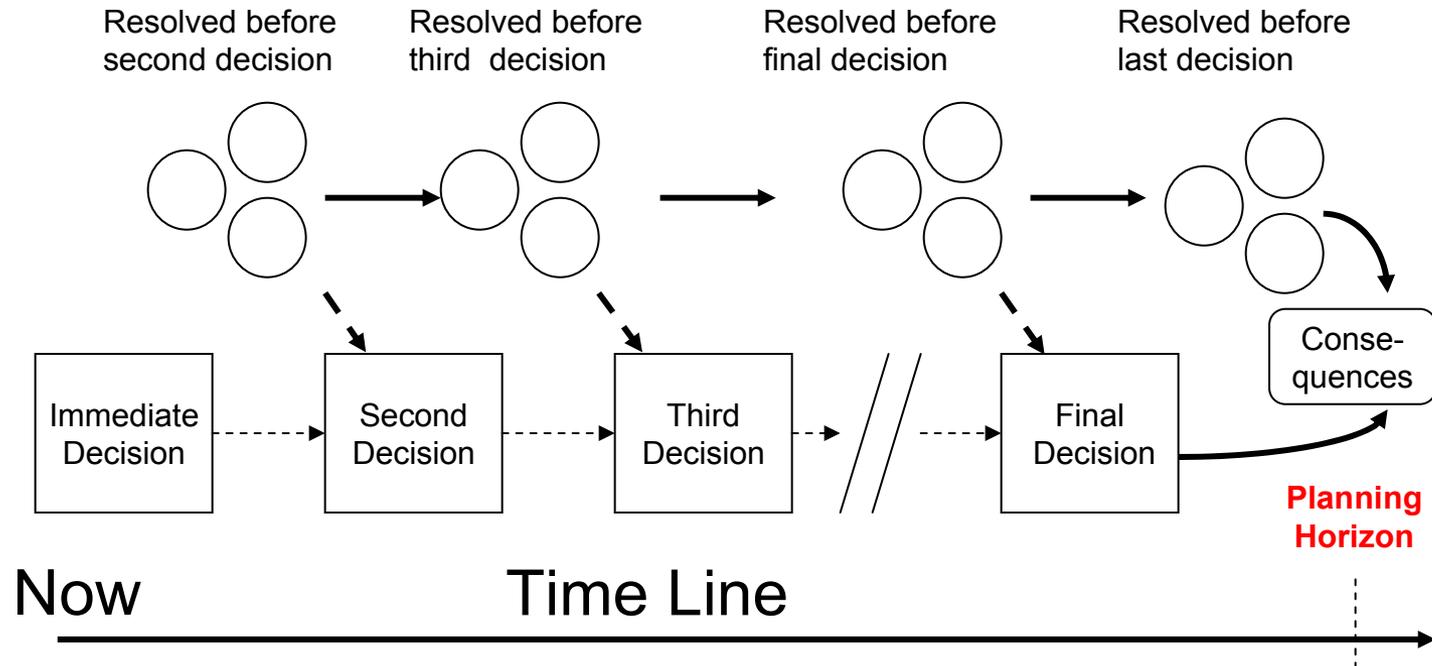
- Profit, Casualties, Environmental Damage, Health Risk – Single measure modeling trade-off needs to be developed: Measured in # Utils.

**This is the topic of multivariate attribute  
utility theory. Discussed in Chapters 13-16**

# Consequences

## Planning Horizon =

Time when decision maker finds out the results



## For requisite decision models:

Stop when future decisions and future uncertain events are not essential to **the immediate decision**.

# Time Value of Money: A Special Kind of Trade-off

\$100 @ 10% annual interest now = \$110 **one** year later

\$110 @ 10% annual interest now = \$121 **one** year later

or

\$100 @ 10% annual interest now = \$121 **two** years later

$PV(X)$  = **Present value** of dollar amount  $x$

$R\%$  = Interest during the period

$FV_n(X)$  = **Future value** after  $n$  periods

$$FV_n(X) = \left(1 + \frac{R}{100}\right)^n * PV(X)$$

# Time Value of Money: A Special Kind of Trade-off

## At immediate decision:

Future values must be converted to present values

$$PV(X) = \frac{FV_n(X)}{\left(1 + \frac{R}{100}\right)^n}$$

## Note difference between:

1. 10% Annual Interest Rate
2. 10% Annual Interest Rate compounded monthly

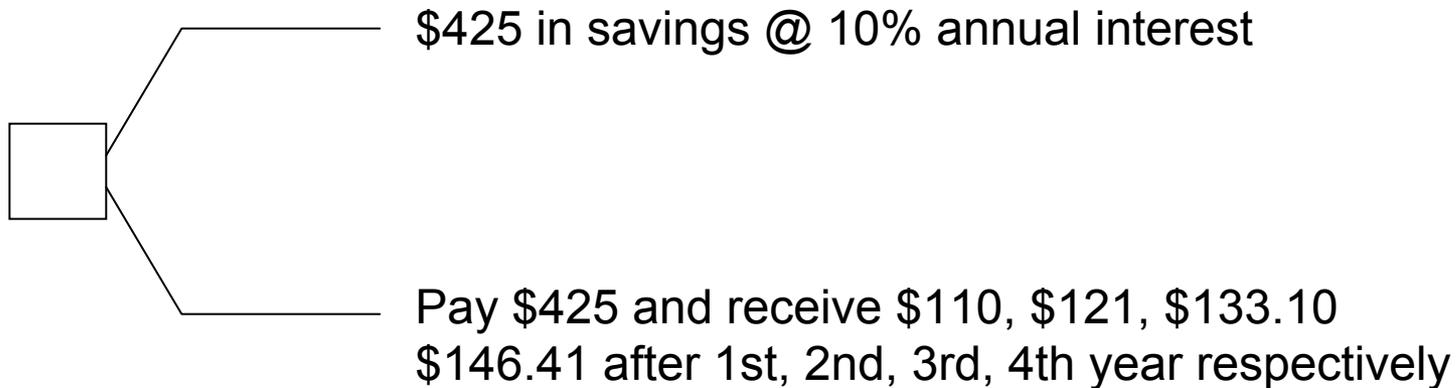
\$100 @10% Annual Interest = \$110 dollars after one year

\$100 @ 10/12% Monthly Interest over 12 periods =

$$\left(1 + \frac{10}{12 \times 100}\right)^{12} \times \$100 = \$110.47$$

# Time Value of Money: A Special Kind of Trade-off

## Stream of cash flows



**What is the preferred alternative?**

# Time Value of Money: A Special Kind of Trade-off

Year	Future Value	Present Value
1	\$110	\$110/1.1
2	\$121	\$121/(1.1) <sup>2</sup> = \$100
3	\$133.10	\$133.10/(1.1) <sup>2</sup> = \$100
4	\$146.41	\$146.41/(1.1) <sup>2</sup> = \$100
<b>Total</b>	<b>\$510.41</b>	<b>\$400</b>

$X_k$  = Cost/revenue at **the end of period k**

$$NPV(X_0, X_1, \dots, X_n) = \sum_{k=0}^n \frac{X_k}{\left(1 + \frac{R}{100}\right)^k}$$

$R\%$  = Same interest rate over **all n periods**

# Time Value of Money: A Special Kind of Trade-off

## Note:

$X_k = \text{negative} \Leftrightarrow X_k$  is cost       $X_k = \text{positive} \Leftrightarrow X_k$  is revenue

## What if the interest rate changes per period?

$R_k \%$  = Interest Rate **during period k**

$$NPV(X_0, X_1, \dots, X_n) = \sum_{k=0}^n \frac{X_k}{\prod_{j=0}^k \left(1 + \frac{R_j}{100}\right)^j}$$