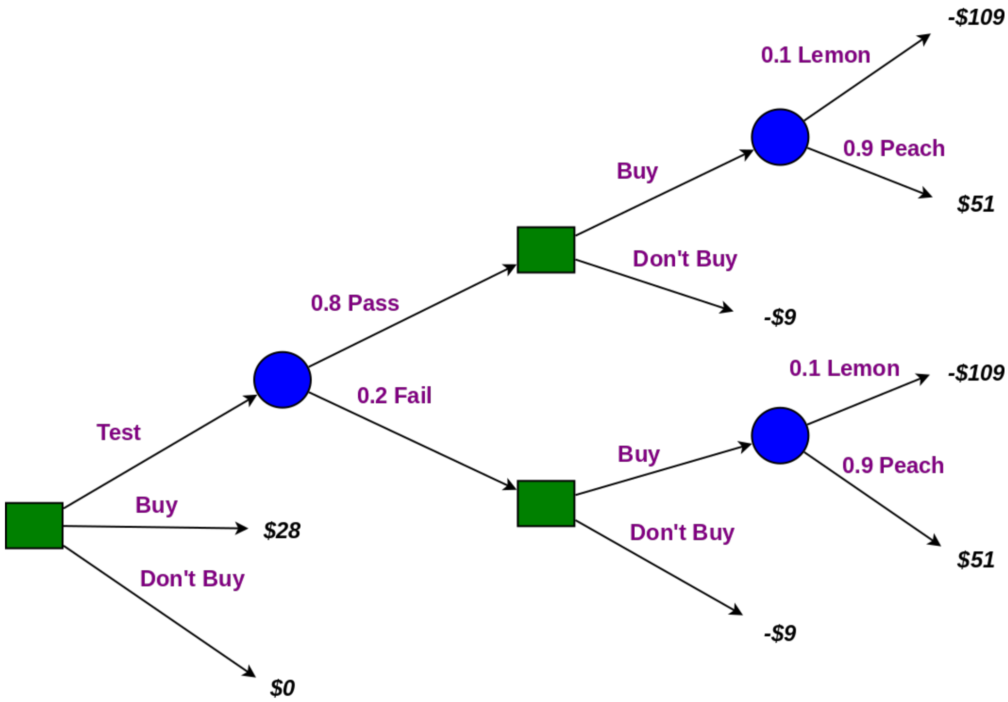
CSC520 Fall 2021 Assignment 5

Due November 15^{th} at 11:59pm

This assignment consists of three questions which involve written answers and code. In order to complete the assignment you must submit a written report in pdf form detailing your answers to the questions as well as your code. As discussed in class all work *must* be your own. You may not use third party libraries or example code to complete the assignment with the exception of csv file loaders. All reports must be clear and well written. All code must be clear, readable, and well-commented. Upload your report as a file called `<unityid>-Assign5.pdf` and your sourcecode in a zip called `<unityid>-Assign5.zip`.

Question 1 Decision Theory Support System (80 points)

For this assignment you will implement a basic decision support too that is designed to build a decision tree, calculate values for the entries and then report both the expected value of each lottery and the action for each decision node. You have been given a file that represents the decision tree shown in the example below.



The file contains three types of entries *Decision* blocks represent a basic decision and include the specification of a name, and a set of named choices each of which leads to a named outcome, decision, or lottery. *Lottery* blocks specify a set of alternatives with probabilities attached, these in turn lead to named outcomes, decisions, or lotteries. Finally *Outcome* lines specify a name and an integer utility value. Note that the file defines a compressed model, the same item may appear under multiple locations however the relevant utility value or choice. Your code will need to rerun the calculations differently in each case. Trees always begin with a node labelled `Start` and end with outcome leaves.

When run your code should first generate a decision tree in memory using classes for the relevant items. As the tree is generated you should log the creation of each new node in the tree where Number is a numeric index which is incremented for each node:

```
Adding Node <Number> <Type> <Name> <Parent>
```

Your code will then calculate the expected value of each lottery and the decision for each node and print the results to the screen:

```
Expected Value Node:<Number>,<Name> <Value>
Decision Node:<Number>,<Name> <Decision> <Value>
```

Question 2 Bayesian Network Calculations (20 points)

You have been given a set of probability tables that define a probability distribution. For this question you must use these tables to define a Bayes' Net and submit it with your work. You must then use the network to answer the following questions. Crucially you must *show and explain your work including possible reductions, conditional independencies, and simplifications.*

1. What is $P(F = f)$
2. What is $P(C = t|G = t)$
3. What is $P(E = f|A = t, B = f)$
4. What is $P(C = t, G = t|H = f)$

Prior and conditional probabilities known beforehand:

A	P(A)
T	0.02

A	B	P(B | A)
T	T	0.3
F	T	0.1

A	D	C	P(C | A, D)
T	T	T	0.85
F	T	T	0.3
T	F	T	0.5
F	F	T	0.12

D	P(D)
T	0.21

D	E	P(E | D)
T	T	0.3
F	T	0.01

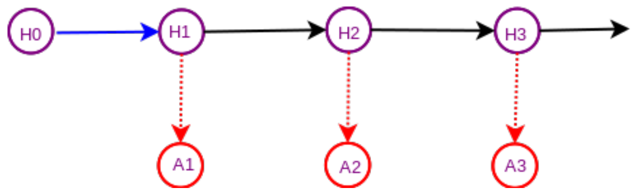
D	F	P(F | D)
T	T	0.8
F	T	0.2

B	E	G	P(G | B, E)
T	T	T	0.91
T	F	T	0.4
F	T	T	0.79
F	F	T	0.97

E	F	H	P(H | E, F)
T	T	T	0.71
T	F	T	0.04
F	T	T	0.1
F	F	T	0.25

Question 3 Markov Models (*20 points extra credit*)

Consider the Markov model shown below.



$$p(H_i = O|H_{i-1} = O) = 0.5$$
$$p(H_i = A|H_{i-1} = O) = 0.4$$
$$p(H_i = N|H_{i-1} = O) = 0.1$$

$$p(H_i = O|H_{i-1} = A) = 0.3$$
$$p(H_i = A|H_{i-1} = A) = 0.5$$
$$p(H_i = N|H_{i-1} = A) = 0.2$$

$$p(H_i = O|H_{i-1} = N) = 0$$
$$p(H_i = A|H_{i-1} = N) = 0.4$$
$$p(H_i = N|H_{i-1} = N) = 0.6$$

$$p(H_0 = O) = 0.3$$
$$p(H_0 = A) = 0.4$$
$$p(H_0 = N) = 0.3$$

$$p(A_i = R|H_i = O) = 0.8$$
$$p(A_i = F|H_i = O) = 0.1$$
$$p(A_i = B|H_i = O) = 0.1$$

$$p(A_i = R|H_i = A) = 0.2$$
$$p(A_i = F|H_i = A) = 0.4$$
$$p(A_i = B|H_i = A) = 0.4$$

$$p(A_i = R|H_i = N) = 0$$
$$p(A_i = F|H_i = N) = 0.5$$
$$p(A_i = B|H_i = N) = 0.5$$

1. If $P(H_2|[B, R]) = \langle 0.3, 0.5, 0.2\rangle$ calculate $p(H_4|[B, R, R, F])$ show your work.
2. Calculate the most likely sequence of hidden states for the observed sequence $[R, F, B, B, R]$ show your work.