Decision Analysis
Part 3:
Influence Diagrams

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Working Example

Decision tree:

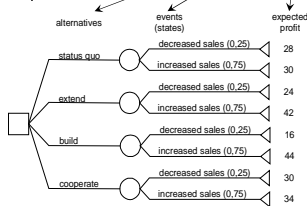| | alternatives | events (states) | expected profit |
status quo	decreased sales (0,25)	28
	increased sales (0,75)	30
extend	decreased sales (0,25)	24
	increased sales (0,75)	42
build	decreased sales (0,25)	16
	increased sales (0,75)	44
cooperate	decreased sales (0,25)	30
	increased sales (0,75)	34
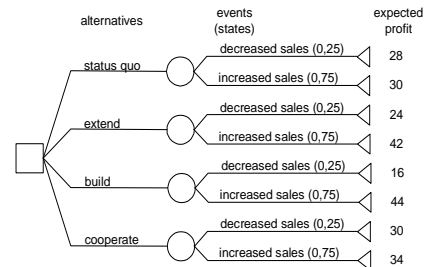
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Motivation for Influence Diagrams

Decision trees:
* sometimes too detailed,
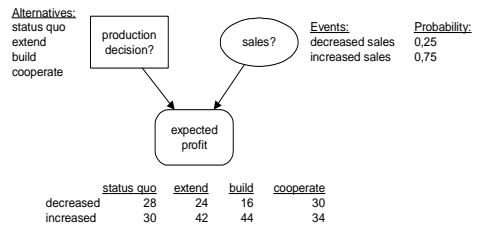* grow exponentially,
* contain repeated information.

Only three different elements:

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Working Example

Equivalent *Influence diagram*:

Alternatives:
status quo
extend
build
cooperate

production decision?

sales?

Events: Probability:
decreased sales   0,25
increased sales   0,75

expected profit

	status quo	extend	build	cooperate
decreased	28	24	16	30
increased	30	42	44	34

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Influence Diagram

Influence diagram is a:
* high-level (compact),
* visual representation,
* displaying relationships between essential elements that affect the decision.

Two levels of detail:
* higher: only elements and relations
* lower: detailed information defined with each element

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Elements of Influence Diagrams

Decision

Decision node:
represents alternatives

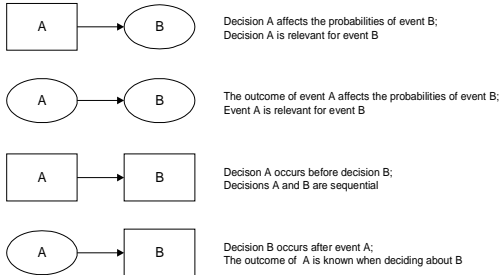Chance

Chance Node:
represents events (states of nature)

Value

Value

Value Node represents:
* consequences
* objectives, or
* calculations

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Arcs in Influence Diagrams

A → B (box to oval)	Decision A affects the probabilities of event B; Decision A is relevant for event B
A → B (oval to oval)	The outcome of event A affects the probabilities of event B; Event A is relevant for event B
A → B (box to box)	Decison A occurs before decision B; Decisions A and B are sequential
A → B (oval to box)	Decision B occurs after event A; The outcome of A is known when deciding about B

Developing Influence Diagrams

Two basic strategies:

* Start with outcomes and model towards decisions and events

* Gradually add more and more detail

Common Mistakes

1. An influence diagram is not a flowchart.

2. An arc from a chance node into a decision node means that the decision-maker knows the outcome of the chance node when making the decision.

3. There can be no cycles:
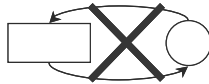
Decision Trees : Influence Diagrams

* DT display more information, the details of a problem, but they may become "messy".
* ID show a general structure of a problem and hide details.
* ID are particularly valuable for the structuring phase of problem solving and for representing large problems.
* Solving algorithms: DT straightforward, ID difficult
* Any properly built ID can be converted into a DT, and vice versa.

* Bayesian networks are ID's containing only event nodes

Solving Influence Diagrams

A. Convert ID to DT, solve DT

or

B. Solve directly by node reduction:
1. Cleanup: one consequence C, no cycles, transform calculation nodes to one-event chance nodes...
2. Repeat until ID solved:
   1. Reduce (calculate EV of) all chance nodes that directly precede C and do not precede any other node.
   2. Reduce (calculate EV of) the decision node that directly precedes C and has as predeccessors all of the other direct predeccessors of C.
+ arc reversal where there are no nodes corresponding to 2.2

Influence Diagram Software

Add-Ins for Microsoft Excel:
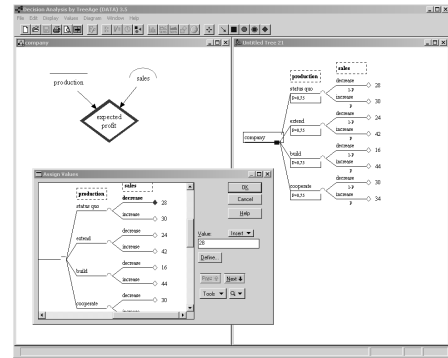* PrecisionTree: http://www.palisade-europe.com/precisiontree/

Influence-Diagram Development Programs:
* GeNIe: http://genie.sis.pitt.edu/
* TreeAge Pro (DATA): http://www.treeage.com/
* DPL: http://www.syncopationsoftware.com/
* Analytica: http://www.lumina.com/ana/whatisanalytica.htm
* HUGIN: http://www.hugin.com/
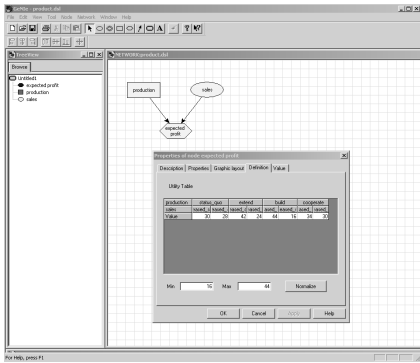* Netica: http://www.norsys.com/

Exercises

Exercise 1: DATA

Exercise 2: GeNIe

Exercise 3: Develop ID

Sequential Decision
Introduce product, set price

high	high (.3)	150
EMV: 5	medium (.5)	0
	low (.2)	-200

competitor (.8) medium
EMV: 70 EMV: 70
high (.1) 250
medium (.6) 100
low (.3) -50

introduce
EMV: 156
low
EMV: -50
high (.1) 100
medium (.2) 50
low (.7) -100

no competitor (.2)
EMV: 500
high 500
medium 300
low 100

do not introduce
EMV: 0
0
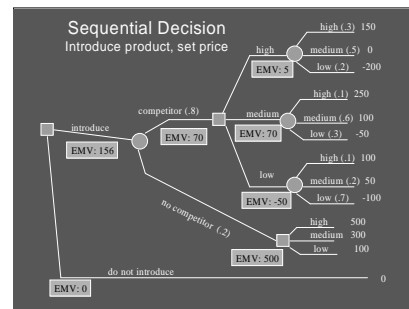
Example 1: Gradual Development (1/3)

Influence diagram of a
new product decision

Revenue   Cost

Introduce
Product?   Profit
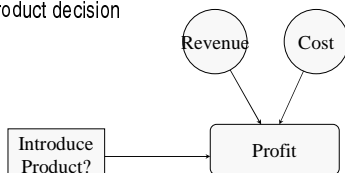
Example 1: Gradual Development (2/3)

Influence diagram
with additional detail

Units
Sold   Fixed
Cost   Variable
Cost

Price

Introduce
Product?   Profit

Example 1: Gradual Development (3/3)

Price, Units Sold, Fixed Cost, Unit Variable Cost, Revenue, Cost, Introduce Product?, Profit

Intermediate calculation

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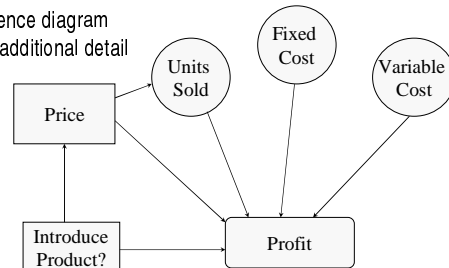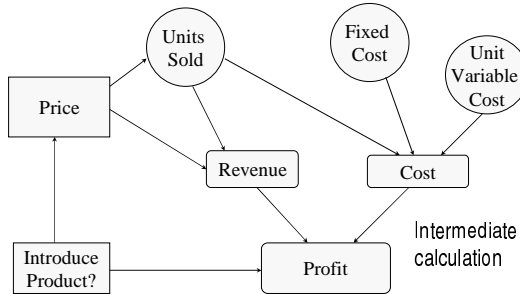
Example 2: Multiple Objectives (1/2)

Influence diagram of a venture capitalist's decision

Venture succeeds or fails, Invest?, Return on investment

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Example 2: Multiple Objectives (2/2)

Invest?, Venture succeeds or fails, Return on investment, Computer Industry Growth, Overall Satisfaction
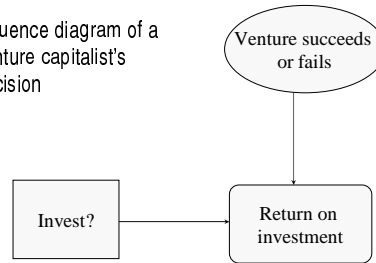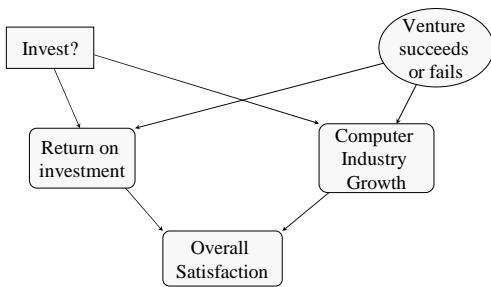
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Example 3: Intermediate Calculations
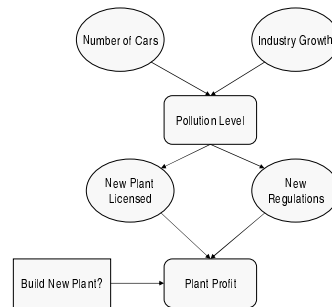
Number of Cars, Industry Growth, Pollution Level, New Plant Licensed, New Regulations, Build New Plant?, Plant Profit

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Example 4: Evacuation Decision (1/2)

Will hit / Will miss, Forecast, Hurricane Path, Hits / Misses, Evacuate / Stay, Decision, Consequences

Decision table:
Decision \ H. Path

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Example 4: Evacuation Decision (2/2)

Forecast, Hurricane Path, Evacuate?, Consequences, Wait for Forecast?

Decision table:
Decision \ H. Path \ Wait

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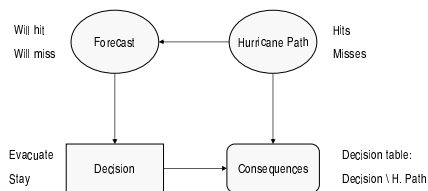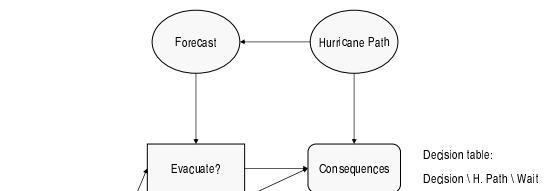
Exercise 4

Create influence diagrams representing the decision trees encountered so far:

1. Oilco
2. Take an umbrella
3. Service station

Exercise 5: Tractor Buying (1/3)

- Your uncle is going to buy a tractor. He has two alternatives:
    1. A new tractor (17 000 €)
    2. An used tractor (14 000 €)
- The engine of the old tractor may be defect, which is hard to ascertain. Your uncle estimates a 15 % probability for the defect.
- If the engine is defect, he has to buy a new tractor and gets 2000 € for the old one.
- Before buying, your uncle can take the old tractor to a garage for an evaluation, which costs 1 500 €.
    - If the engine is OK, the garage can confirm it without exception.
    - If the engine is defect, there is a 20 % chance that the garage does not notice it

Exercise 5: Tractor Buying (2/3)
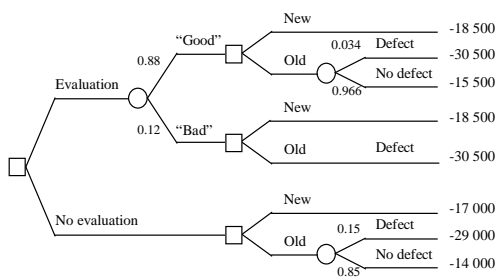
Exercise 5: Tractor Buying (3/3)

Do the following:

1. Solve the decision tree
2. Develop equivalent influence diagram:
    1. structure of nodes
    2. detailed node data (names, values, probabilities)

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