Decision Under Uncertainty

State and decision in 421 game

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Grail: Control complex system

as efficiently as possible...

1. Determine State and Action space:
   - List the variables describing the system configurations
   - List the variables describing the possibility of control.
   - Evaluate the branching

That drawback a first estimation of the complexity of our system

In 421:

$$\text{State: } \left\{h \in [0,2], \quad d1, d2, d3, \in [0,6]^3\right\} (648 states)$$

$$\text{Action: } \left\{a1, a2, a3, \in [keep, roll]^3\right\} (8 actions)$$

Grail: Control complex system

as efficiently as possible...

1. Determine State and Action space:
2. Define, compute, learn, optimize a **policy**
   - i.e. a function that returns an action to perform considering a reached state s.

$$\text{Policy:} \quad \pi(s) \in \text{Action}$$

Markovian condition:

The state is sufficient to determine the best action to perform, no need to look back all the history of the trajectory of the system.

Scripted policy

A succession of `if`, `them`, `else` statement:

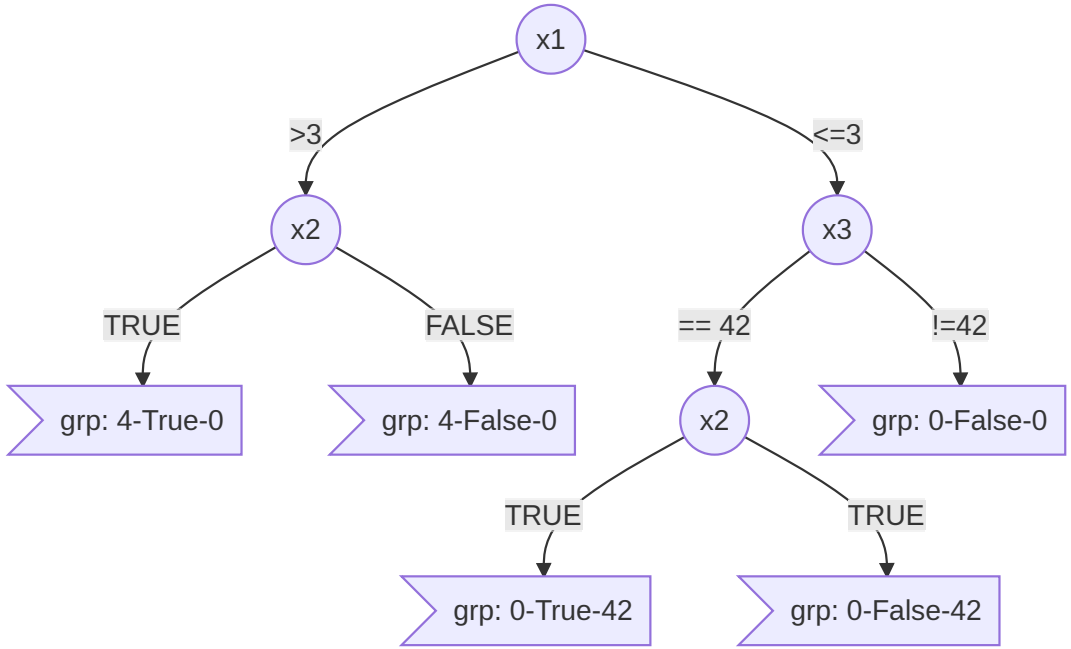
```
state= { "D1": self.dices[0], "D2": self.dices[1],
    "D3": self.dices[2] }

if state["D3"] == 1 :
    if state["D2"] == 2 :
        if state["D1"] == 4 :
            action= "keep-keep-keep"
        else:
            action= "roll-keep-keep"
    else:
        action= "roll-roll-keep"
else:
    action= "roll-roll-roll"
```

Scripted Policy as Decision Tree

A Tree:

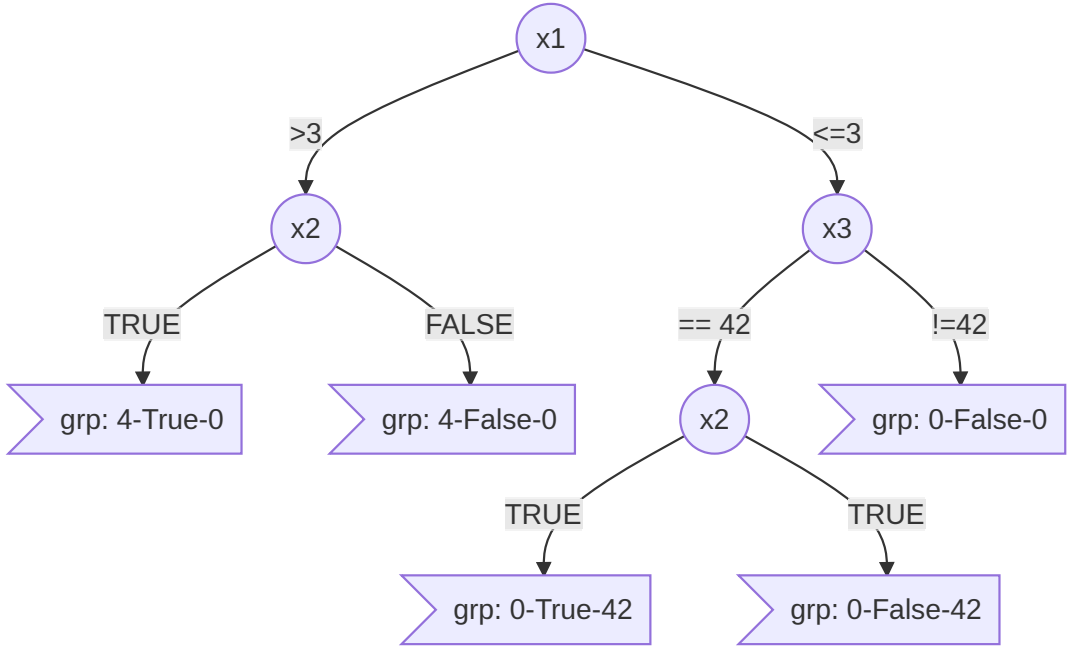
- is a directed graph structure (with **Nodes** and **Oriented Edges**),
- connected, with no loop and a unique path from any 2 nodes.



Scripted Policy as Decision Tree

A Decision Tree

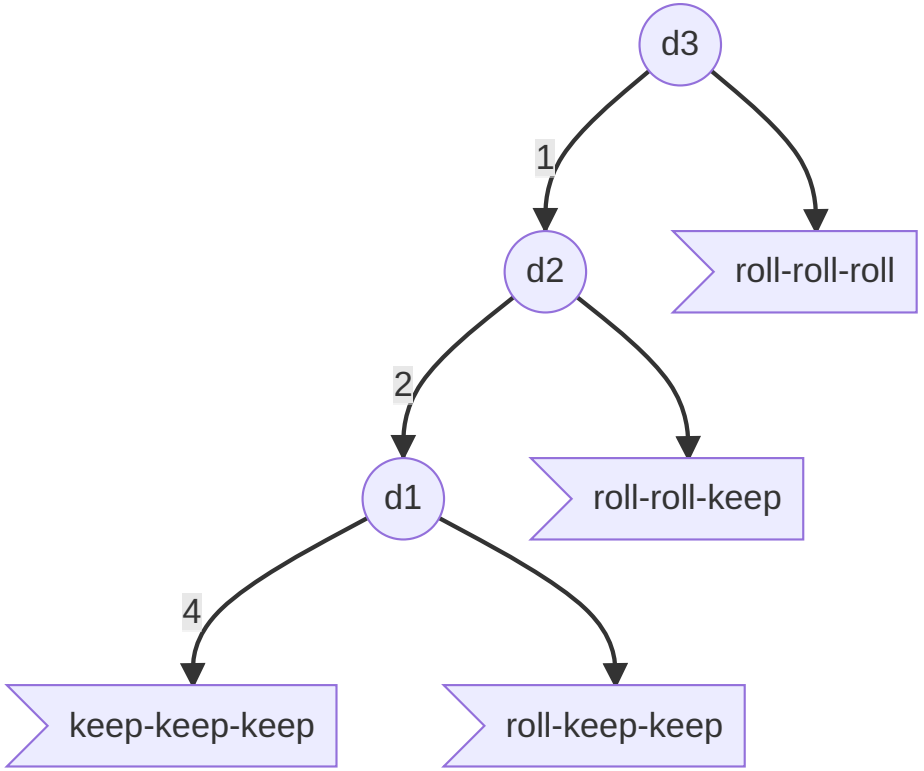
Nodes: variables ; **Edges:** assignment ; **leaf:** group of states / actions



- Expert based Decision tree or learned :[ID3 algorithm](#) (supervised learning))

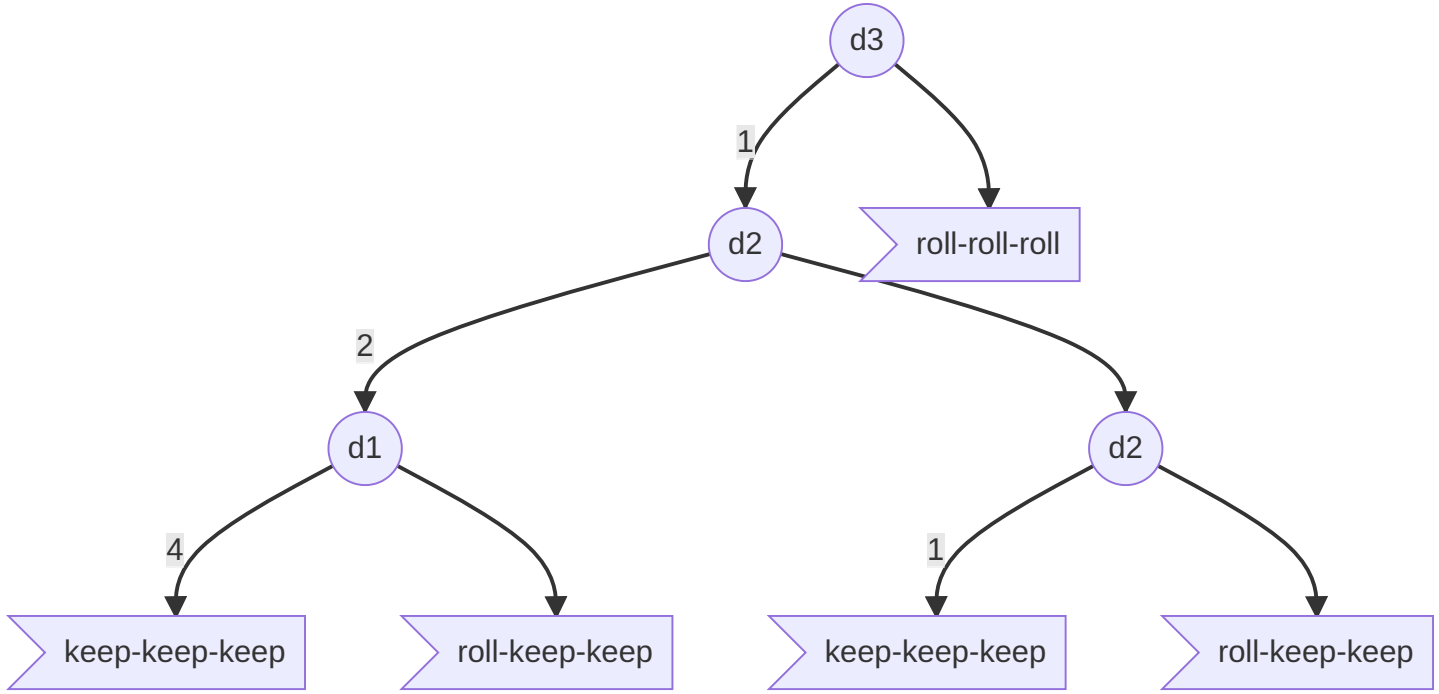
Based on state variable prevalence

Decision Tree (421):



Score: **222** (vs **160** for random)

A Second Decision Tree



(with a score around **320**)

A Second Decision Tree

```
if state["D3"] == 1 :
    if state["D2"] == 2 :
        if state["D1"] == 4 :
            action= "keep-keep-keep"
        else:
            action= "roll-keep-keep"
    elif state["D2"] == 1 :
        if state["D1"] == 1 :
            action= "keep-keep-keep"
        else:
            action= "roll-keep-keep"
    else:
        action= "roll-roll-keep"
else:
    action= "roll-roll-roll"
```