Making Hard Decisions

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Chapter 3

Structuring Decisions

Draft: Version 1

Introduction

Suppose elements of Decision Problem (DP) are available, i.e.:

- **Objectives that apply to the decision context**
- **Immediate decision and subsequent decision(s)**
- **Alternatives for each decision**
- **Uncertain elements (events)**
- **You know how to evaluate consequences**

How does one proceed structuring the DP?

STEP 1: Filter & Operationalize the Objectives

- Classify objectives as means or fundamental objectives
- Classify how to measure fundamental objectives

Introduction

STEP 2: Structure the elements in a logical framework

- Structure Logic and time sequence between decisions
- Structure Logic (dependence) between the uncertain events
- Structure time sequence of uncertain events related to the sequence of decisions
- Represent Logic by using **Influence Diagrams** or **Decision Trees**

STEP 3: Fill in the Details, e.g.;

- Give precise (unambiguous) definitions of decisions & uncertain events
- Specify probability distributions for the uncertain events through a combination of data analysis & expert judgment.
- Specify precisely (unambiguous) how consequences are measured and formalize trade off between objectives.

Introduction

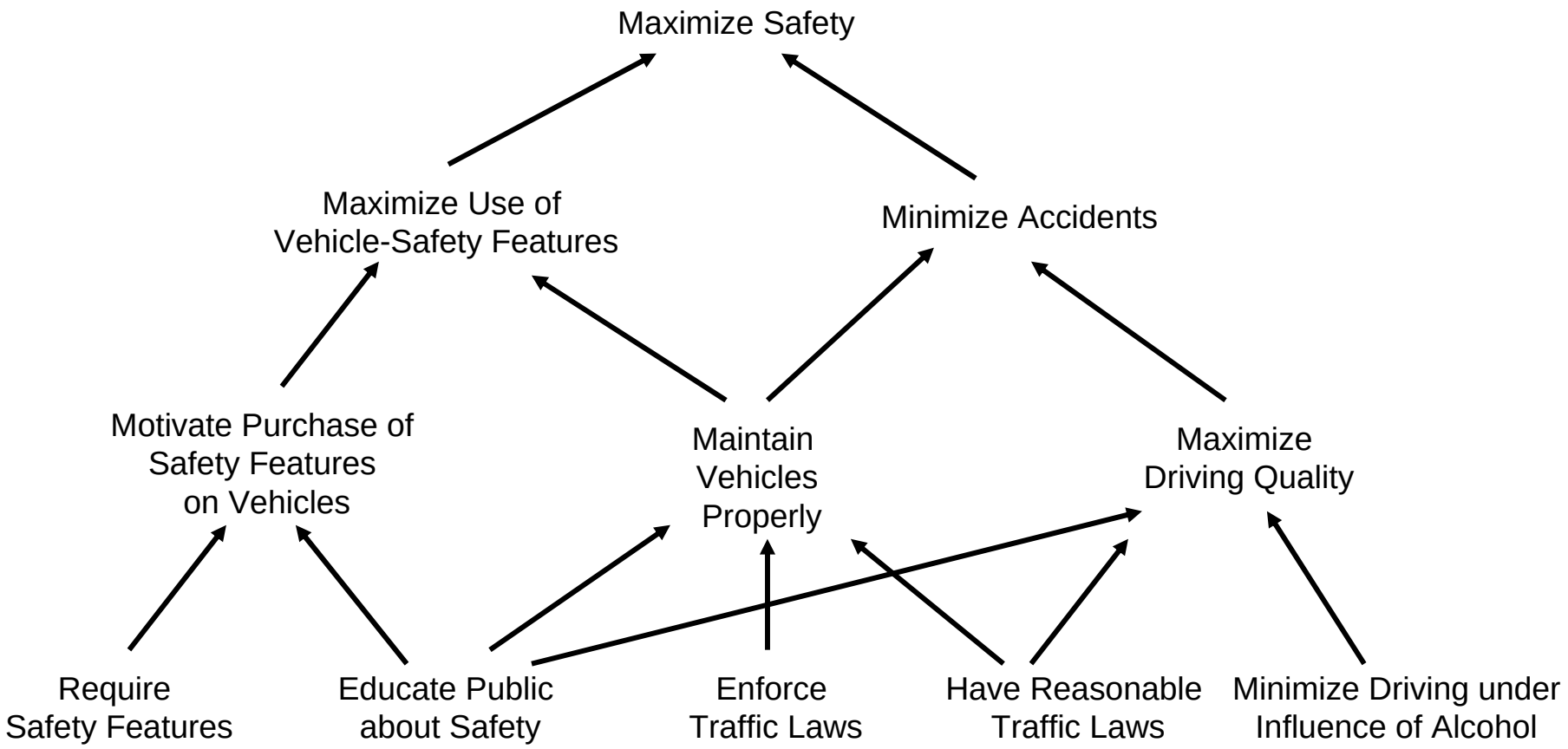
Comment with Respect to STEP 1:
Identifying objectives is Creative Process

1. **Develop a wish list.** What do you want? What should you want?
2. **Identify alternatives.** What is the perfect alternative, a terrible alternative, some reasonable alternatives, what is good or bad about each?
3. **Consider problems and shortcomings.** What is wrong or right with your organization? What needs fixing?
4. **Predict consequences.** What has occurred that was good or bad? What might occur that you care about?
5. **Identify goals, constraints, and guidelines.** What are your aspirations? What limitations are placed on you?
6. **Consider different perspectives.** What would your competitor or constituency be concerned about? At some time in the future, what would concern you?
7. **Determine strategic objectives.** What are your ultimate objectives? What are your values that are absolutely fundamental?
8. **Determine generic objectives.** What objectives do you have for your customers, your employees, your shareholders, yourself? What environmental, social, economic, or health and safety objectives are important?

Source: Keeny, R.L. (1994) " Creativity in Decision Making with Value-Focused Thinking," Sloan Management Review, Sumer, 33-41

STEP 1: Filter & Operationalize Objectives

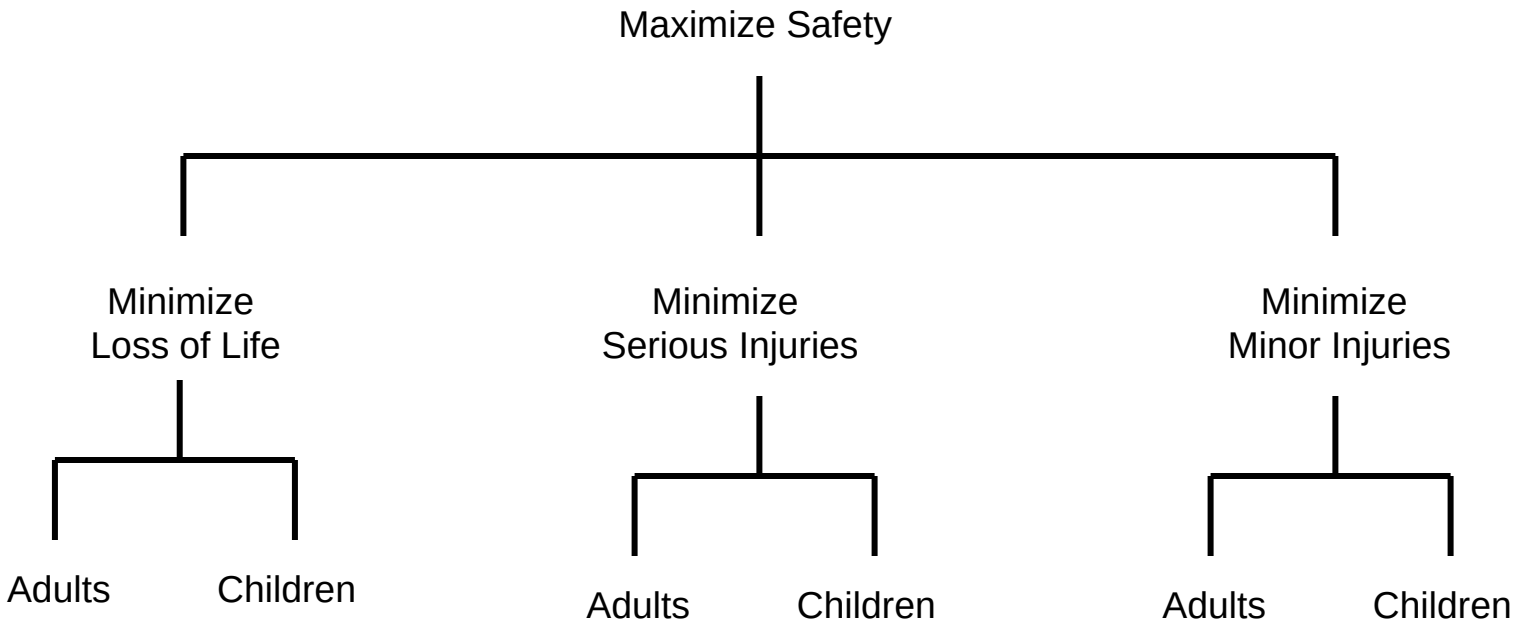
Classify objectives as means or fundamental objectives



Example of **Means Objective Network**

STEP 1: Filter & Operationalize Objectives

Classify objectives as means or fundamental objectives



Example of **Fundamental Objective Hierarchy**

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STEP 1: Filter & Operationalize Objectives

Questions to aid in classifying objectives

	Fundamental Objectives	Means Objectives
To Move:	*Downward in Hierarchy:*	*Away from Fundamental Objectives:*
Ask:	"What do you mean by that?"	"How could you achieve this"
To Move:	*Upward in Hierarchy:*	*Toward Fundamental Objectives:*
Ask:	"Of what more general objective is this an aspect?"	"Why is that important?"

Decision Problems are evaluated using only the **Fundamental Objective Hierarchy**

STEP 1: Filter & Operationalize Objectives

Getting the decision context right:

- Enlarging Decision Context may increase the number of objectives and alternatives that are relevant.

- Decreasing the Decision Context may cause current relevant objectives or alternatives to become irrelevant.

Think of Example: Travel from A to B Comfortably

Three questions need to be answered affirmatively:

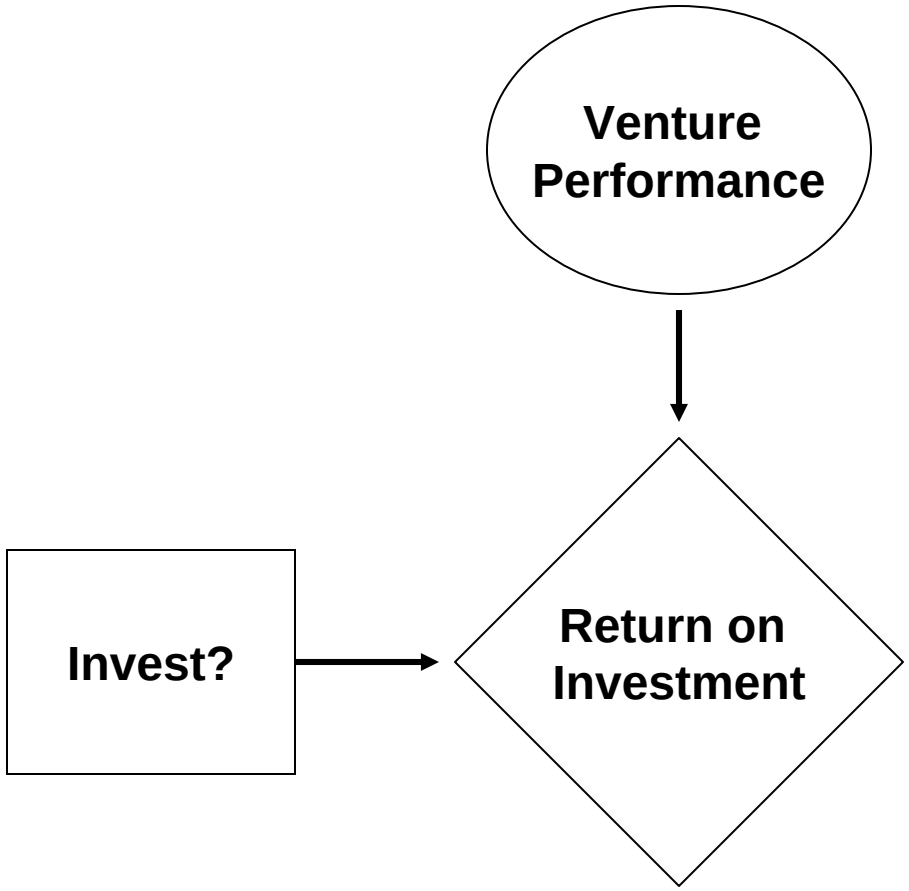
- Are you addressing the right problem?

- Can you make the decision? (Decision Ownership)

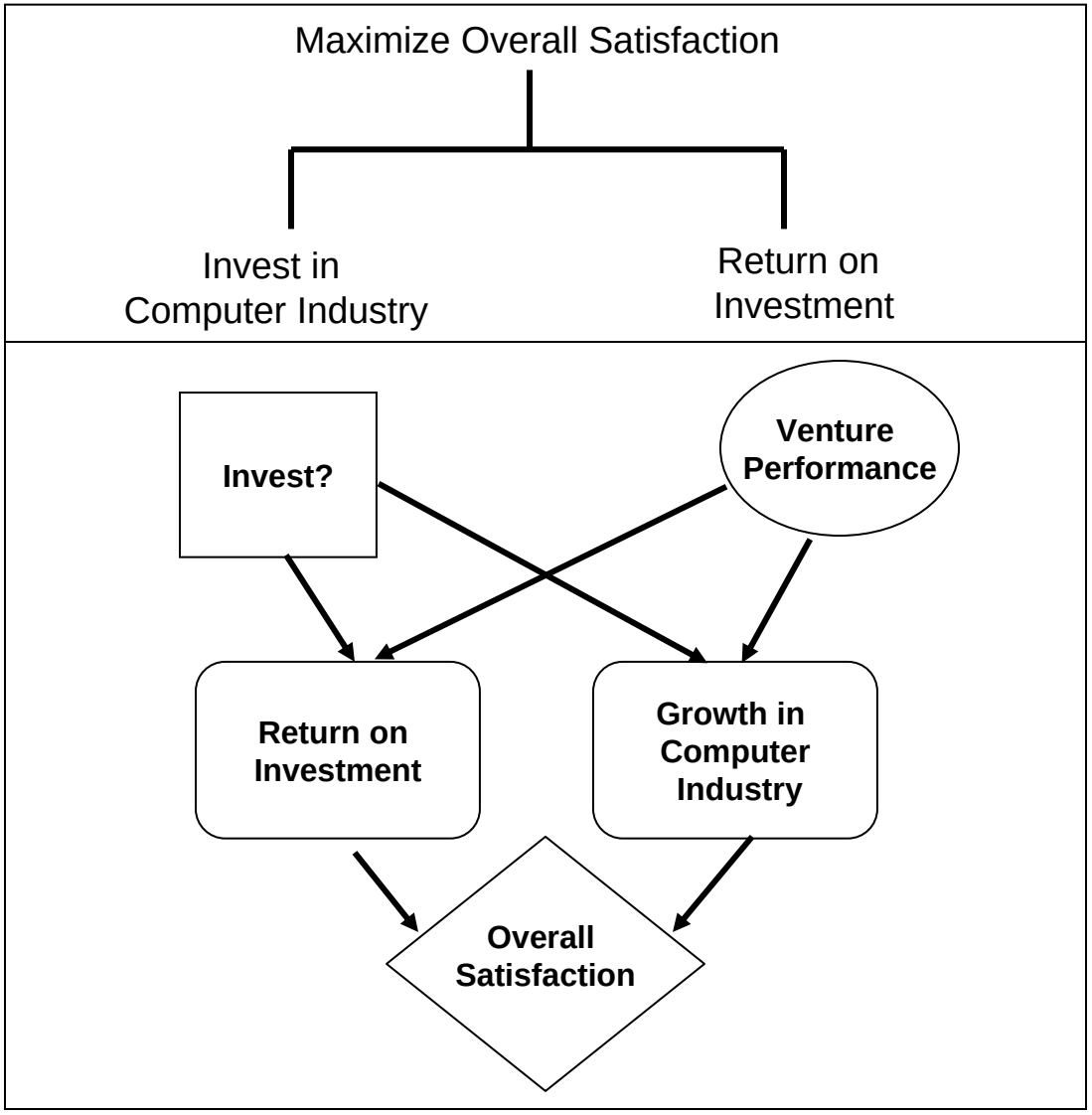
- Do you have the resources (Time & Money) to analyze the DP in the current decision context?

Step 2: Structure Elements in a Logical Framework

Investment example:



Step 2: Structure Elements in a Logical Framework



Fundamental Objective Hierarchy

Influence Diagram

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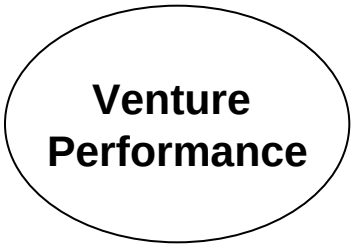
Step 2: Structure Elements in a Logical Framework

Influence Diagrams

1. Elements are represented by:

Decision Nodes:

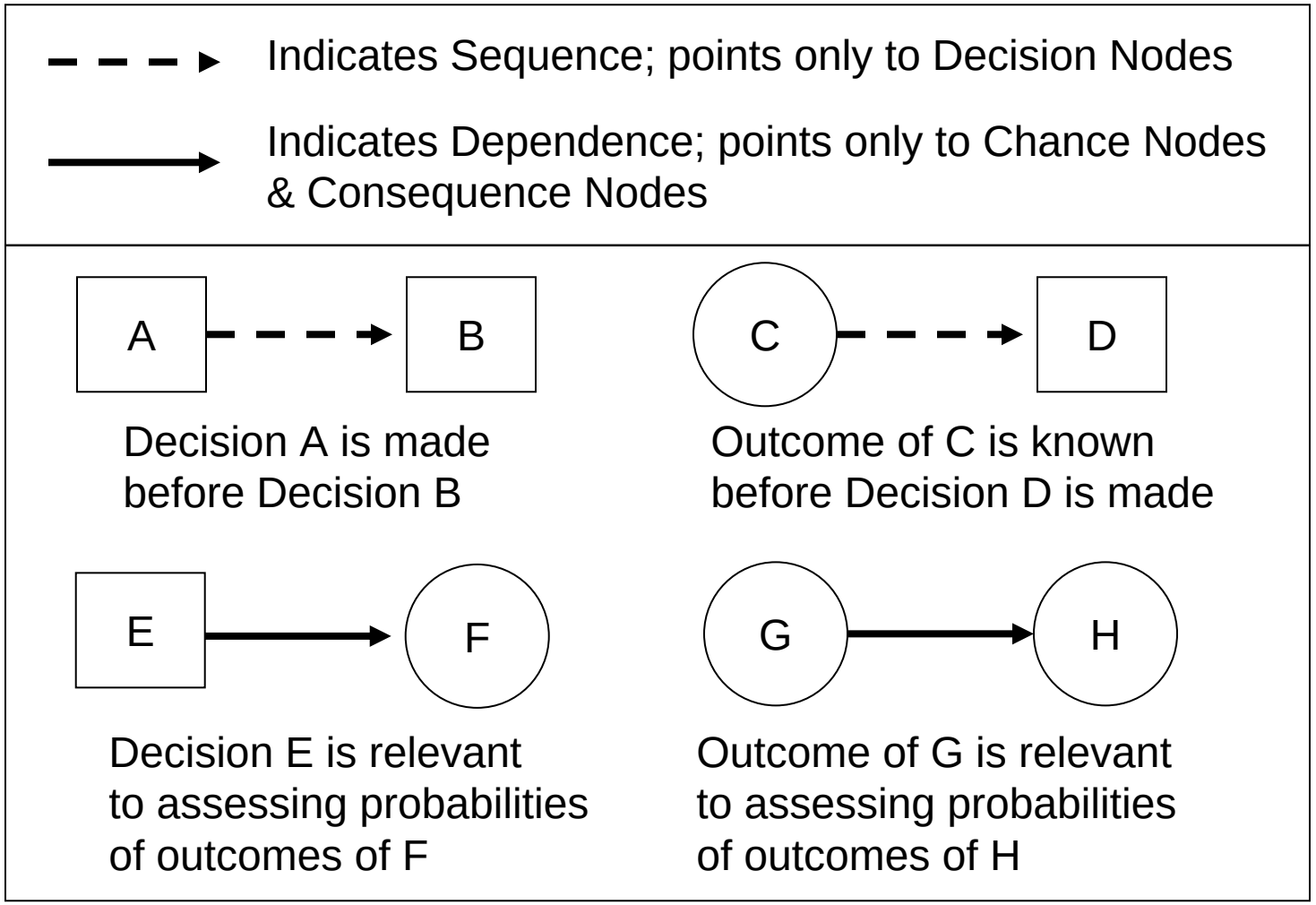
Chance Nodes:



Consequence Nodes:

Step 2: Structure Elements in a Logical Framework

2. Logical relationships are represented by arrows:



Step 2: Structure Elements in a Logical Framework

- It is important to note here that we deviate from the convention in the book that does not distinguish between sequence arcs and influence arcs.
- This distinction is made here only for teaching purposes. Once one is comfortable with the differences between these arcs and their interpretations one could use solid arcs throughout the influence diagram

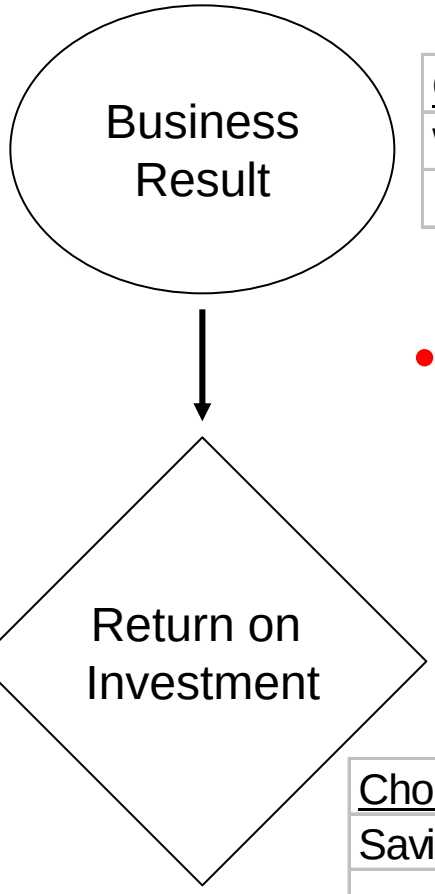
Comments on Influence Diagrams:

- Influence diagram captures current state of knowledge
- An influence diagram should NEVER contain cycles
- Interpreting an influence diagram is generally easy
- Creating influence diagrams is difficult

Step 2: Basic Influence Diagrams

Basic Risky Decision

- One should be able to identify basic influence diagrams and modify/combine them to match specific problems



Outcomes
Wild Success
Flop

- Involves **one decision** and **one uncertain event**

Alternatives
Savings
Business

Choice	Business Result	Return
Savings	Wild Success	2200
	Flop	2200
Business	Wild Success	5000
	Flop	0

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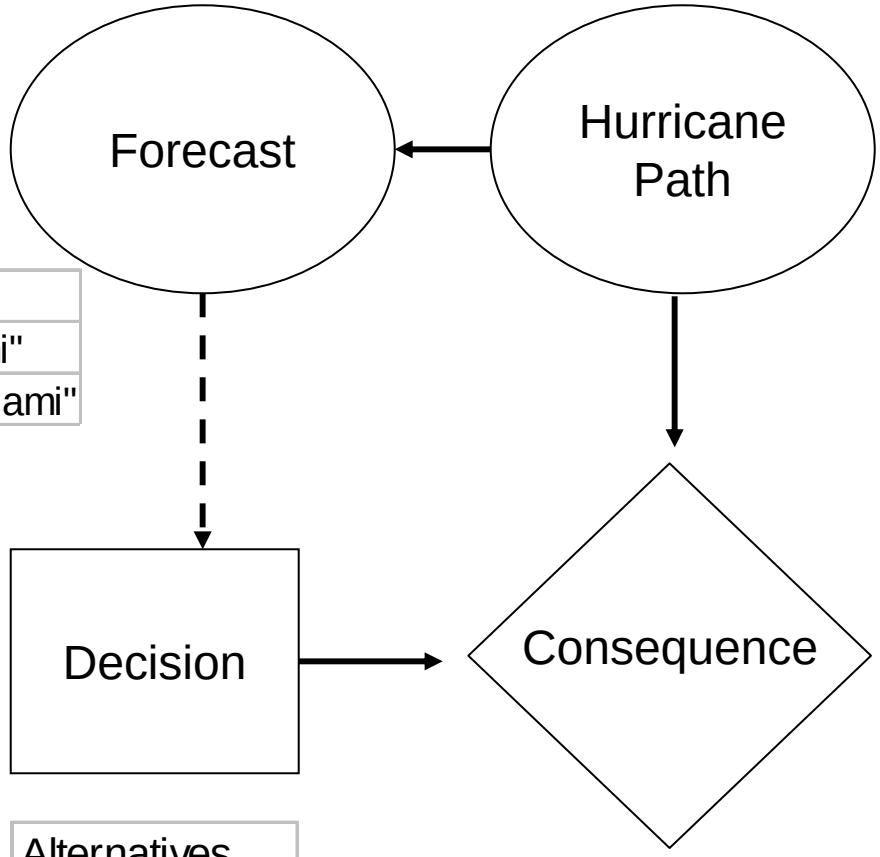
Step 2: Basic Influence Diagrams



Outcomes
Hits Miami
Misses Miami

Forecast
"Hits Miami"
"Misses Miami"

Alternatives
Evacuate
Stay

Imperfect Information:

- Involves one decision and two uncertain events **at the time of the Decision Analysis**.
- One uncertain event is known **at the time that the immediate decision is made.**
- Solving the influence diagram results in **one** optimal decision for **each** possible outcome of the information source.

		Consequence	
Choice	Outcome	Risk	Cost
Evacuate	Hits Miami	Low Risk	High Cost
	Misses Miami	Low Risk	High Cost
Stay	Hits Miami	High Risk	Low Cost
	Misses Miami	Low Risk	Low Cost

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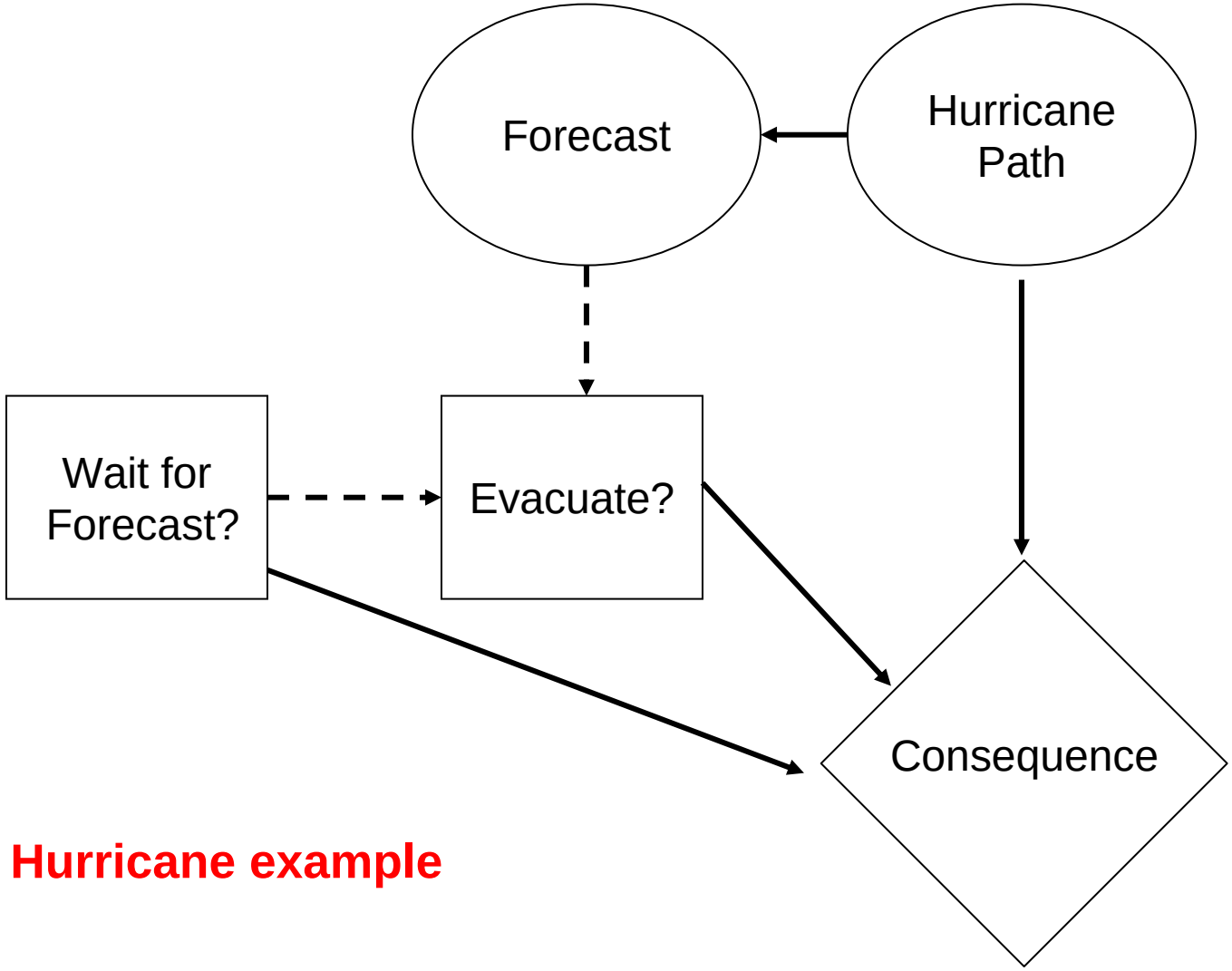
Step 2: Basic Influence Diagrams

Sequential Decisions:



Hurricane example

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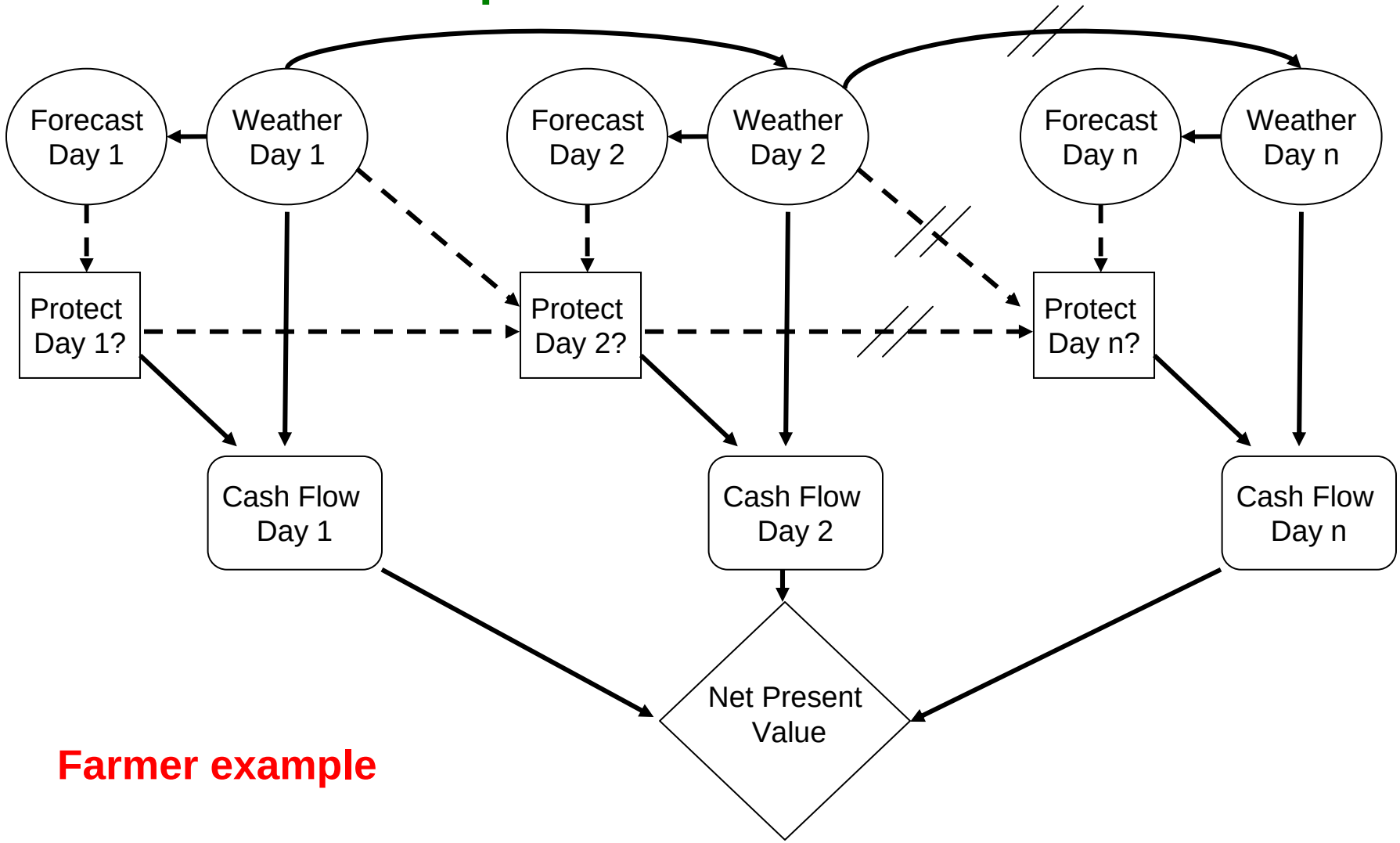
Step 2: Basic Influence Diagrams

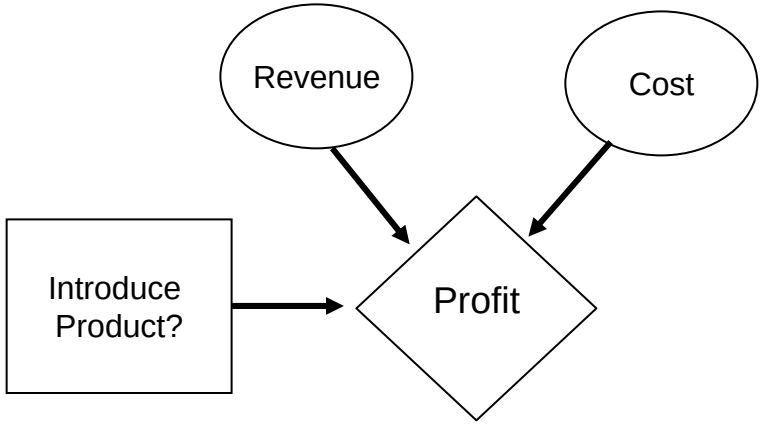
Sequential Decisions:



Farmer example

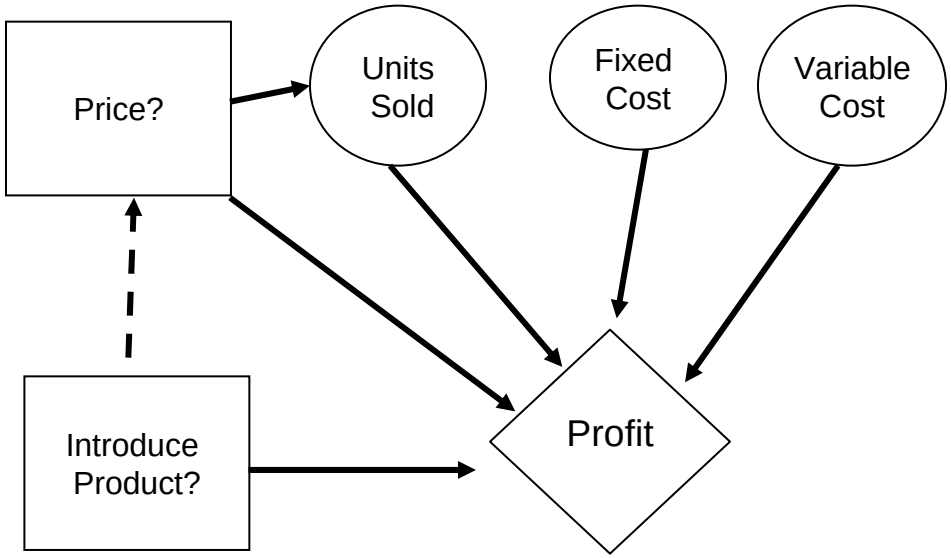
Step 2: Basic Influence Diagrams

Intermediate calculations for additional clarity:



Version 1

Version 2



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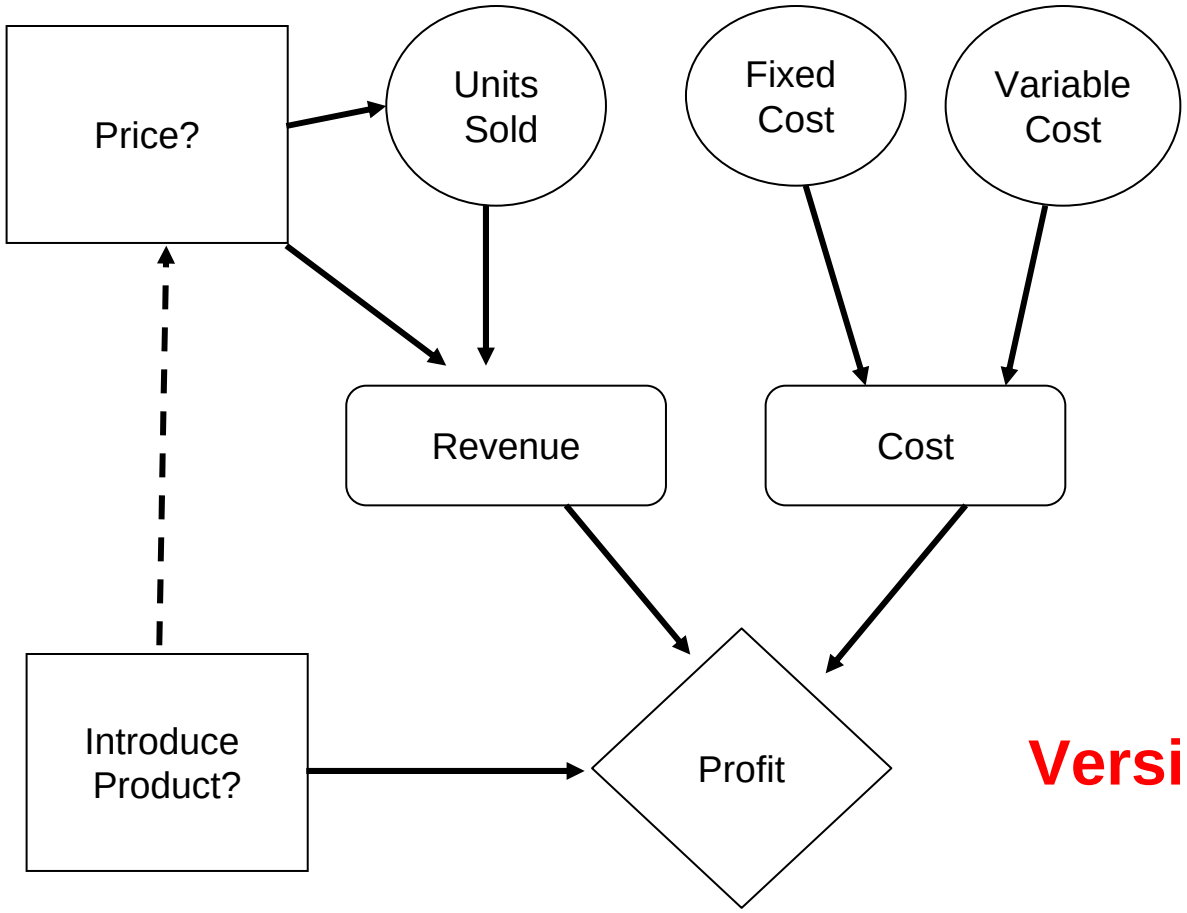
Step 2: Basic Influence Diagrams

Intermediate calculations for additional clarity:



Version 3

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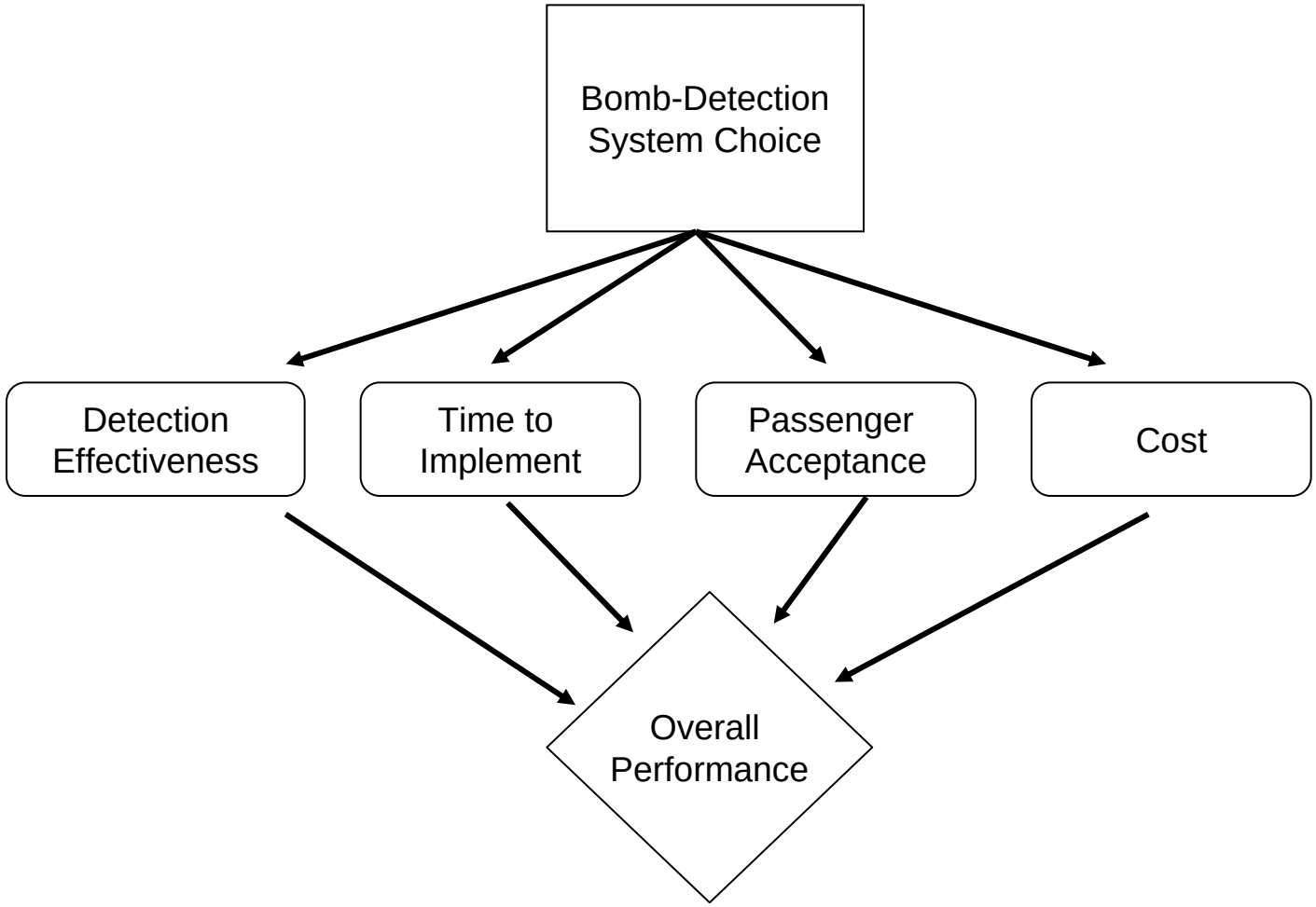
Step 2: Basic Influence Diagrams

Intermediate calculations reflecting Fundamental Objective Hierarchy:



Step 2: Building an Influence Diagrams

1. List all the decisions.
2. Draw **sequence arcs** between decisions. - - - - →
3. Identify the consequence node.
4. Breakdown the consequence node using the FOH.
5. Draw **relevance arcs** from decision nodes to the ⟶ intermediate calculation nodes.
6. List all the uncertainty nodes.
7. Draw the **relevance arcs** between uncertainty nodes. ⟶
8. Draw the **sequence arcs** from uncertainty nodes to the decision nodes. - - - - →
9. Draw the **relevance arcs** from the decision nodes to the uncertainty nodes. ⟶
10. Draw the **relevance arcs** from the uncertainty nodes to the intermediate calculation nodes. ⟶

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Step 2: Building an Influence Diagram

All details (outcomes, choices, payoff) should be developed in a tabular format for each node in the influence diagram.

Common Mistakes:

- See influence diagrams as **flow charts**.
- Many chance nodes going into the **immediate decision** node to reflect uncertainty.
- The inclusion of **cycles**.

Building an Influence Diagram: Example

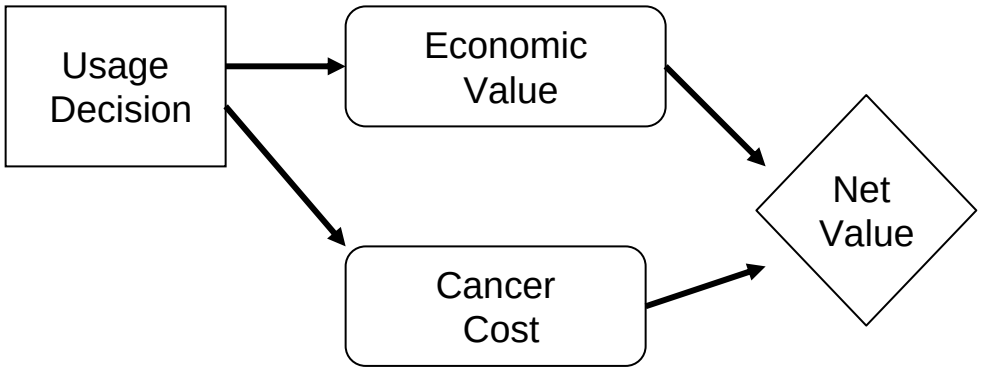
Toxic Chemicals and the EPA

The Environmental Protection Agency often must decide **whether to permit the use** of an economically beneficial chemical that may be carcinogenic (cancer-causing). Furthermore, the decision often must be made **without perfect information** about either **the long-term benefits** or **health hazards.** Alternative courses of action are to permit the use of the chemical, restrict its use, or to ban it al together. **Tests can be run** to learn something about the **carcinogenic potential**, and **survey data** can give an indication of the extent to which people are exposed when they do use the chemical. These pieces of information are both important in making the decision. For example, if the chemical is only mildly toxic and the exposure rate is minimal, then restricted use may be reasonable. On the other hand, if the chemical is only mildly toxic but the exposure rate is high, then banning its use may be imperative.

Building an Influence Diagram: Example

Toxic Chemicals and the EPA

STEPS 1 - 5



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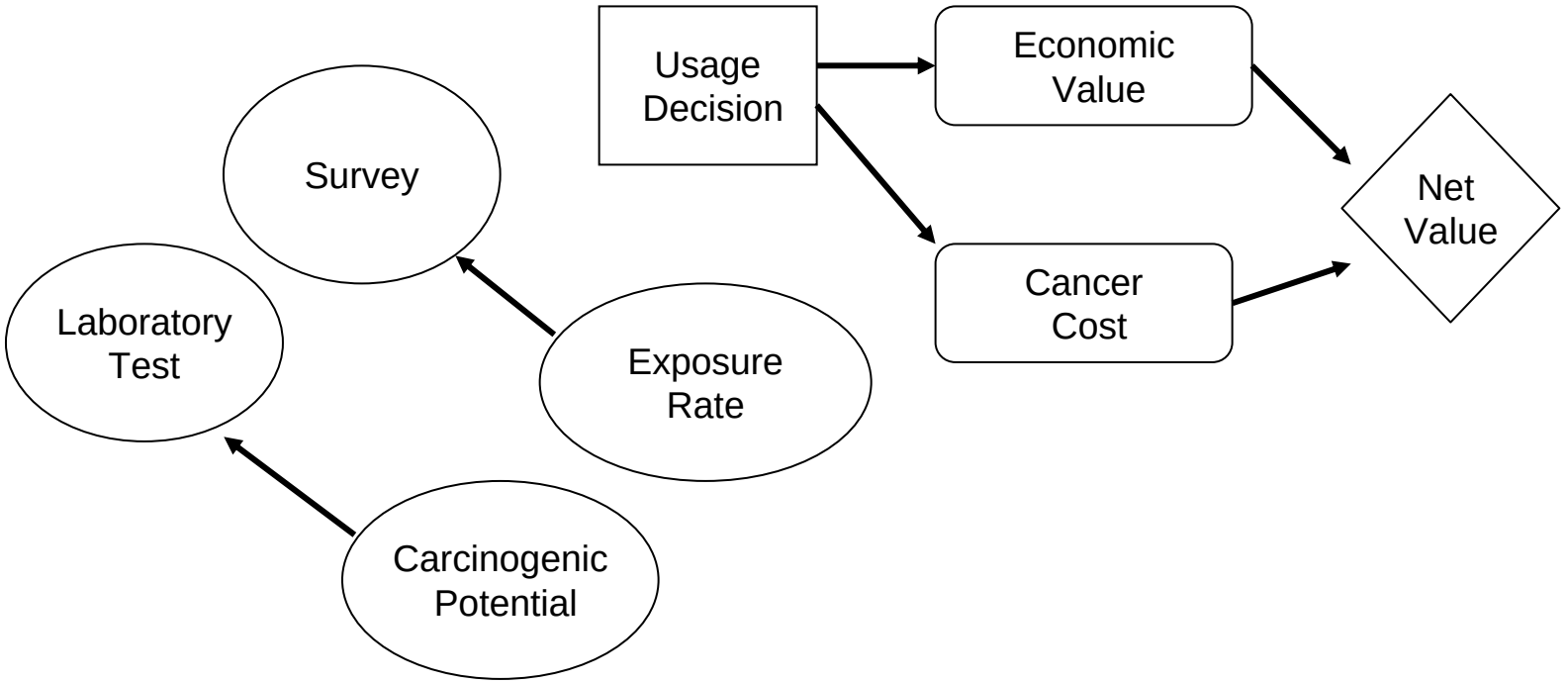
Building an Influence Diagram: Example

Toxic Chemicals and the EPA

STEPS 6 - 7



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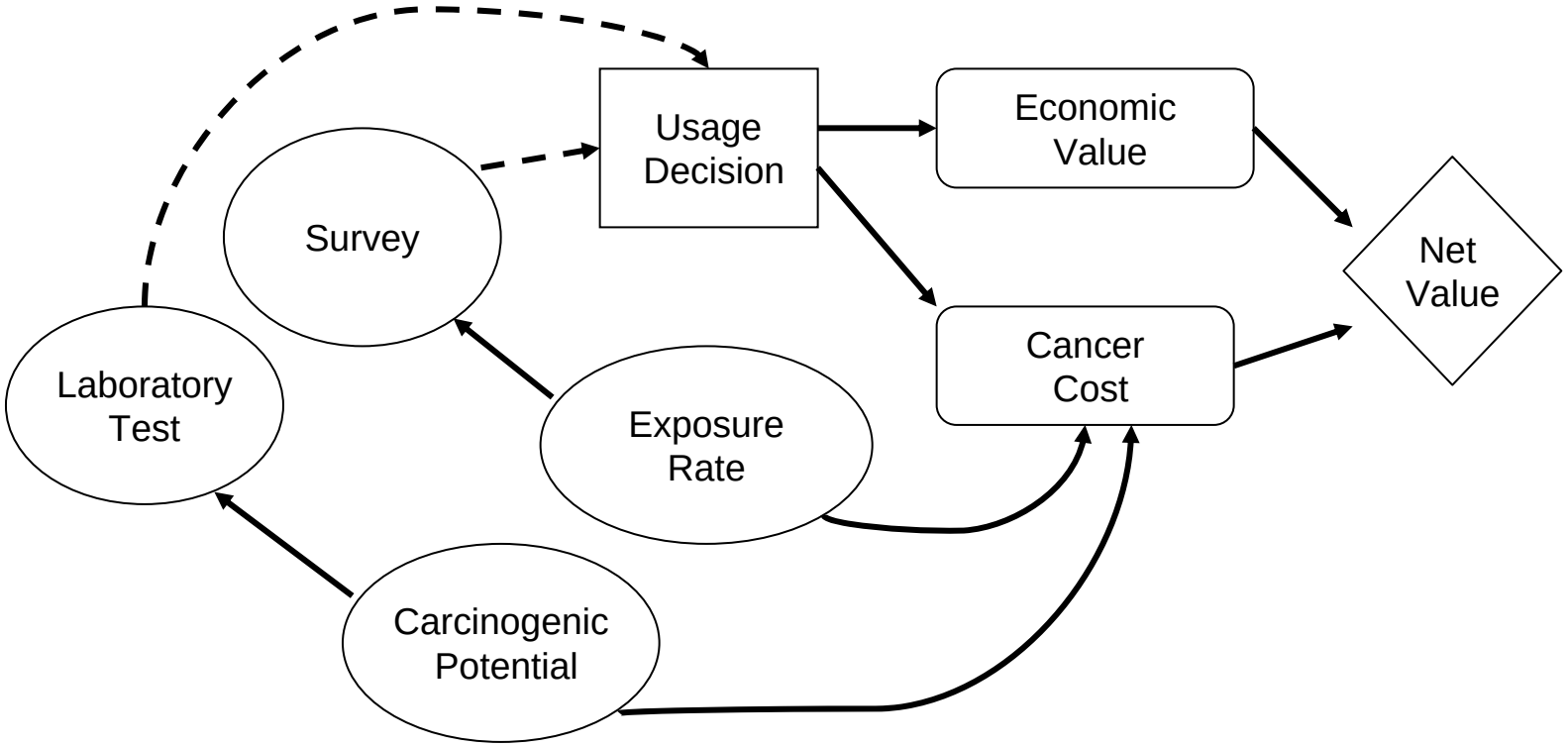
Building an Influence Diagram: Example

Toxic Chemicals and the EPA

STEPS 9 - 10



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Building an Influence Diagram: Example

Test Analyze and Fix (TAAF)

We are deciding on **whether or not to release** a new product. The product reliability, that is, the probability that the product functions satisfactorily, is a main driver in **profits** that may be derived from the product. We may decide to **release the product immediately** based on our best current assessment of the product reliability **or test the product**. A test consists of selecting a single product and seeing if it performs its required task. If it does not, the product is **redesigned** using the test results and a fixed cost for redesign is incurred. This redesign **may or may not improve** the product reliability. After the redesign we may decide to **release the redesigned product** or test the redesigned product. If the redesigned product does not perform its task, the redesigned product will be redesigned using the latest test results, etc. This **cycle** continues until the time has come that the **final decision** to release or not to release has to be made. The testing and re-design takes **one week** (regardless of the outcome of the test) and we have **two weeks** to make the **final decision**. Assume that the product reliability and the cost of testing affect the profits.

Building an Influence Diagram: Example

Test Analyze and Fix (TAAF)

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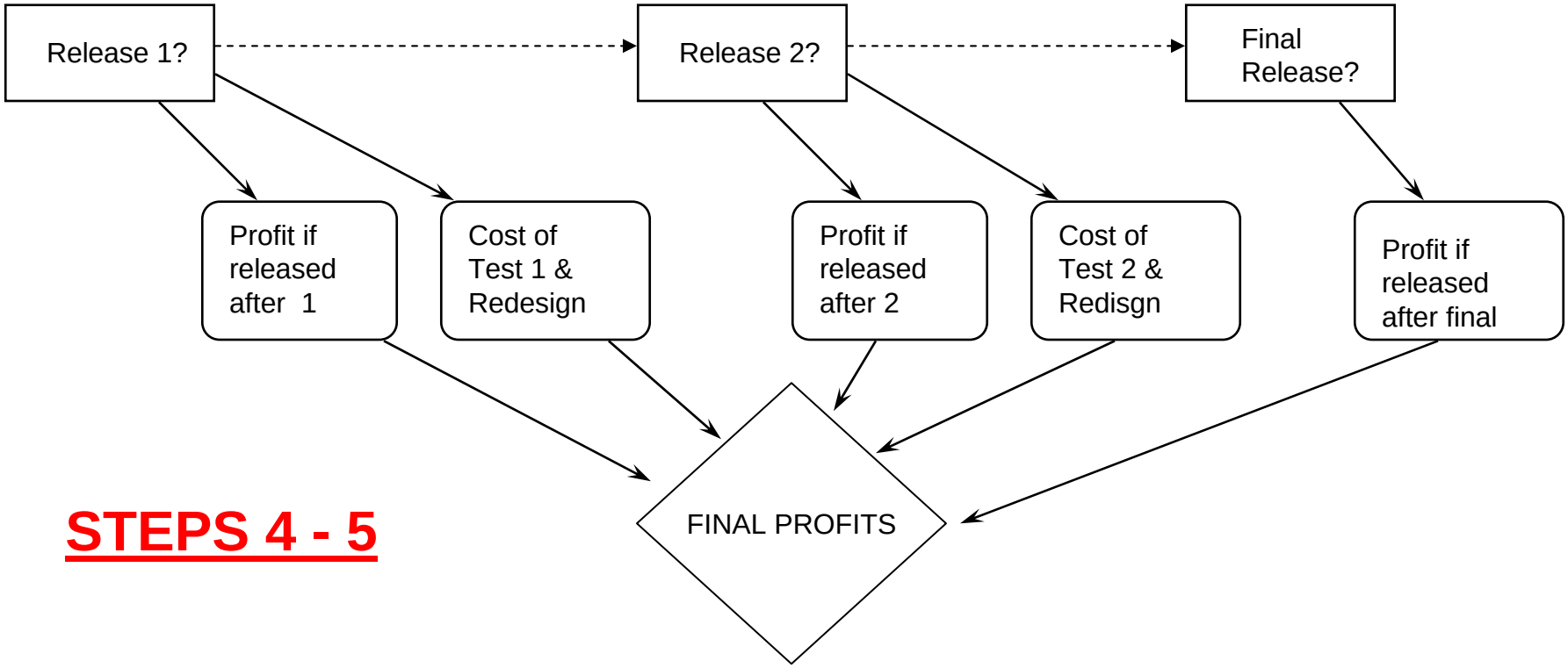
STEPS 1 - 3

Building an Influence Diagram: Example

Test Analyze and Fix (TAAF)



STEPS 4 - 5

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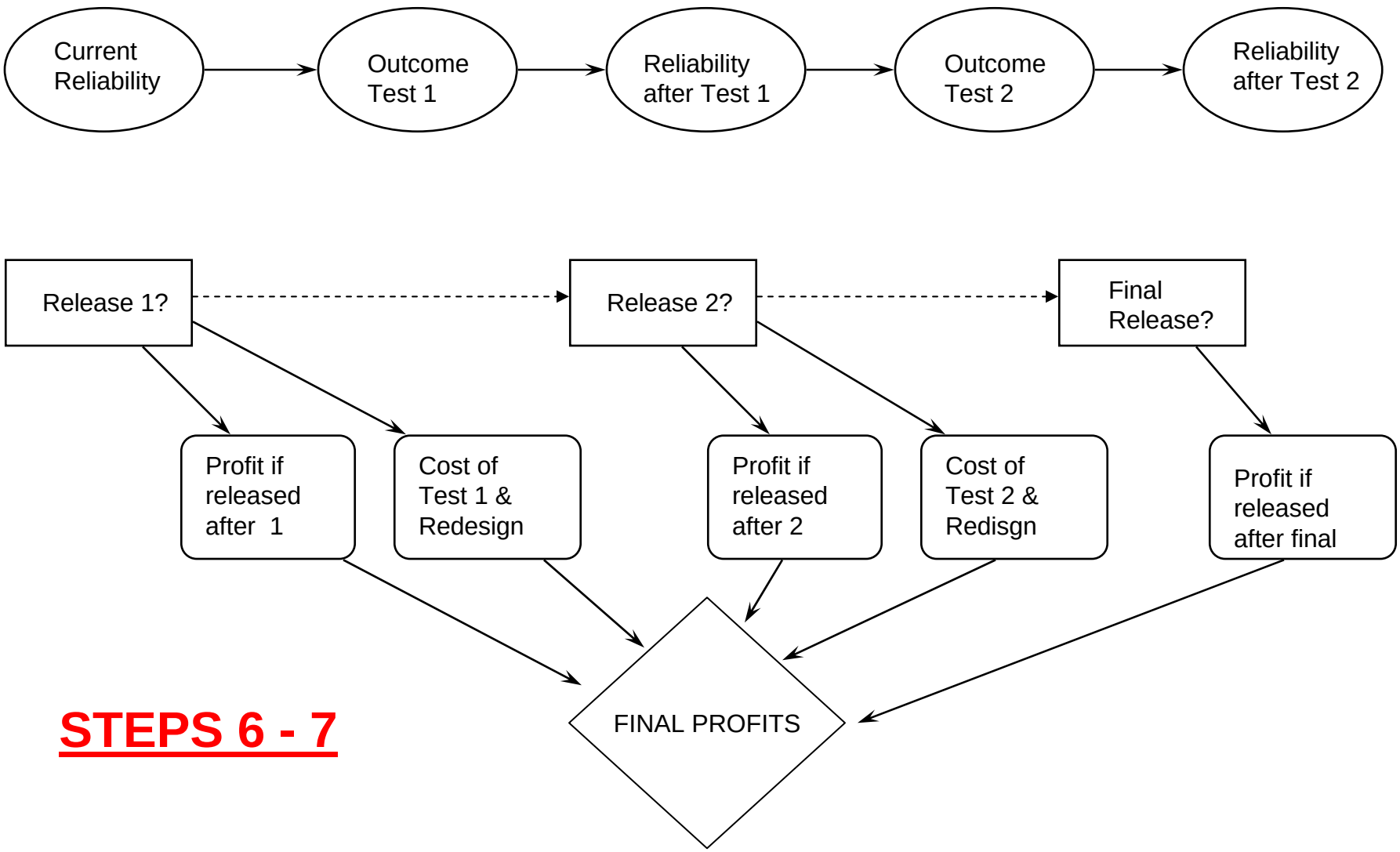
Building an Influence Diagram: Example

Test Analyze and Fix (TAAF)



STEPS 6 - 7

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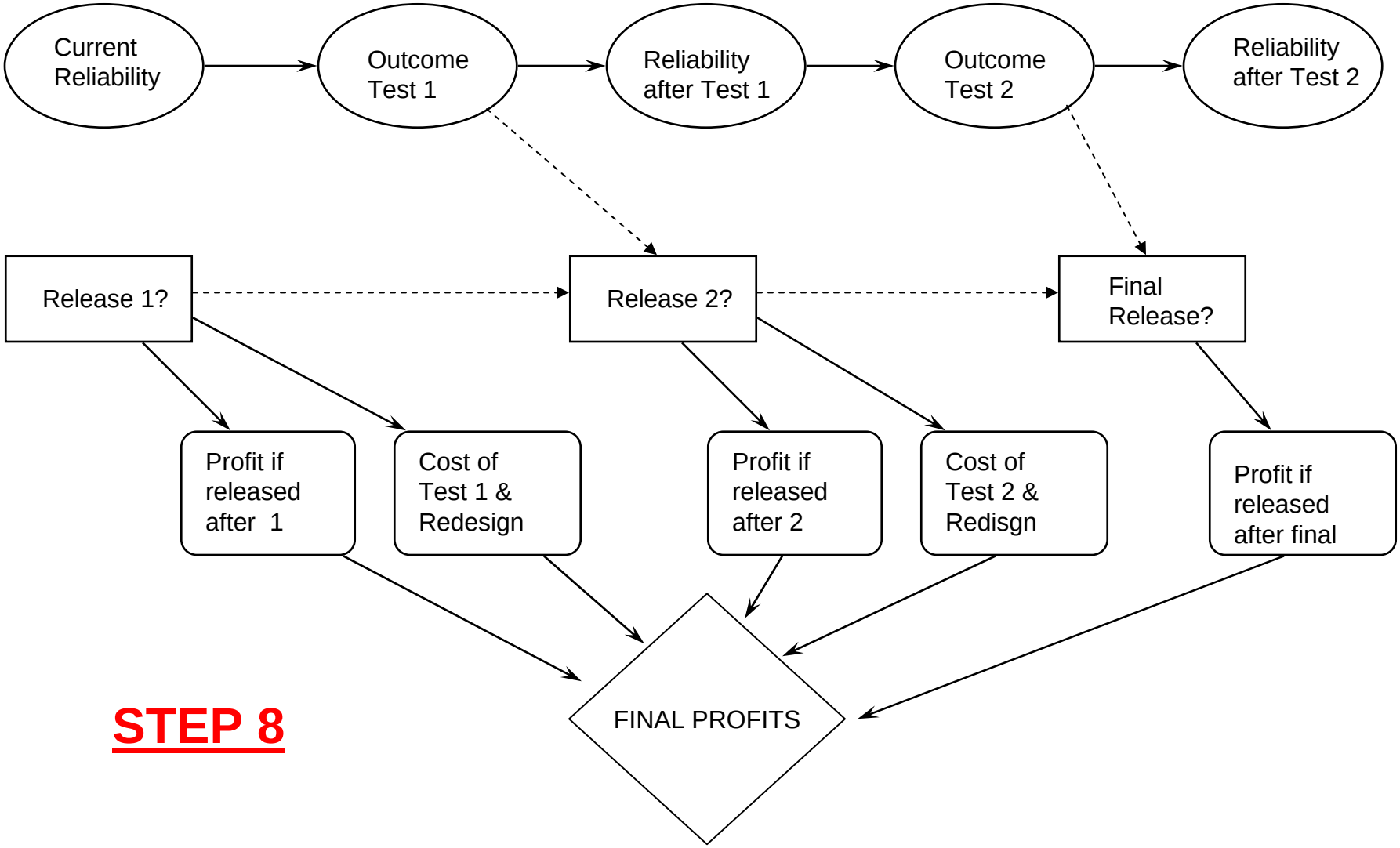
Building an Influence Diagram: Example

Test Analyze and Fix (TAAF)



STEP 8

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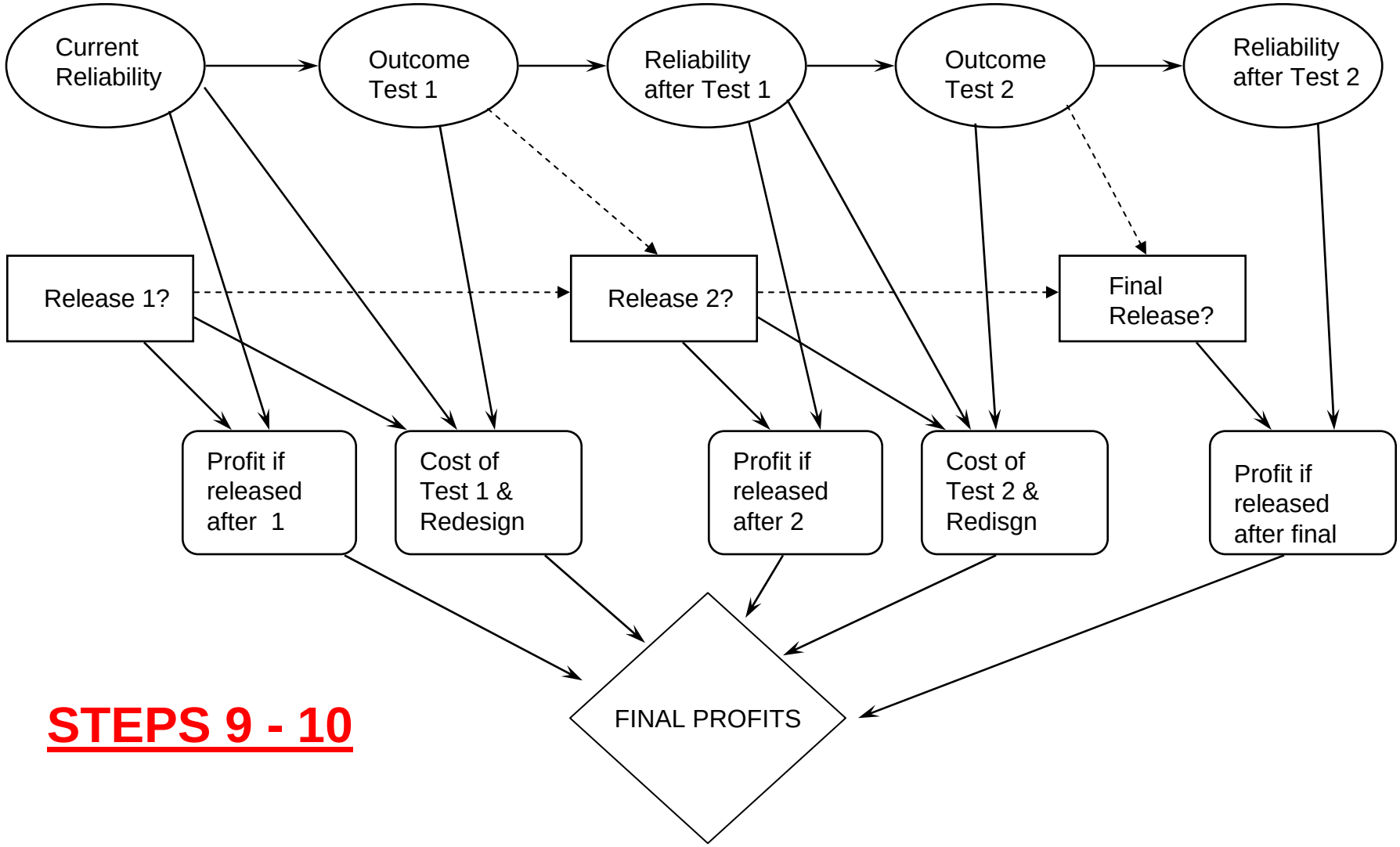
Building an Influence Diagram: Example

Test Analyze and Fix (TAAF)



STEPS 9 - 10

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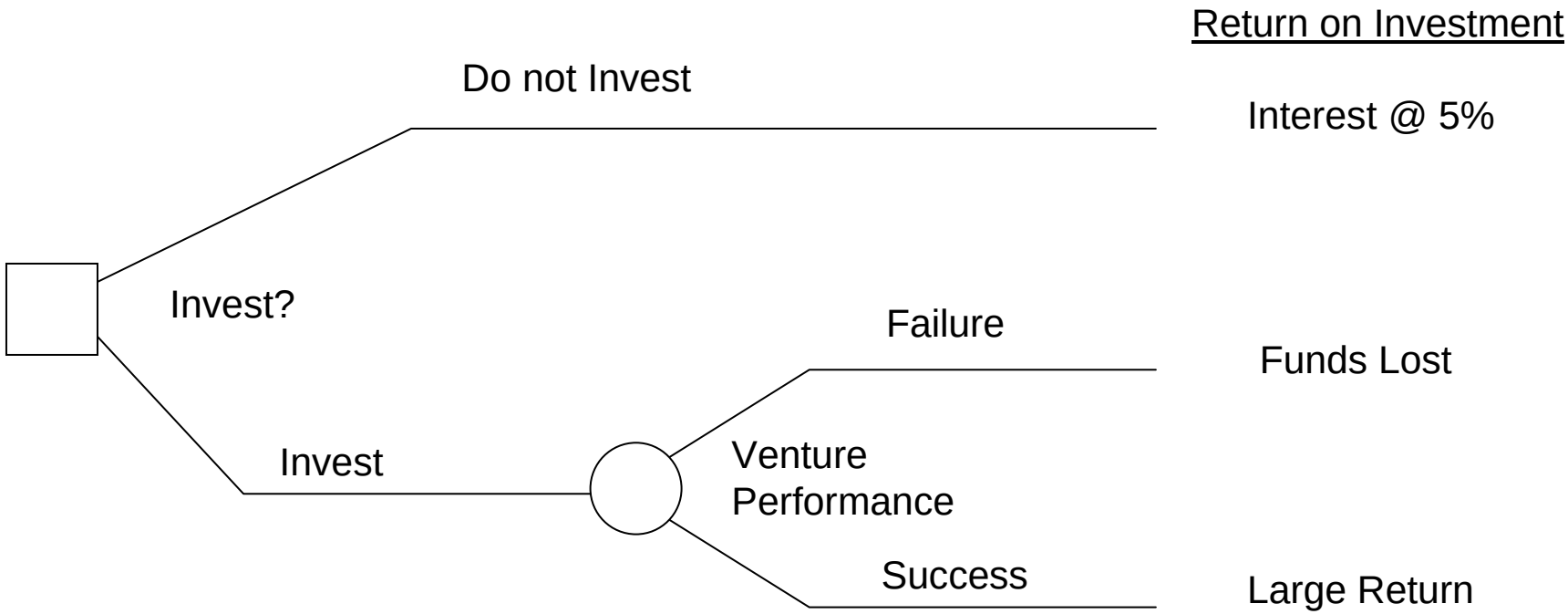
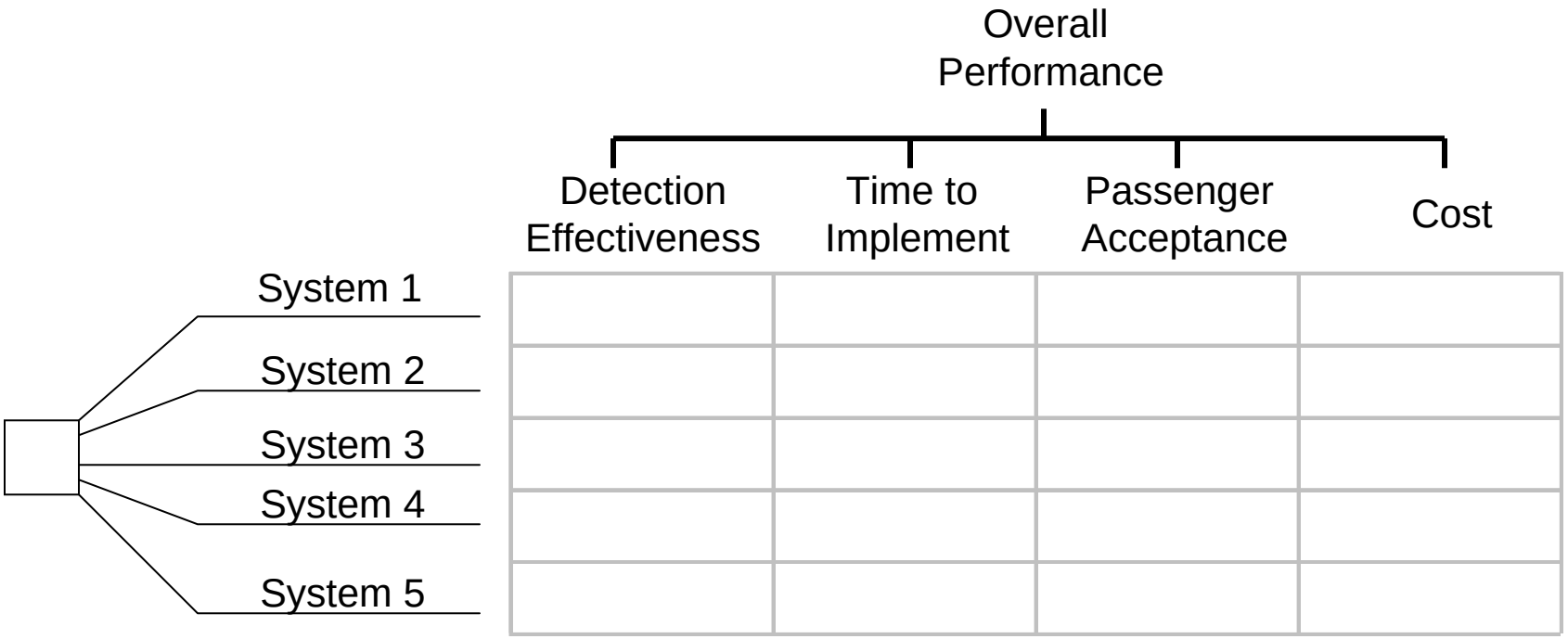
Step 2: Structure Elements in a Logical Framework

Investment example:



Step 2: Structure Elements in a Logical Framework

Decision trees and fundamentals-objective hierarchy:



Decision Trees reveal more detail than Influence Diagrams

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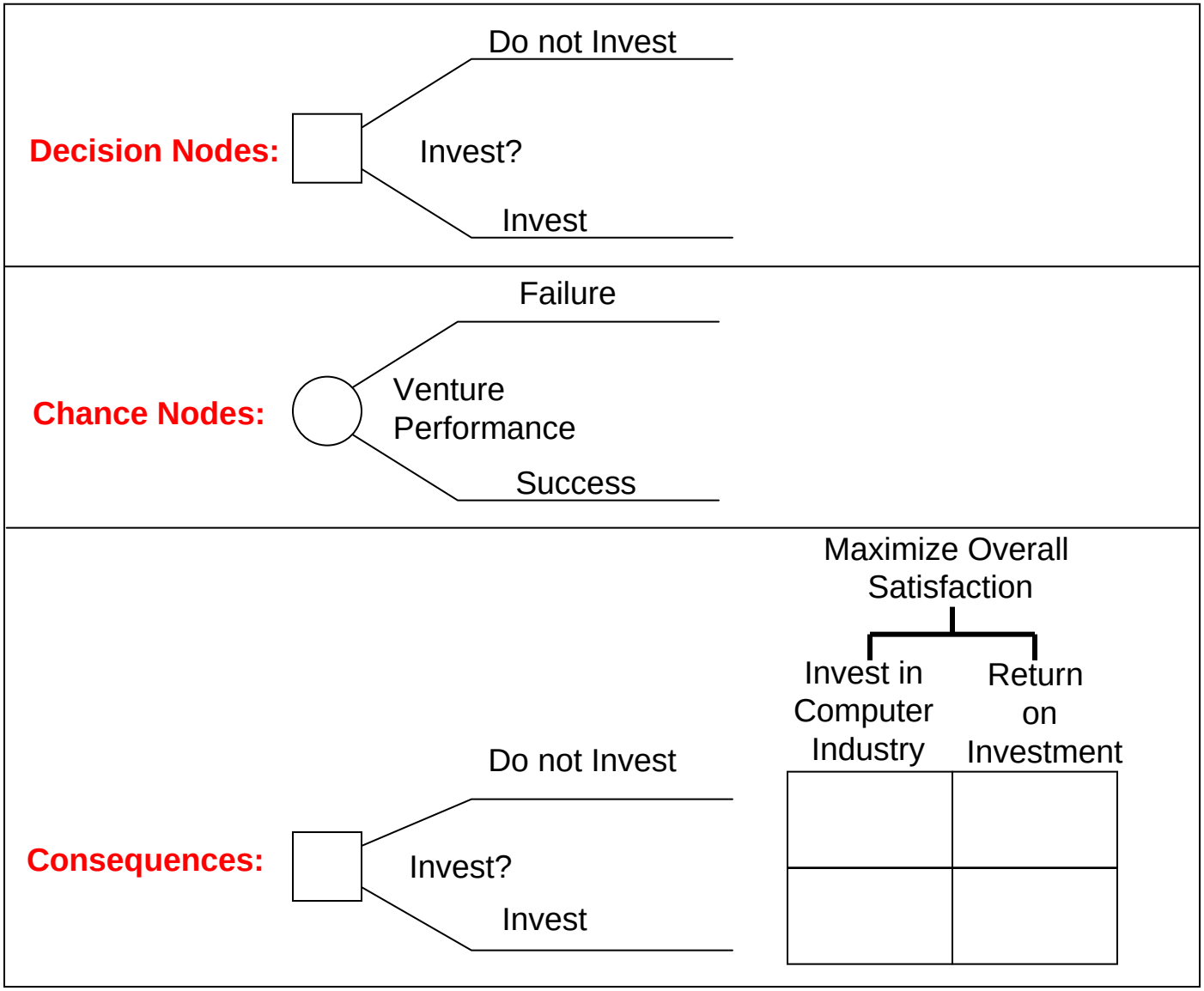
Step 2: Structure Elements in a Logical Framework

Elements are represented by:



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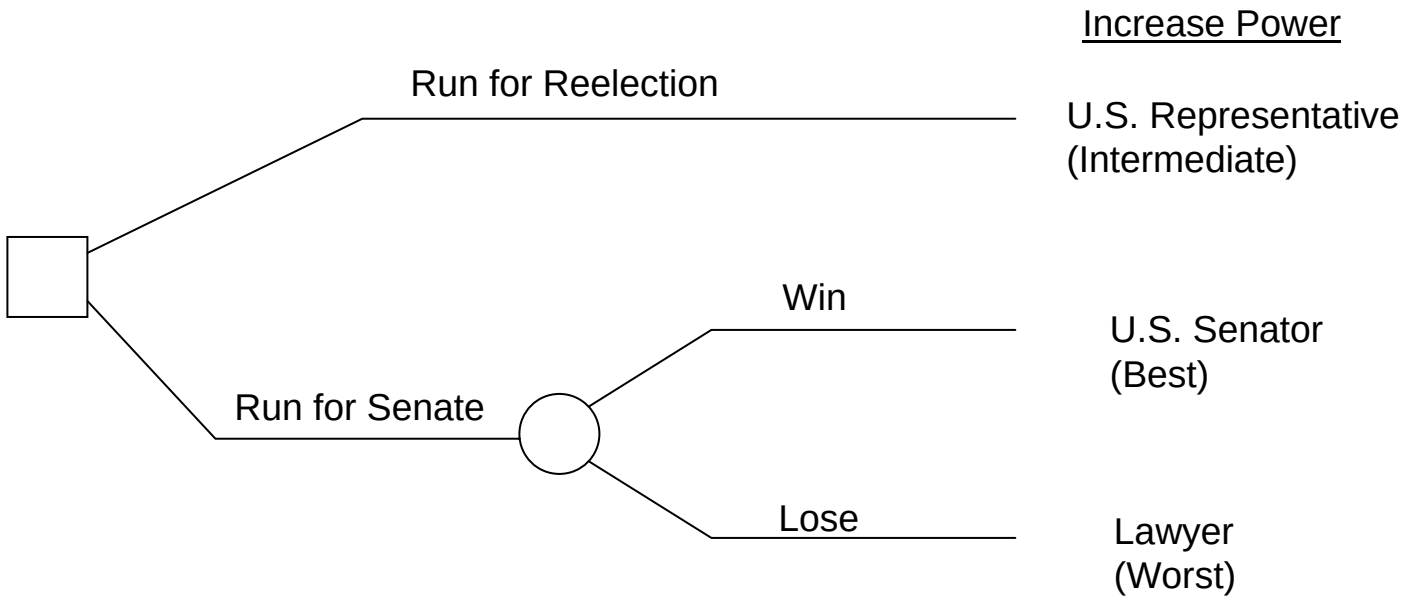
Step 2: Structure Elements in a Logical Framework

1. Decision Trees are evaluated from left to right
2. Only one alternative can be chosen after each decision node
3. Outcome from a chance event need to be complete, i.e. not more than one outcome can happen at the same time and one outcome will happen.
4. Decision Trees represent all possible future scenarios
5. Think of nodes as occurring in time sequence
6. If for chance nodes the order is not important then use the easiest interpretation.

Step 2: Basic Decision Trees

The Basic Risk Decision



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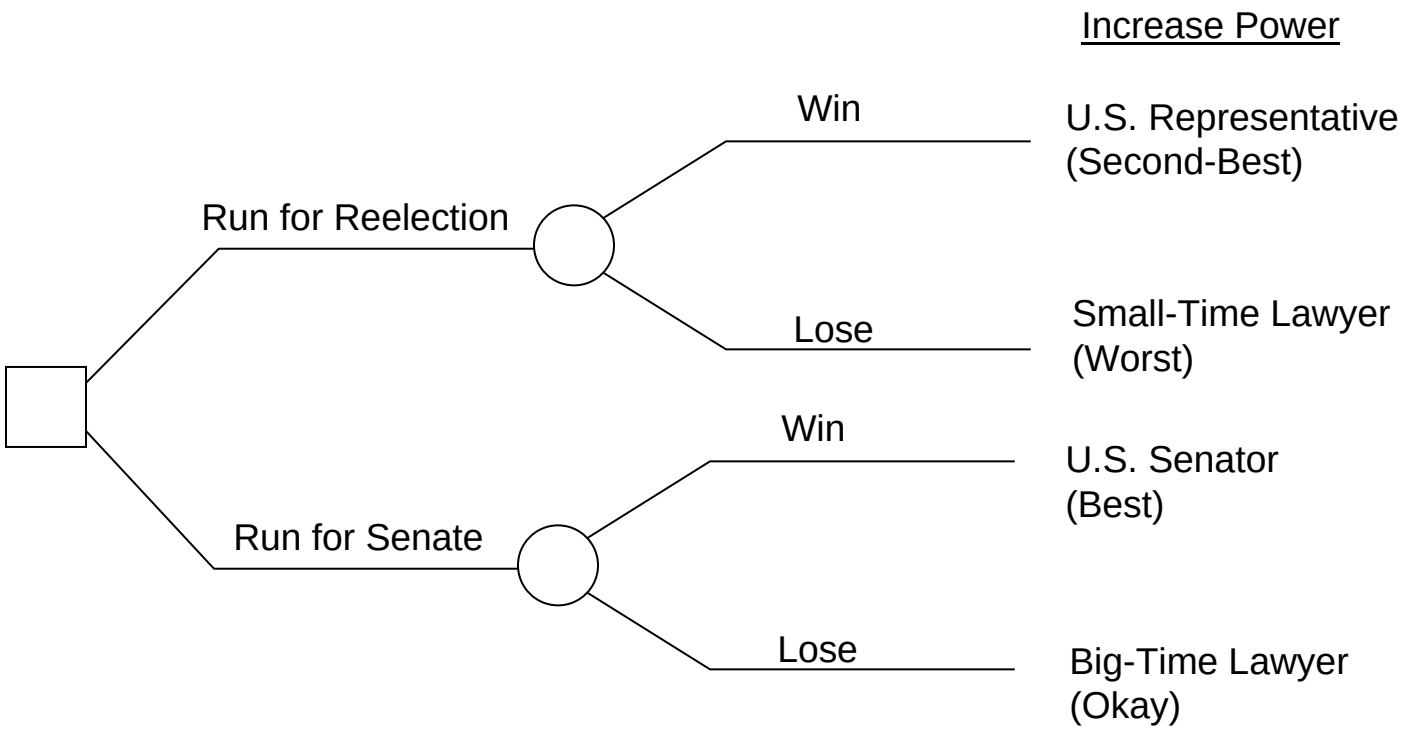
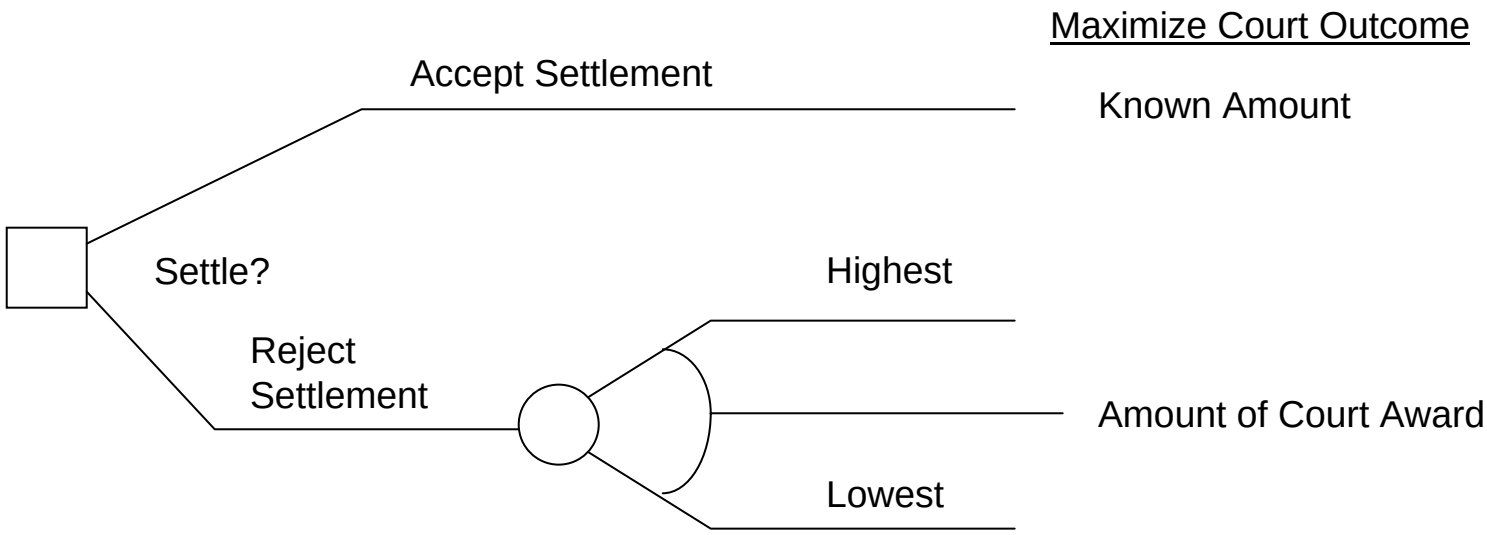
Step 2: Basic Decision Trees

The Double Risk Dilemma



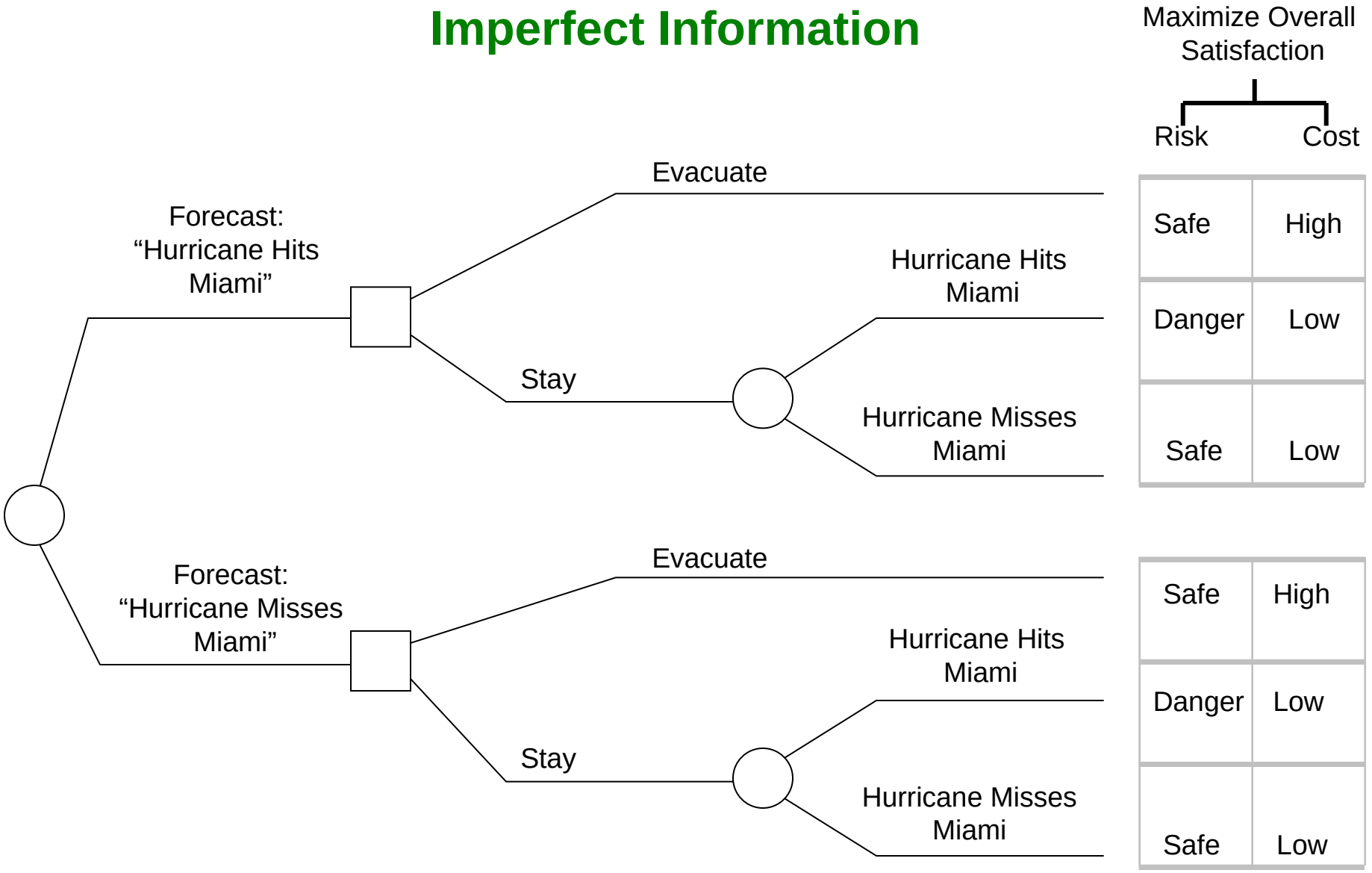
Step 2: Basic Decision Trees

Rang-of-Risk Dilemma



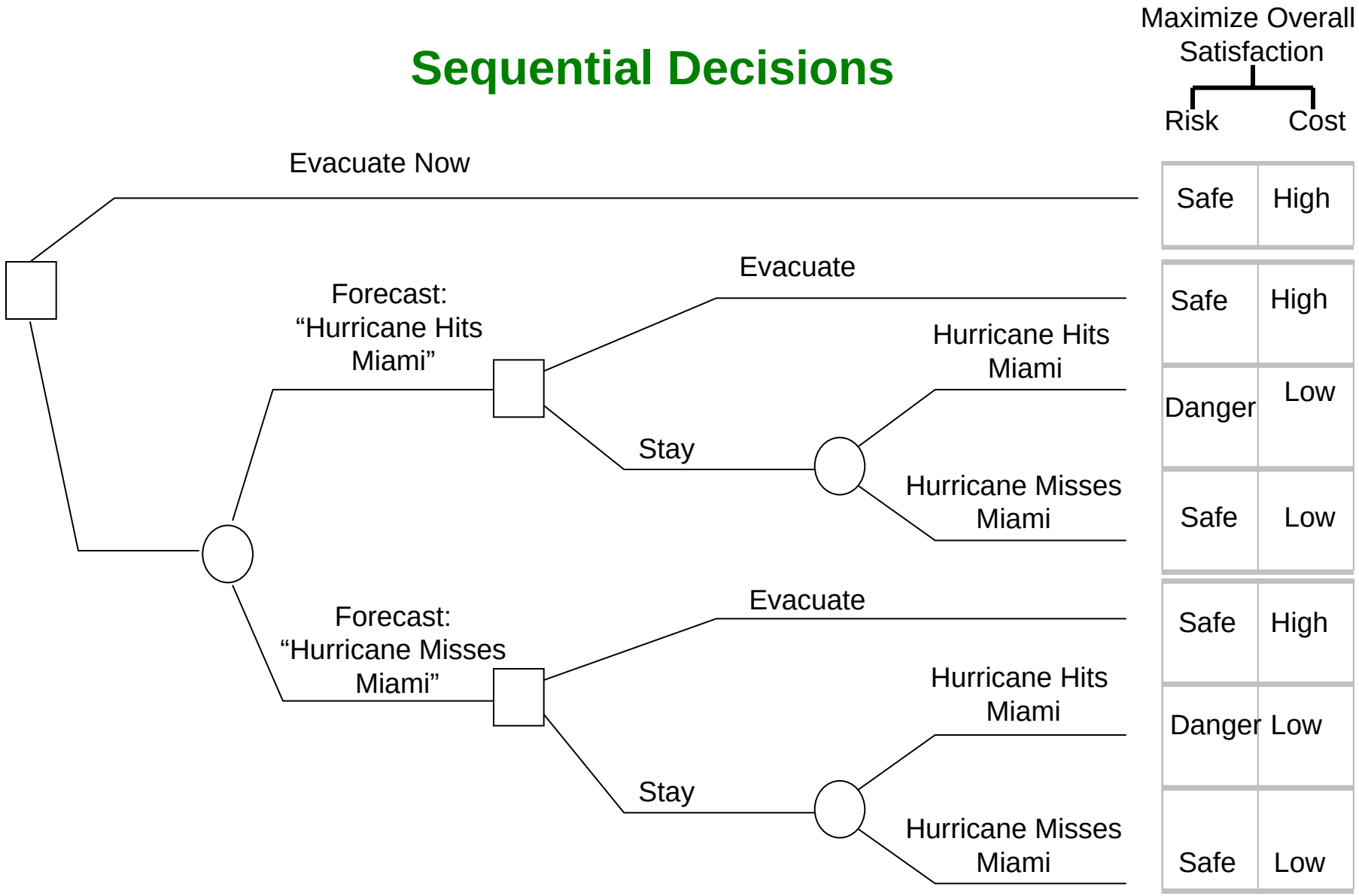
Step 2: Basic Decision Trees

Imperfect Information



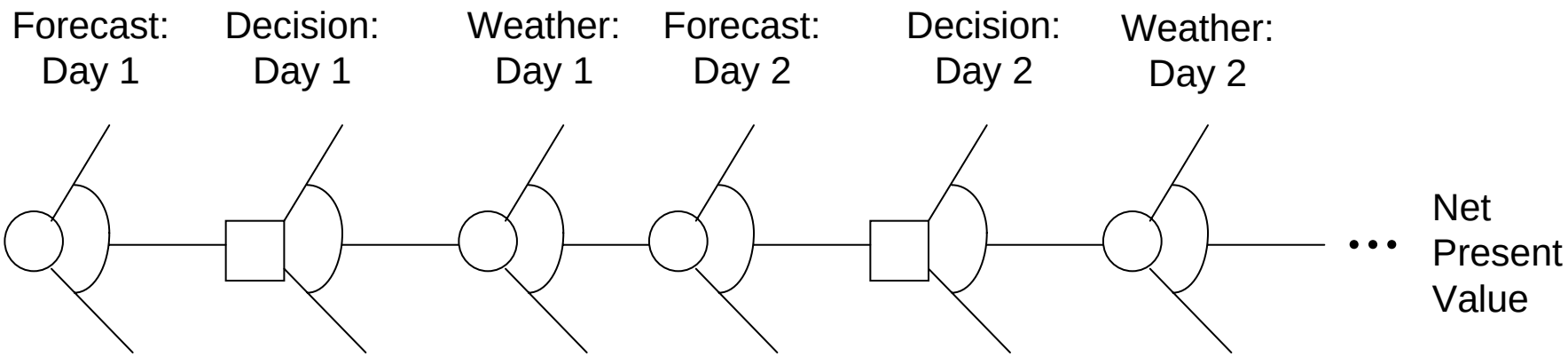
Step 2: Basic Decision Trees

Sequential Decisions



Step 2: Basic Decision Trees

Sequential Decisions



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Decision Trees and Influence Diagrams Compared

- When DP is **complex** decision trees, may get **too large** for presentation.
- For **presentation** a DP influence diagram are superior.
- Decision trees show more detail, hence are more useful for in-depth **understanding**.
- Influence diagrams are better in the **structuring phase**.
- For sensitivity analysis decision trees may be better.
- Influence diagram present the **relevance between uncertainty nodes**, decision trees do not.
- Influence diagrams and decision trees are **isomorphic.**
- Each technique has its strength and weakness. Using both may work **complementary**.
- Both must pass **the clarity test.** No misunderstanding should be possible about the basic key elements in the decision problem.

Step 3: Fill in the Details

1. Define the elements in the decision model clearly

Consider EPA Example:

Objective: Minimize the **social cost of cancer**. Definition?:
- Incremental Lives Lost ?
- Incremental cases of cancer ?
- Incremental cases of treatable cancer ?

Uncertain Event: **Rate of exposure**. Definition?:
- Number of people exposed to the chemical per day ?
- Ingesting a critical quantity ?
- Skin contact ?

Step 3: Fill in the Details

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Consider EPA Example:

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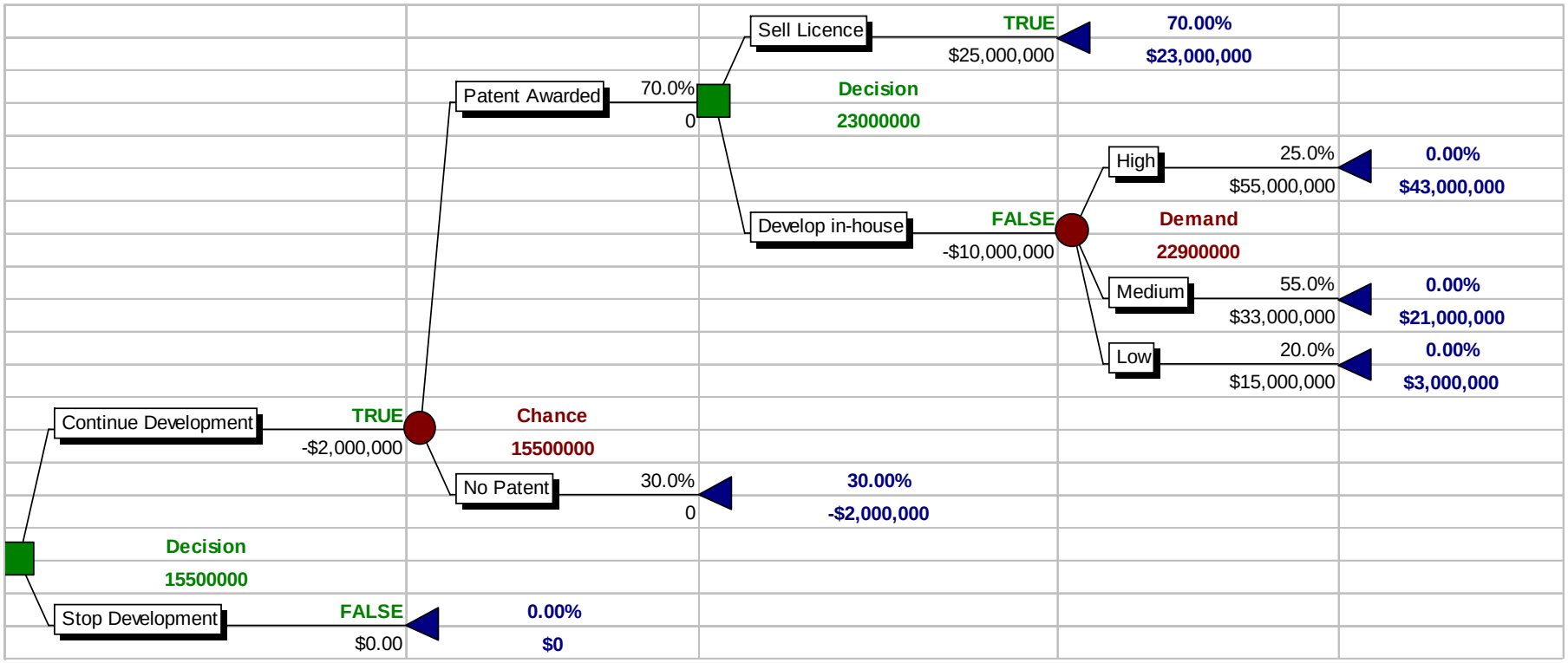
Step 3: Fill in the Details

2. Asses Cash Flows and Probabilities



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Step 3: Fill in the Details

3. Defining Measurement Scales for Fundamental Objectives

Objectives are measured in attributes, e.g: Dollars, Hours, Percentage

1. Objectives with natural attribute scale

OBJECTIVE	ATTRIBUTE
Maximize profit	Money (for example dollars)
Maximize Revenue	Money (for example dollars)
Maximize Savings	Money (for example dollars)
Minimize Cost	Money (for example dollars)
Maximize Market Share	Percentage
Maximize Rate of Return	Percentage
Maximize proximity	Miles, minutes
Maximize Fuel Efficiency	Miles per gallon
Maximize time with friends	Days, Hours
Minimize hypertension	Inches Hg (Blood pressure)

Step 3: Fill in the Details

2. Objectives with no natural attribute scale

Example: **Max Quality**. How does on measure it?

Solution: Define an attribute scale:

BEST, BETTER, SATISFACTORY, WORSE, WORST.

Each category needs to pass the **Clarity Test:**

- An attribute Scale passes the **Clarity Test** if an **outside candidate** using **your definition** can allocate specimens to the identified categories.

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Step 3: Fill in the Details

Example: Measuring Survey Quality:

Best Survey Quality:

State-of-the-art Survey. No apparent crucial issues left unaddressed. Has characteristics of the best survey projects presented at professional conferences.

Worst Survey Quality:

Many issues left unanswered in designing survey. Members of the staff are aware of advances in survey design that could have been incorporated but were not. Not a presentable project.

See **additional category definitions** on Page 82.