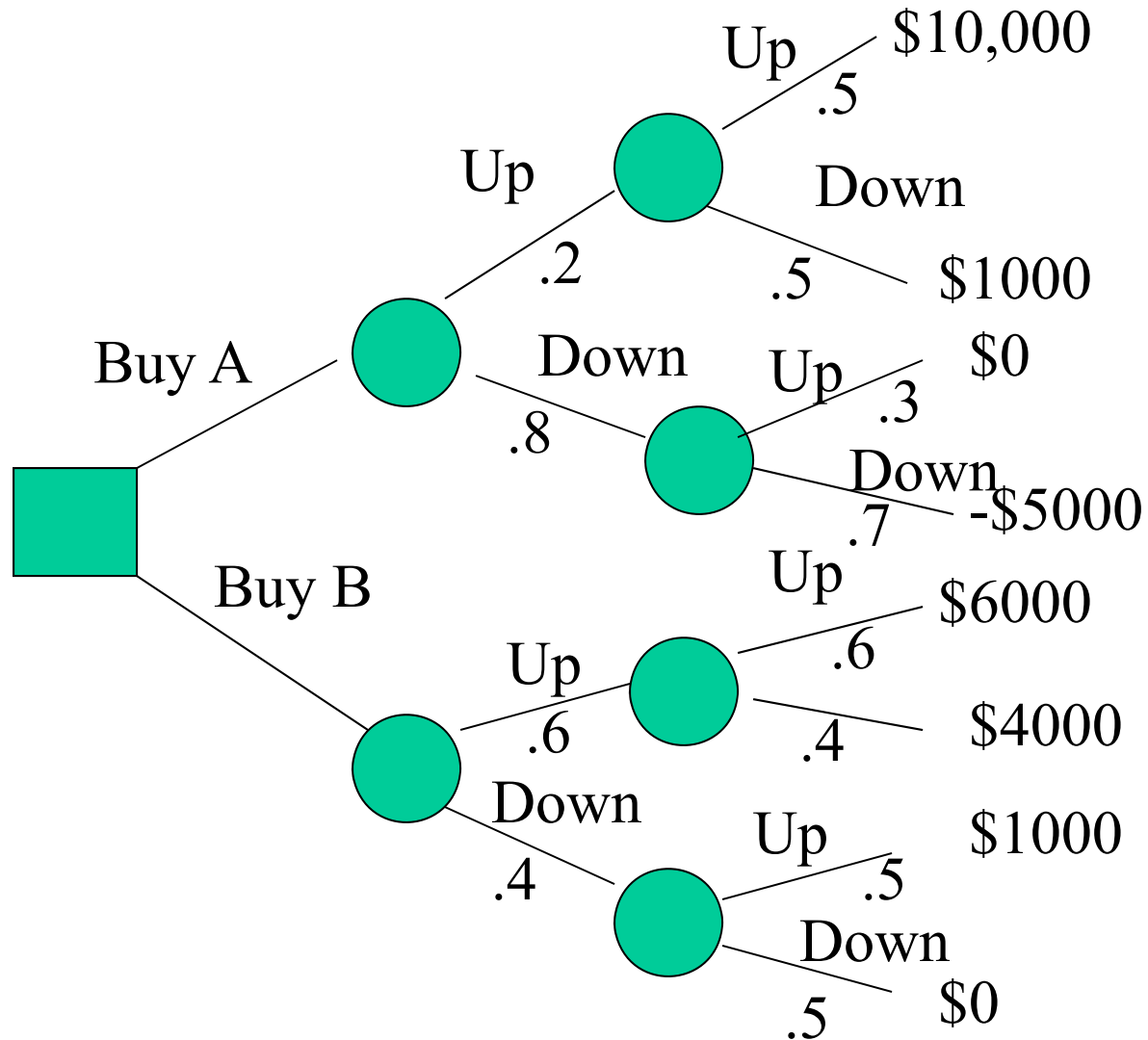# Circular Decision Trees

Robert F. Bordley

Corporate Strategy

General Motors Corporation

Conventional Decision Tree

Observations

Three Level Decision Tree

Somewhat Messy Looking

  Raiffa:Big Trees Become Bushy Messes

  Solution:Trim Trees whenever Possible

  Problem:Requires Preprocessing of Tree with Tornado Charts,etc.

Explicit Use of Probabilities/Utilities

Cannot be directly created in Excel

Structure of Tree

Moves from left to right

Only one node on left; Many on Right

Arcs cannot represent quantitative information

Proposed Solution:

The Circular Decision Tree(Decision Rings)

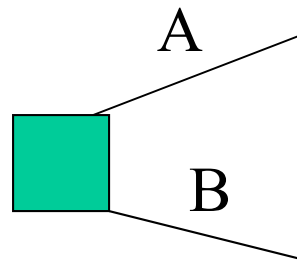 Conveys all the information in a Decision Tree

  Is completely visual

  Is Much more Compact
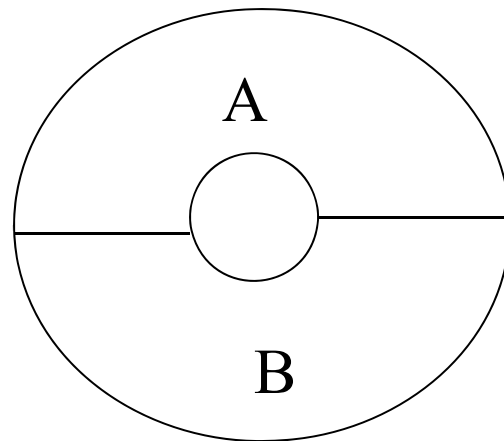
  Can be drawn using Excel/Charts/Doughnut

Step-by-Step Comparison

Drawing First Level
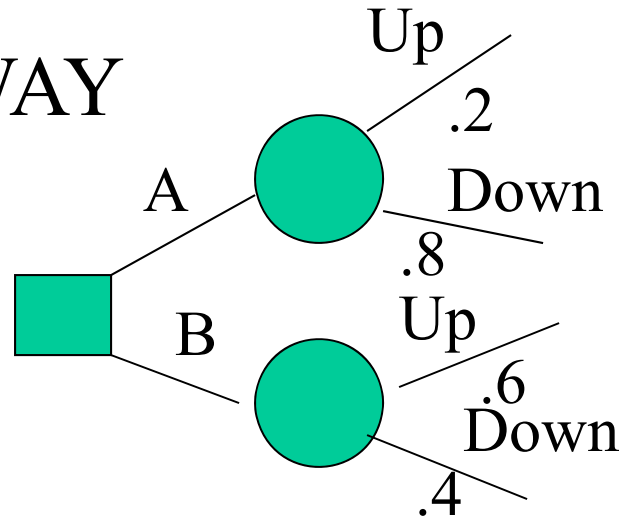
OLD WAY

A

B

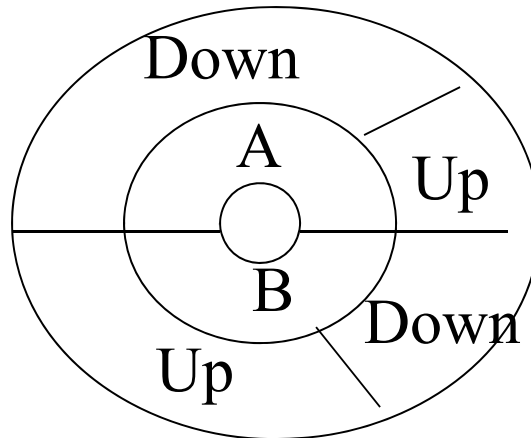NEW WAY

A

B

Observations

- The area allocated to the starting node is small

- The area allocated to the two nodes in the first level is three times as big(2^2-1^2)

- For a decision, the area is allocated evenly between all possible choices

Drawing 2nd Level

OLD WAY

Up

.2

A

Down
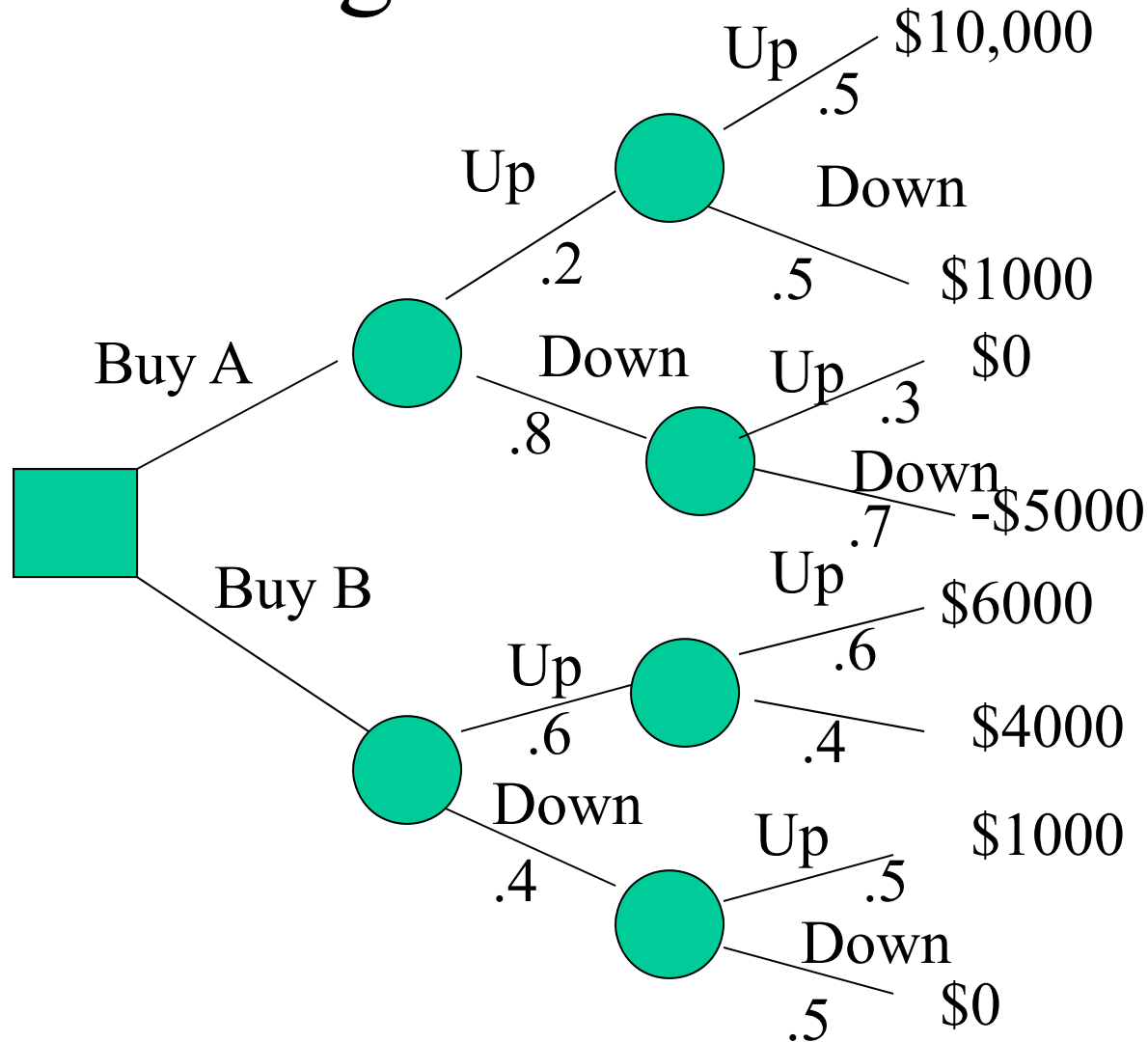
.8

B
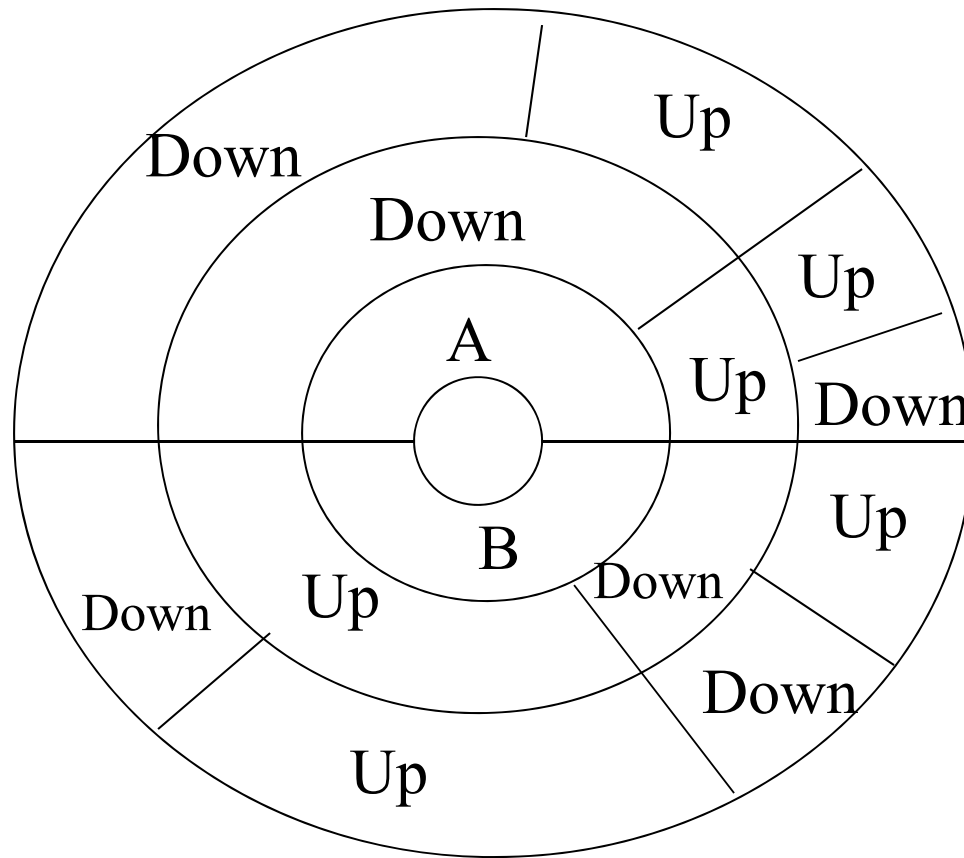
Up

.6

Down

.4

NEW WAY

Down

A

Up

B

Down

Up

Observations

- For an uncertainty, the area in a layer is allocated proportional to the probability of the uncertainty

- Hence The probability of a specific outcome is now represented by the amount of space on the layer allocated to that outcome.

- The area allocated to outcomes on the second layer is given five times as big(3^2-2^2)

Drawing Third Level: Old Way

Buy A

Up .2
- Up .5 — $10,000
- Down .5 — $1000

Down .8
- Up .3 — $0
- Down .7 — -$5000

Buy B

Up .6
- Up .6 — $6000
- Down .4 — $4000

Down .4
- Up .5 — $1000
- Down .5 — $0

Drawing Fourth Level: New Way

How do we Represent Outcome Payoffs: Old Way

- We represent outcome payoffs with numbers(e.g. $10,000)

How do we Solve the Tree:Old Way

- We assign payoffs to endpoints in 3rd layer
- We then assign payoffs to endpoints in 2nd layer
  - If second layer is an uncertainty, then payoff on 2nd layer node is probability weighted average of endpoints from that uncertainty in the 3rd layer
  - If second layer is a decision, then payoff on 2nd layer node is maximum of payoff on endpoints from that decision node in the 3rd layer
- Repeat procedure for endpoints in 1st layer
- Repeat procedure for starting node

How do we represent Outcome Payoffs?

- Highest Payoff ($10,000) is assigned color `white'
- Lowest Payoff(-$5000) is assigned color `black'
- Intermediate Payoffs are assigned intermediate colors
  - $2500 is medium gray
  - $1000 is dark gray
  - $6000 is light gray

How do we solve the Tree: New Way

- We color the segments in the third layer according to their payoff

- If the second layer segment represents an uncertainty, its color is an area-weighted mixture of the colors in the adjacent segments in the 3rd layer

- If the second layer segment represents a decision, its color is the lightest of the colors in the adjacent segments in the 3rd layer

- Repeat procedure with 1st layer and starting node.

Solving the Circular Tree
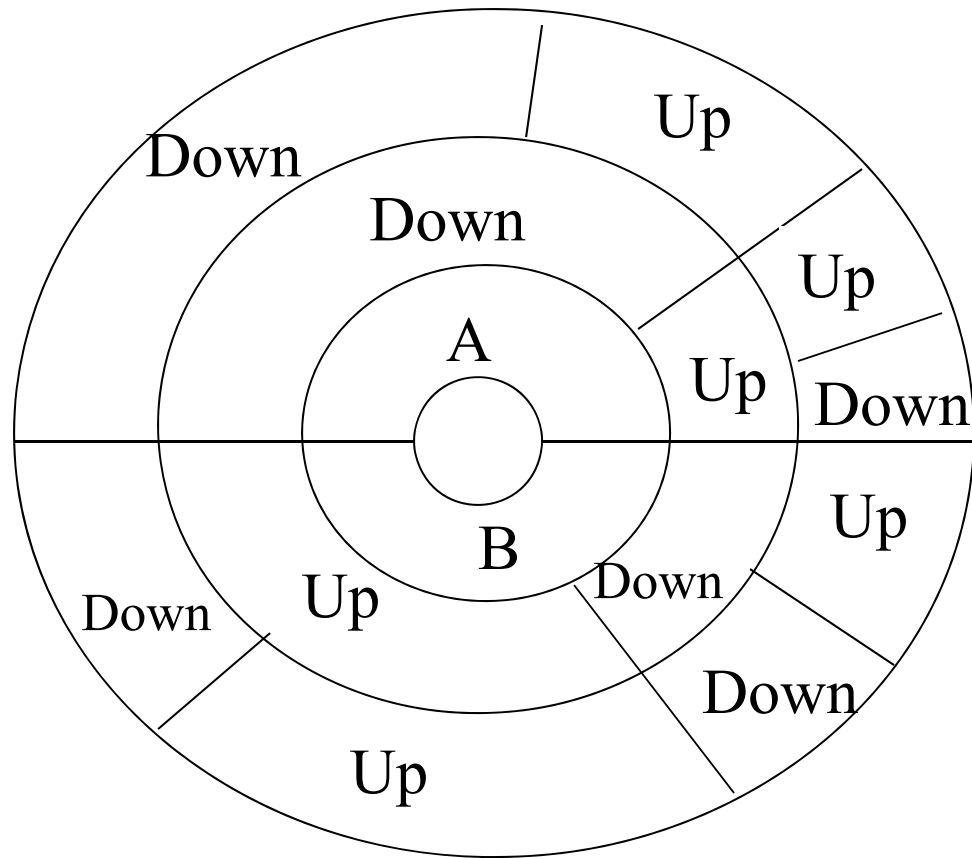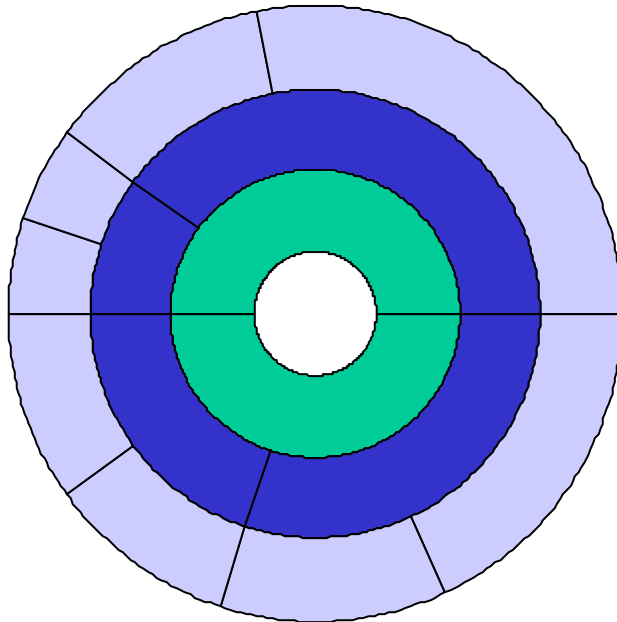
Implementing the Procedure in Excel

- Create three columns in Excel for the three layers of the tree
  - .5   .5(.2)   (.5)(.2)(.5)
  -                       (.5)(.2)(.5)
  -          .5(.8)   (.5)(.8)(.3)
  -                       (.5)(.8)(.7)
  - .5   .5(.6)   (.5)(.6)(.6)
  -                       (.5)(.6)(.4)
  -          .5(.4)   (.5)(.4)(.5)
  -                       (.5)(.4)(.5)

Insert Chart/Doughnut

- Creates a three layer doughnut from these 3 columns

- Adjust the size of the center ring as you please

- Rotate the ring as you please

Circular Decision Tree

Coloring the Doughnut

- Can do it manually in Excel
- Can do it with a macro

Examples

- R&D
- Lattices in Finance