Markov Decision Tree

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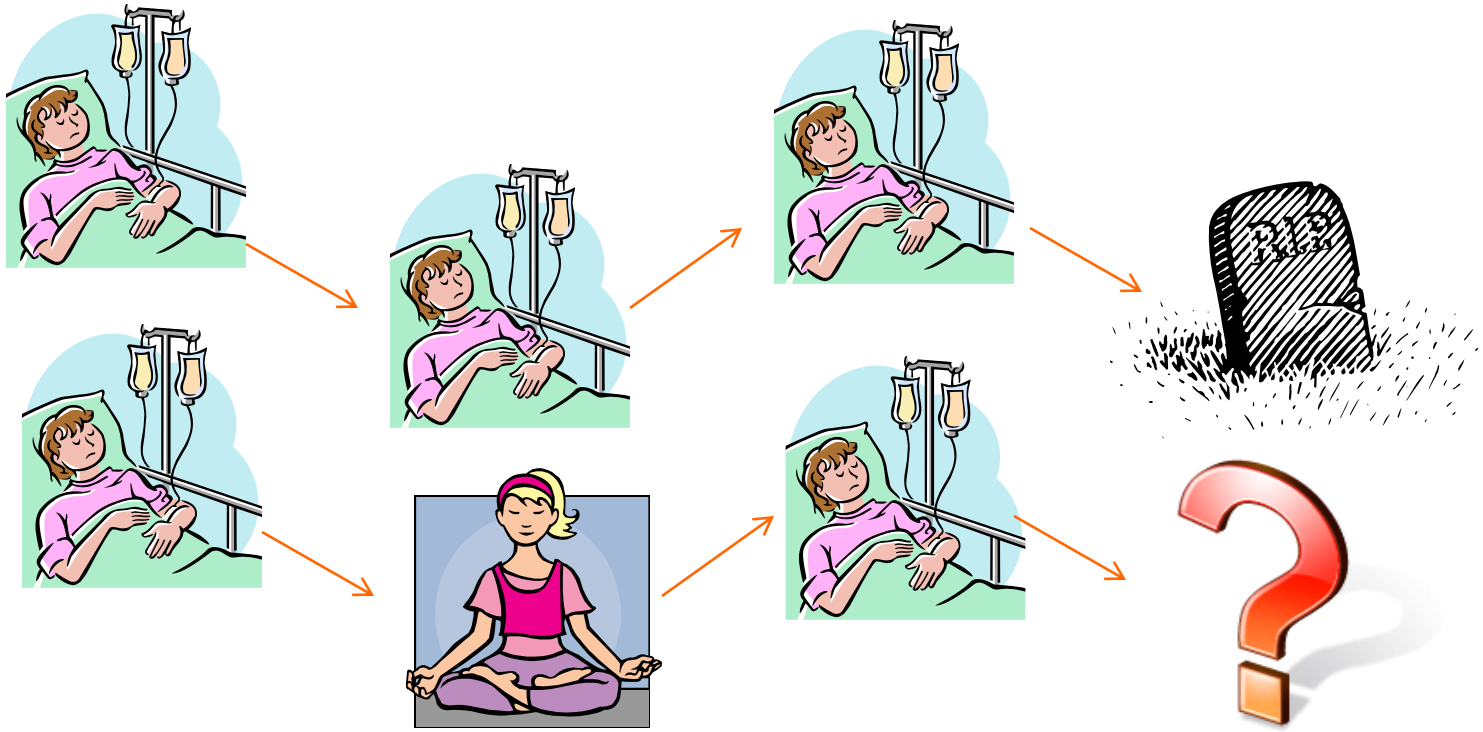
Markov Chain

- Not all problems can be portrayed in a standard decision tree, most medical problems are cyclical and the condition of patients can change over time. A Markov process is characterized by recurrent states over time.



What about in five years?

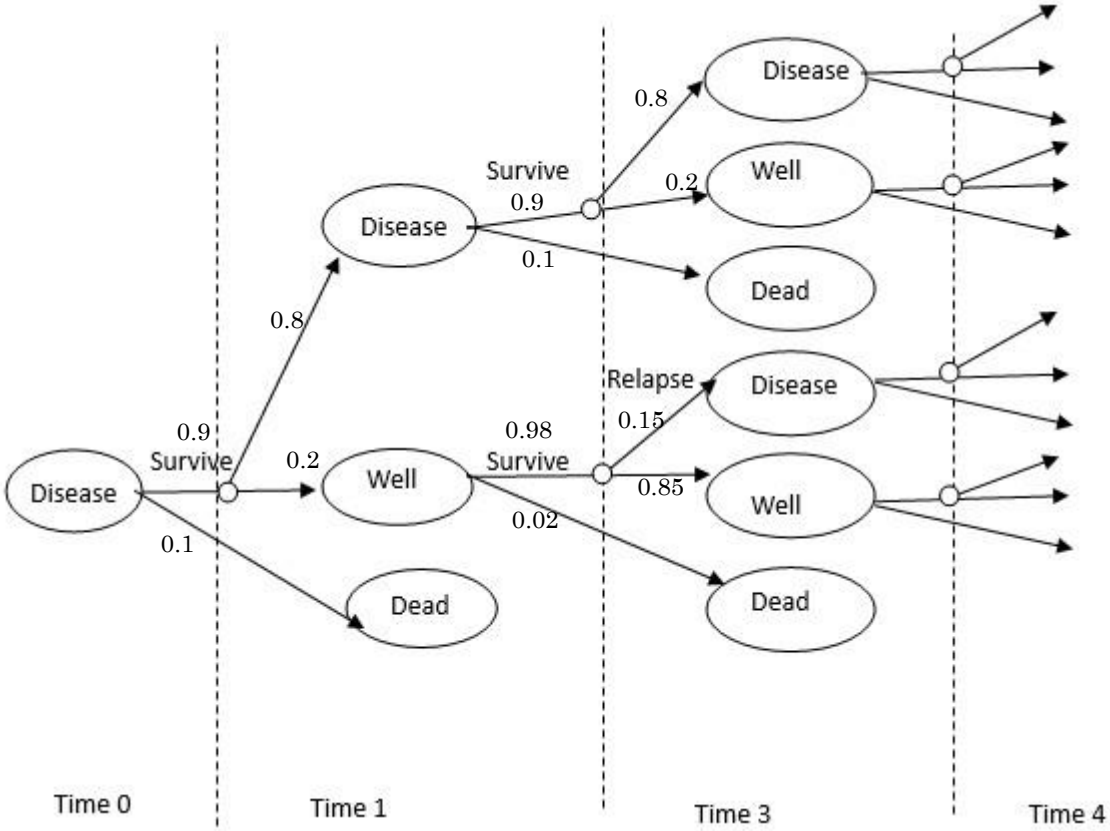
An example of Markov process

- Consider this Markov process (You can find this example in the Treeage software package: Three-State Markov):
- Here's a kind of disease, patients who get this disease can recover but could result in a relapse.
- In each cycle or period (let's say a year), 10% of the patients who catch this disease will die immediately.
- Among the rest of them who survive at first, after treatment, only 20% of them will recover and the rest will stay sick;
- Even if people recovered, in one year, there is still 2% chance that they could die. And if they stay alive, 15% of them will catch this disease again.

- States: disease, well, dead.

- Question: How many people (proportion of the population) will be alive in 50 years?

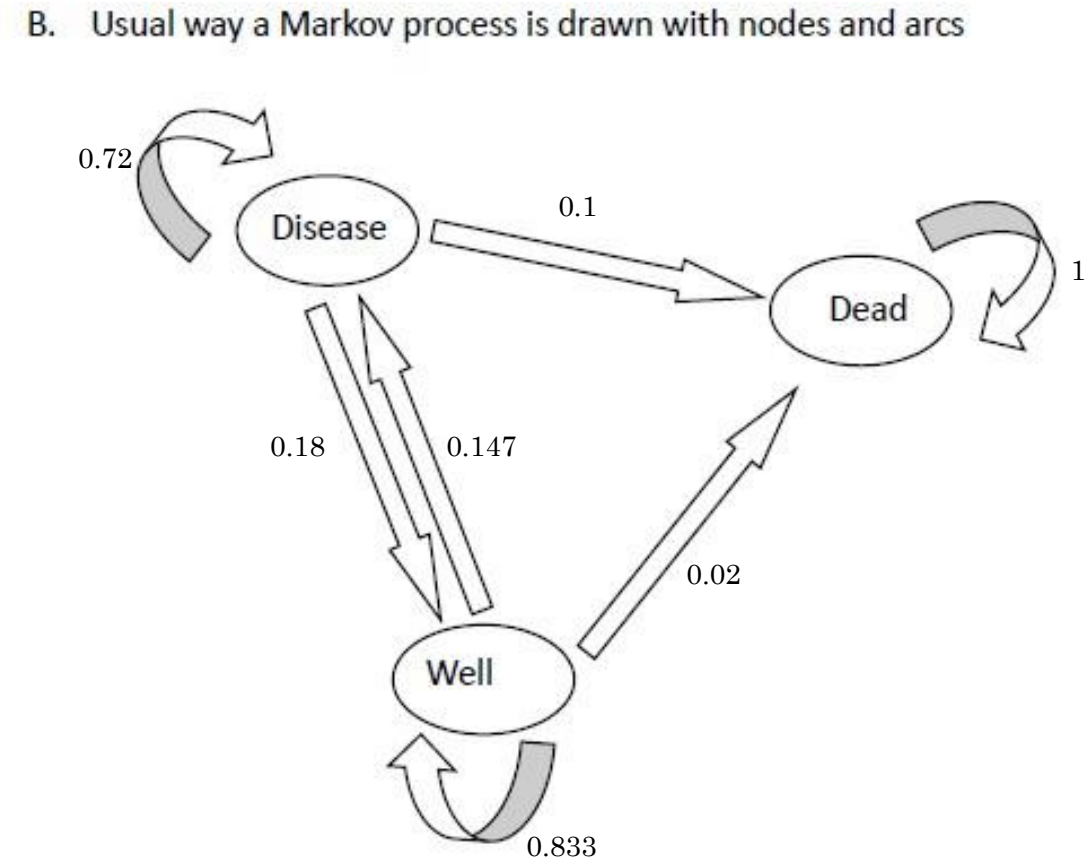
Put the problem in a decision tree



It becomes more complicated when time passes by.
There are some substructures repeating in the tree.

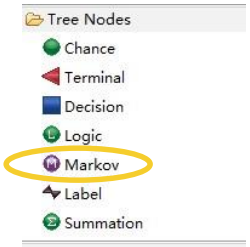
Another interpretation

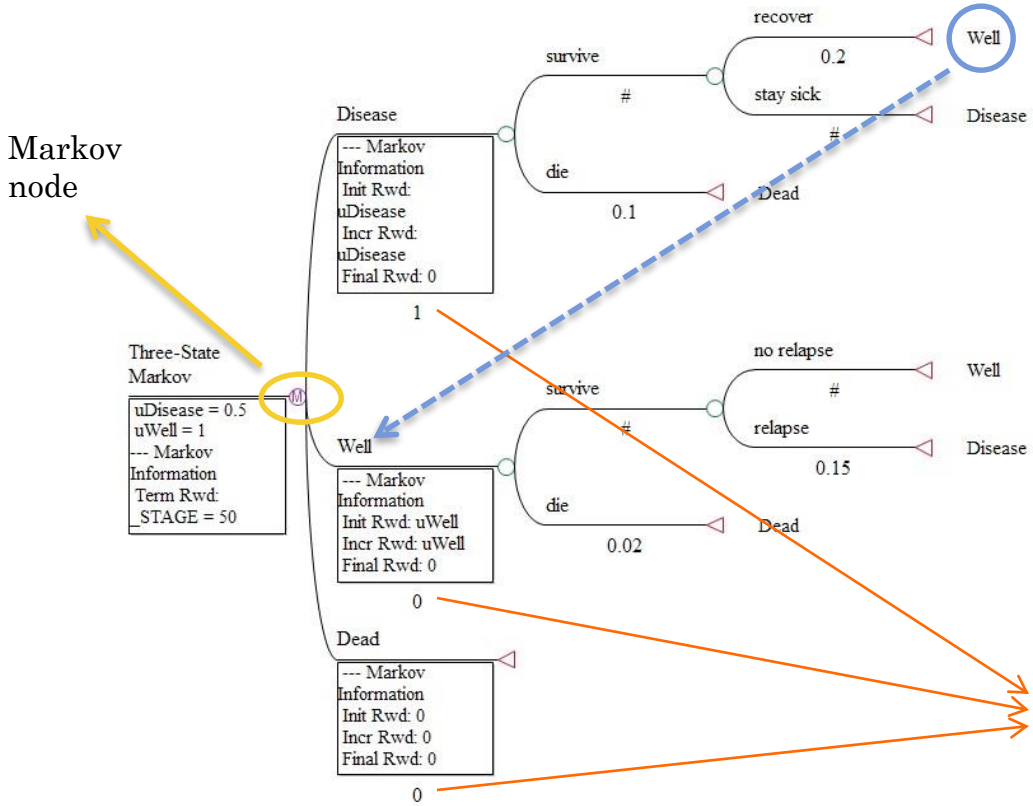
- **Absorbing** states. Being dead is an absorbing state.



A MARKOV TREE

- A Markov tree can be used to present a Markov process.
- A Markov tree is often composed of the following parts: structure, probabilities, rewards (quality adjusted life years) and termination condition.





Why 1, 0, 0?

Because they are initial probability distribution, the starting state is disease.

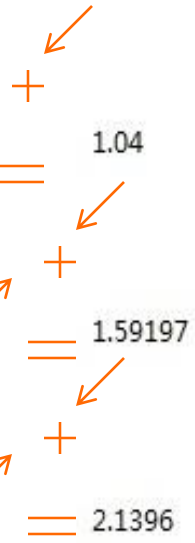
Note: We changed uDisease from 1 to 0.5.

Analysis of a Markov tree

- **Cohort (expected value) analysis:**
  - Compute the probability distribution after n stages.
  - Compute reward (quality) and cumulative reward after n stages.

Markov Cohort (Quick)

Stage	State	Probability	State Reward	Stage Reward	Cumulative Reward
Stage 0				0.5	0.5
	Disease	1	0.5		
	Well	0	0		
	Dead	0	0		
Stage 1				0.54	1.04
	Disease	0.72	0.36		
	Well	0.18	0.18		
	Dead	0.1	0		
Stage 2				0.55197	1.59197
	Disease	0.54486	0.27243		
	Well	0.27954	0.27954		
	Dead	0.1756	0		
Stage 3				0.54763	2.1396
	Disease	0.43339	0.2167		
	Well	0.33093	0.33093		
	Dead	0.23568	0		



Actions

Text Reports

Summary Report

Charts

State Prob.

Survival Curve

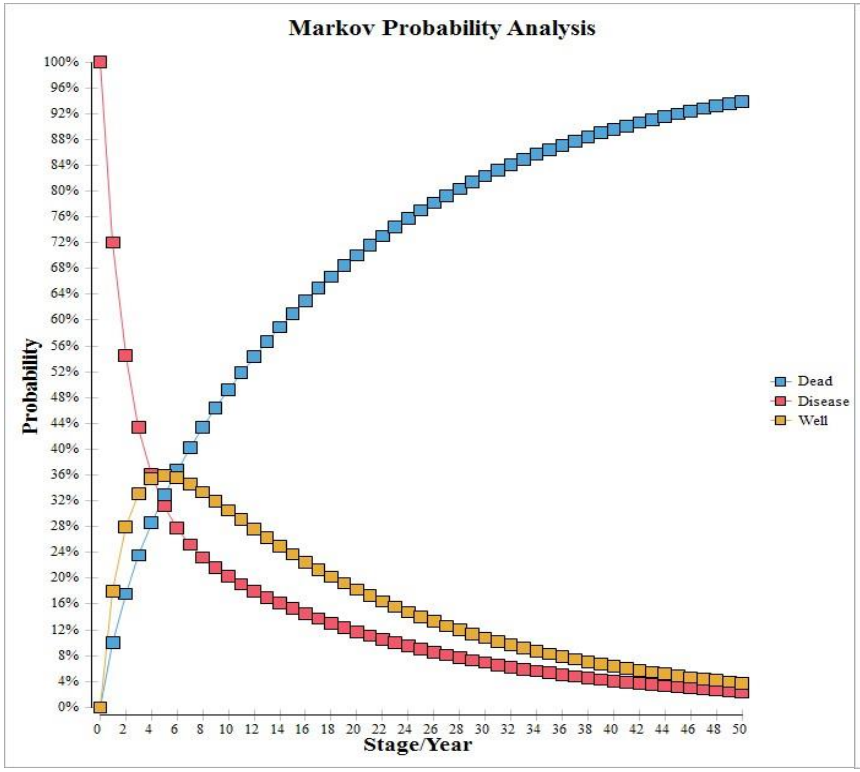
State Reward

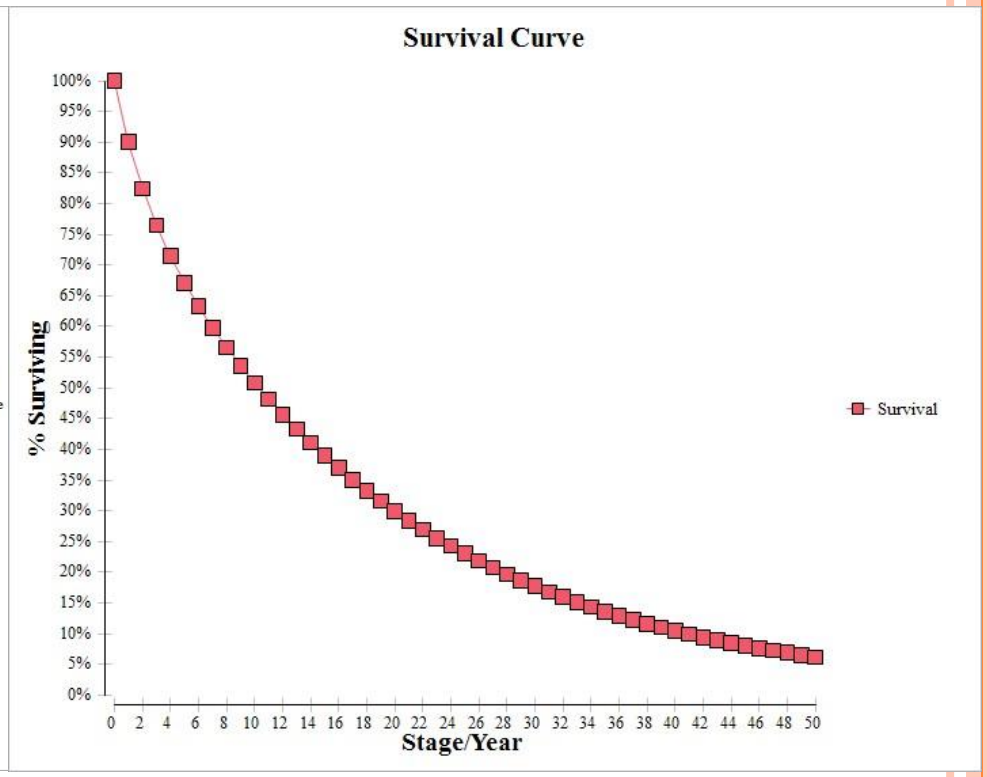
Stage Reward

Cumulative Reward

Analysis of a Markov tree

- **Markov Cohort Graphical Output:**
- State probabilities
- Survival curve
- State reward
- Stage reward
- Cumulative reward





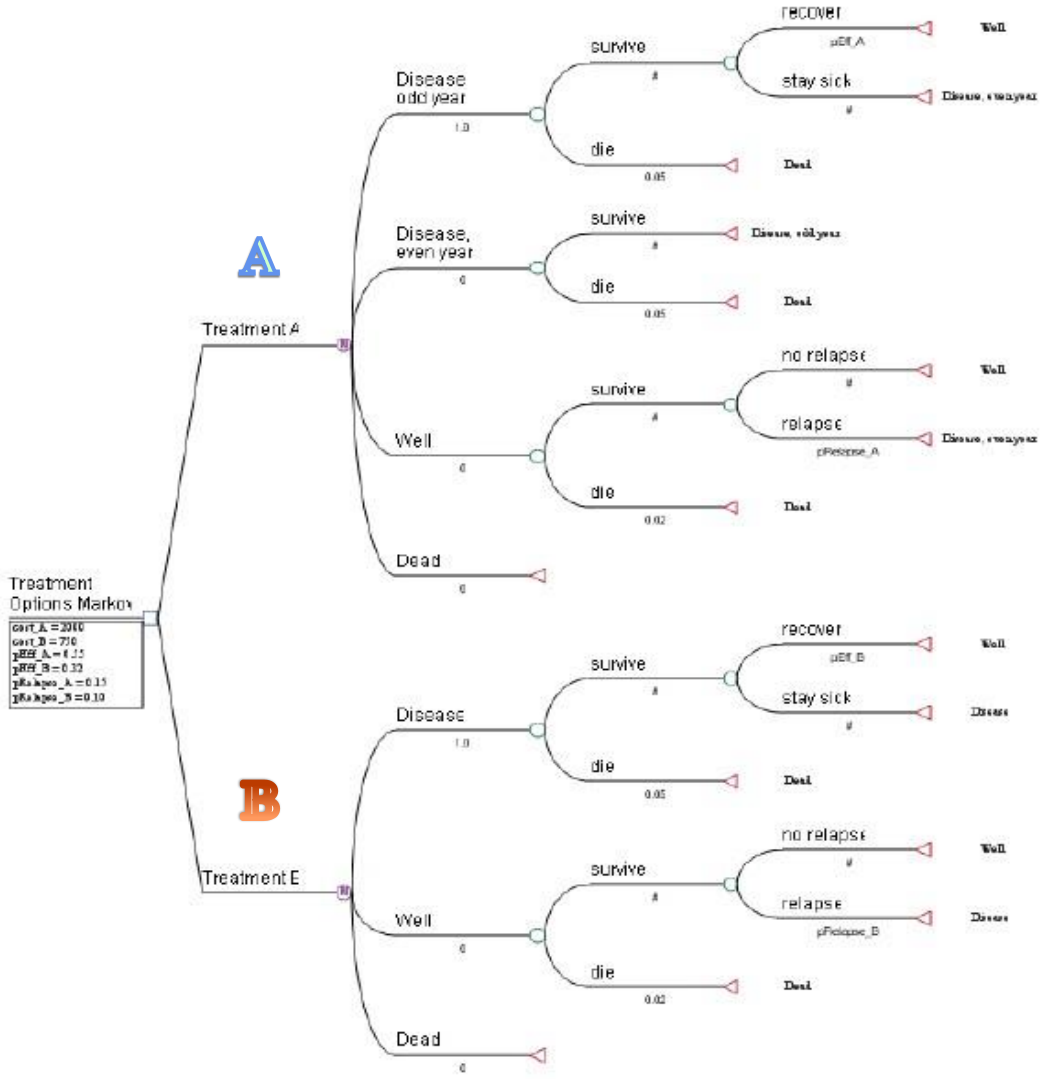
Markov decision tree

If you are interested in comparing two treatments/ Markov Trees:

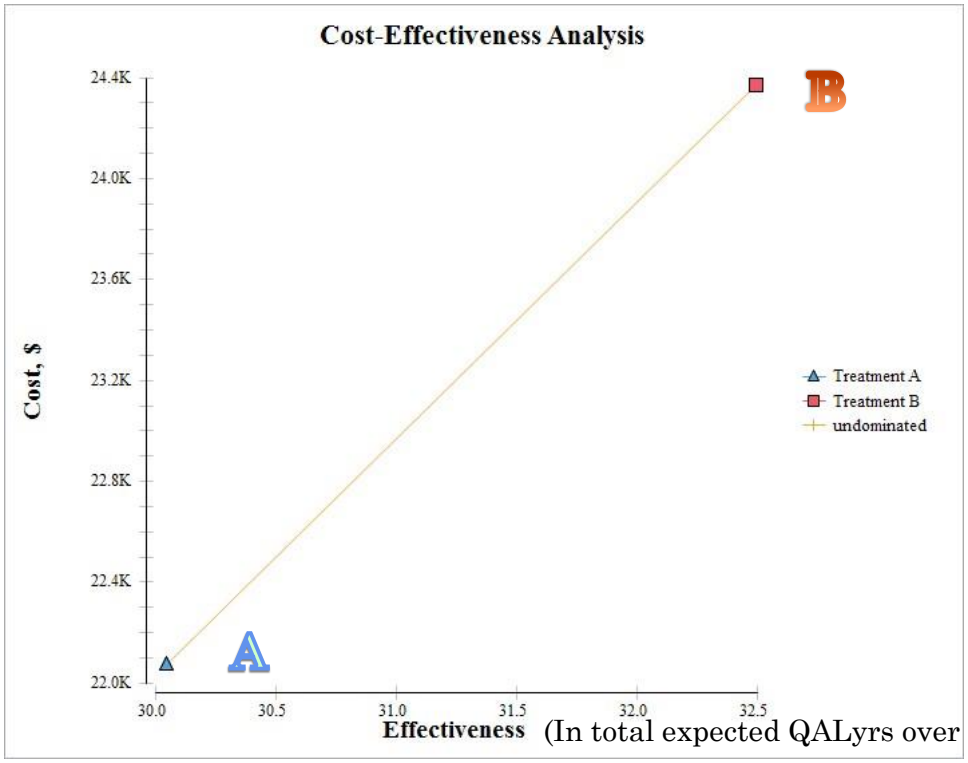
- Markov cycle trees can be appended to paths in a decision tree anywhere you might place a terminal node.
- A decision tree needs you to compare two choices/treatments.
- A Markov decision tree includes Markov subtrees.

A MARKOV DECISION TREE

- Treatment A is presumed to be faster acting, but cannot be used long term due to higher relapse rate.
- Treatment B is slower acting, but can be used on a maintenance basis over a prolonged period, effectively preventing more relapses.



Cost-effectiveness



(In total expected QALyrs over 100 years)

- Treatment A has lower cost but lower effectiveness, while treatment B has higher cost but higher effectiveness.

* Extensions

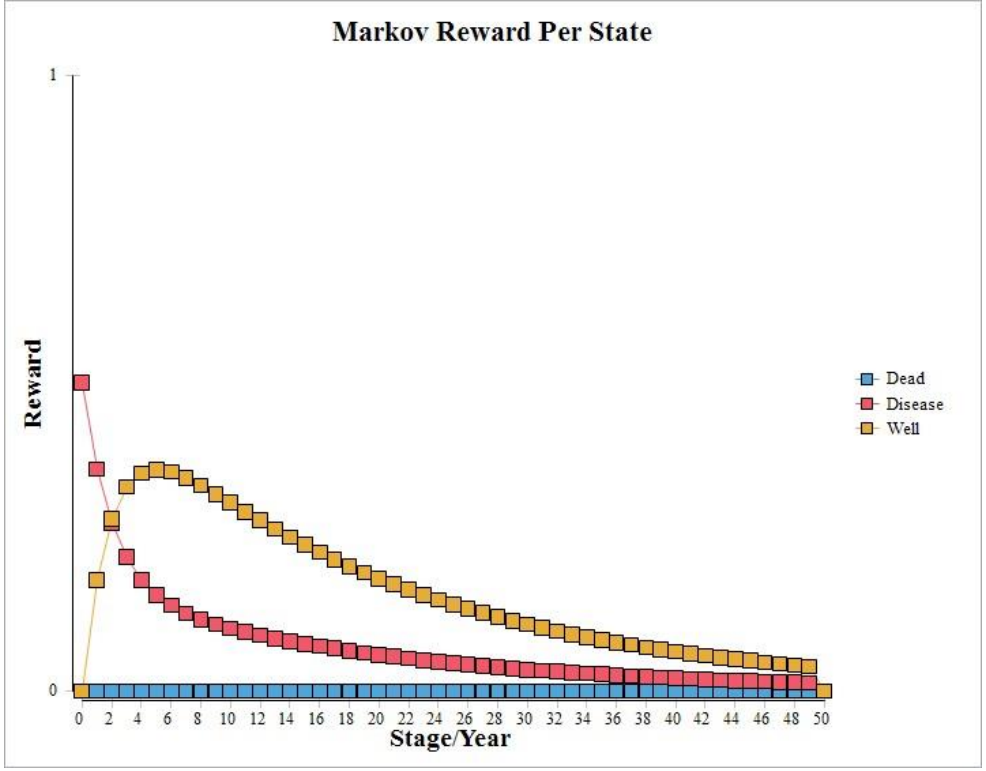
- The default setting of a Markov decision tree is that the transition probabilities are the same for each stage (probability of going from well to sick is the same each stage). But you can introduce a tracker and tunnel variable to make it history-dependent (e.g. different transition probabilities for surgery 1, 2 and 3).

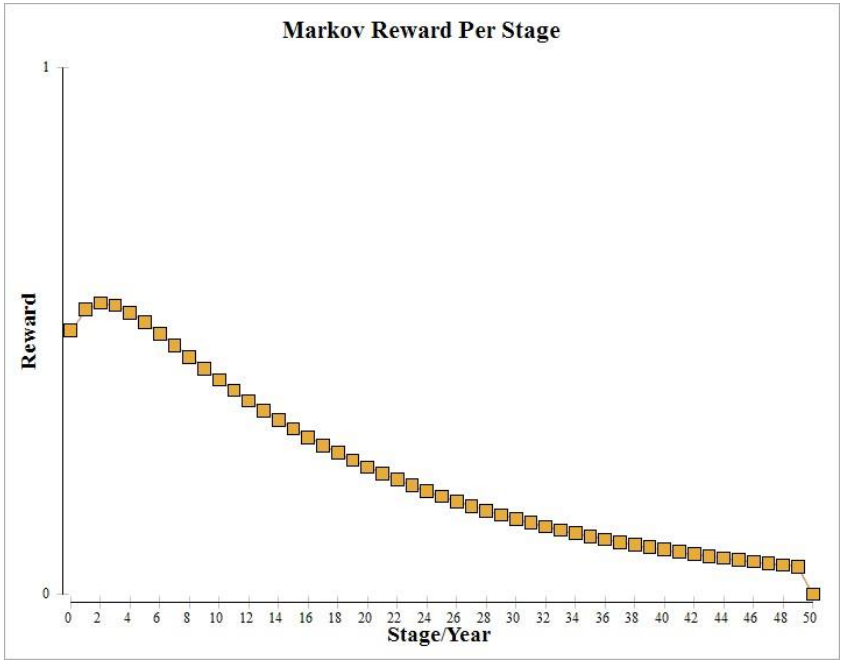
References and useful links

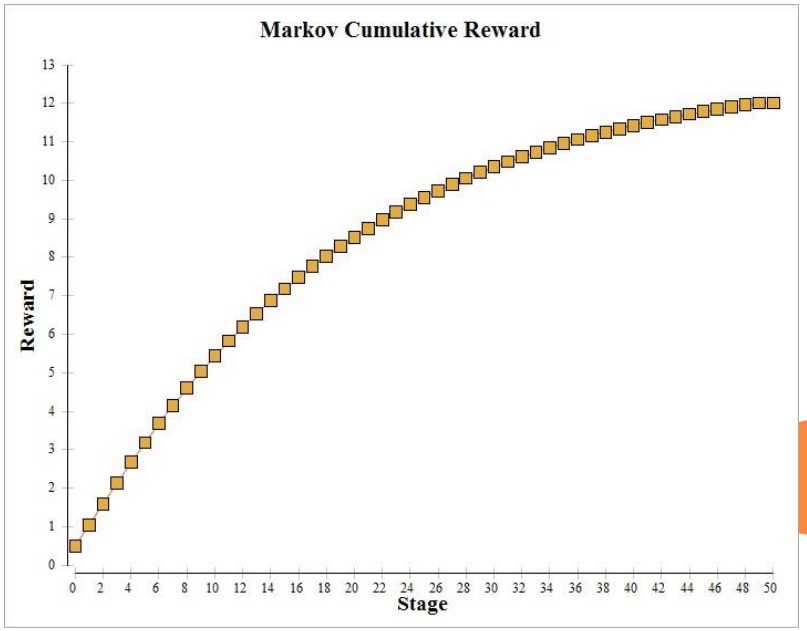
- TreeAge Pro 2013 User‘s Manual

- File to download: How to build a Markov tree(TreeAge Software)
- File to download: Markov Decision Tree
- Also you can find corresponding chapter in manual, page 434.

- Thank you!


Markov Reward Per State
Reward
1
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50
Stage/Year
Dead
Disease
Well


Markov Reward Per Stage
Reward
1
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50
Stage/Year


Markov Cumulative Reward
Reward
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50
Stage