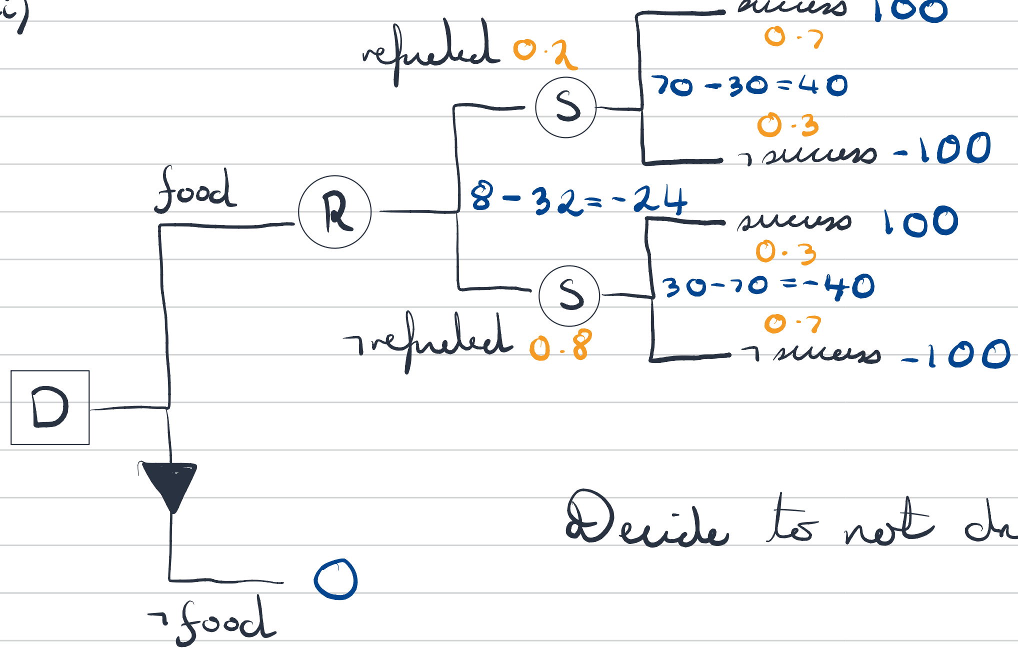
1. (a) Decision = food / ¬ food

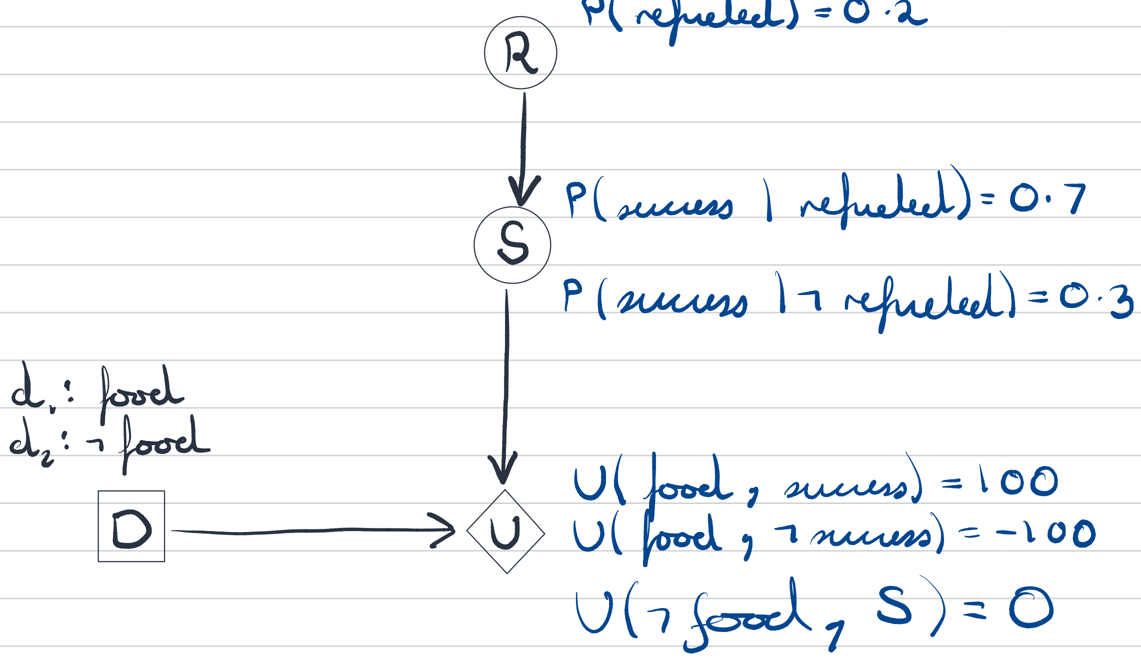
$P(\text{refueled}) = 0.2$
$P(\text{success} \mid \text{refueled}) = 0.7$
$P(\text{success} \mid \neg\text{refueled}) = 0.3$

(i) + (ii)

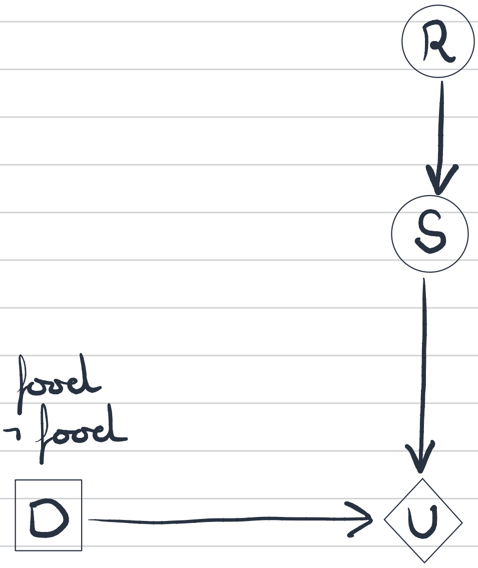


Decide to not drive

(iii)



(iv)



$P(\text{refueled}) = 0.99$

$P(\text{success} \mid \text{refueled}) = 0.7$

$P(\text{success} \mid \neg \text{refueled}) = 0.3$

d_1: food
d_2: $\neg$ food

$U(\text{food}, \text{success}) = 100$
$U(\text{food}, \neg \text{success}) = -100$
$U(\neg \text{food}, \text{success}) = 0$
$U(\neg \text{food}, \neg \text{success}) = 0$

(b) (i)

1. Select an open precondition.
2. Choose an operator or add a new operator that satisfies this precondition.
3. Add the relevant causal link
4. Resolve any clobbering.

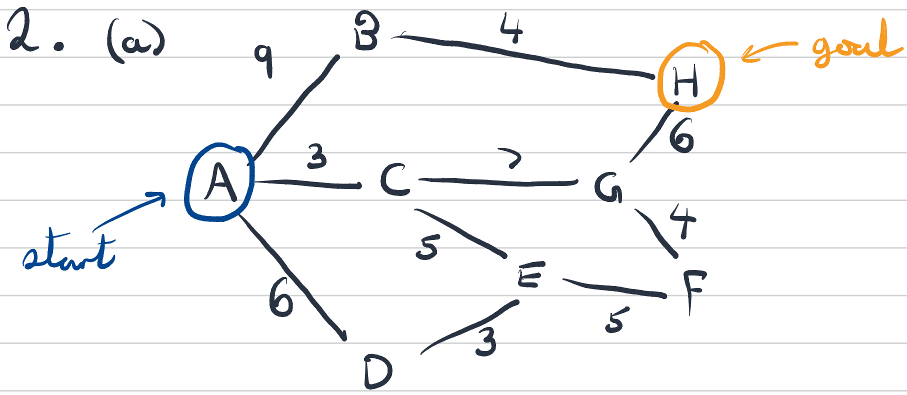
(ii)

- Clobbering occurs when an operations post-condition threatens a causal link.
- To resolve either:
  - promote the clobbered operation by ordering the clobbering action after
  - demote the clobbered operation by ordering the clobbering action before

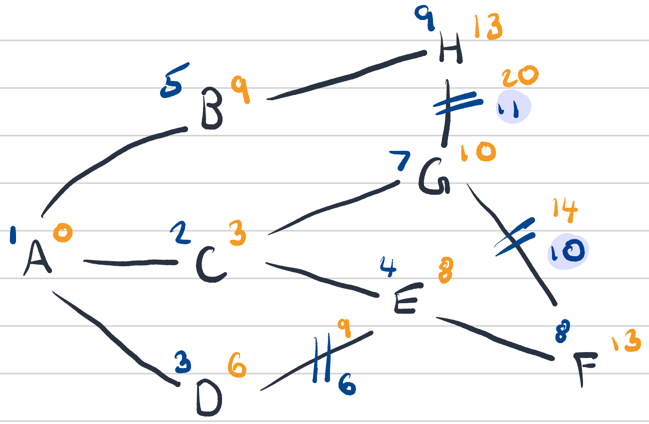
(iii) • Include a step in the plan that includes subplans for different conditions 'sensed' when running the plan.

• Useful when at planning stage knowledge not known or incomplete or dynamic.

2. (a)



(b) (i)

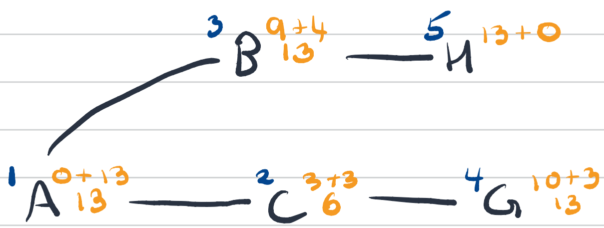


- expanded : <A>, <AC>, <AD>, <ACE>, <AB>, <ACG>, <ACEF>, <ABH>
  8
- route found = <ABH>, cost = 13

(ii)

- expanded : <A>, <AC>, <ACG>, <ACGH>
  4
- route found = <ACGH>, cost = 16

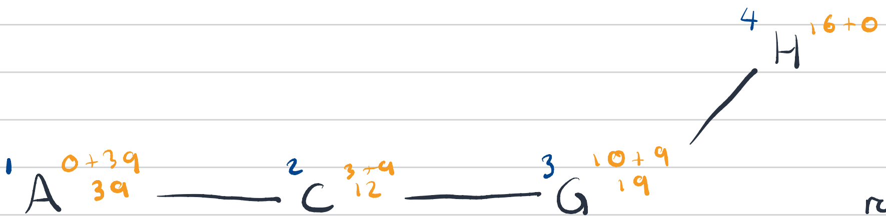
(iii)



- expanded : <A>, <AC>, <AB>, <ACG>, <ABH>
- route found = <ABH>, cost = 13

(c) (i)

Node	A	B	C	D	E	F	G	H
h_2	39	12	9	36	45	27	9	0



nodes expanded = <A>, <AC>, <ACG>, <ACGH>

route found = <ACGH>, cost = 16

(ii) • Optimal path is not discovered.

• Would not always be the case, for example if h_1 values where less than a third of the actual distance to goal

(d)

• Path p to goal selected from frontier.
• Suppose another path p' in frontier.
• Since p chosen before p' and h(p) = 0 ← at goal, then:

$$cost(p) \leq cost(p') + h(p')$$

• Since h is an underestimate, and any p'' that extends p' to goal:

$$cost(p') + h(p') \leq cost(p'')$$

• Therefore:

$$cost(p) \leq cost(p'') \text{ for any other path } p'' \text{ to goal}$$

3. (a) KB = A, A → B, A → C, B → D   Infer D

Forward Chaining

apply all rules possible with current KB

- A
- A → B
- A → C ← not needed to derive D
- B → D

Backward Chaining

- B → D
- A → B
- A

only apply rules required for D

(b) Done in 2017 paper

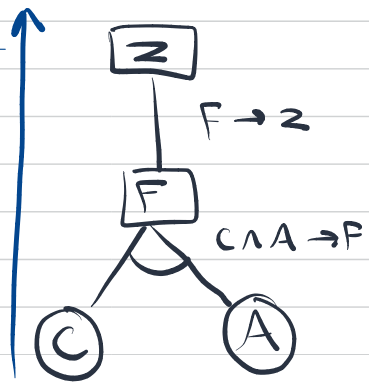
(c) Firing rules in order of KB, and refractoriness

Forward Chaining

Step	KB	Fire
1	A, C	A → E
2	A, C, E	C ∧ A → F
3	A, C, E, F	E → B
4	A, C, E, F, B	B ∧ F → Z
5	A, C, E, F, B, Z	match F → Z but don't fire
6	A, C, E, F, B, Z	All rules checked

Backward Chaining

Step	KB	Fire
1	A, C	B ∧ F → Z
2	A, C	C ∧ A → F
3	A, C, F	E → B
4	A, C, F	A → E
5	A, C, F, E, B	Inferred Z



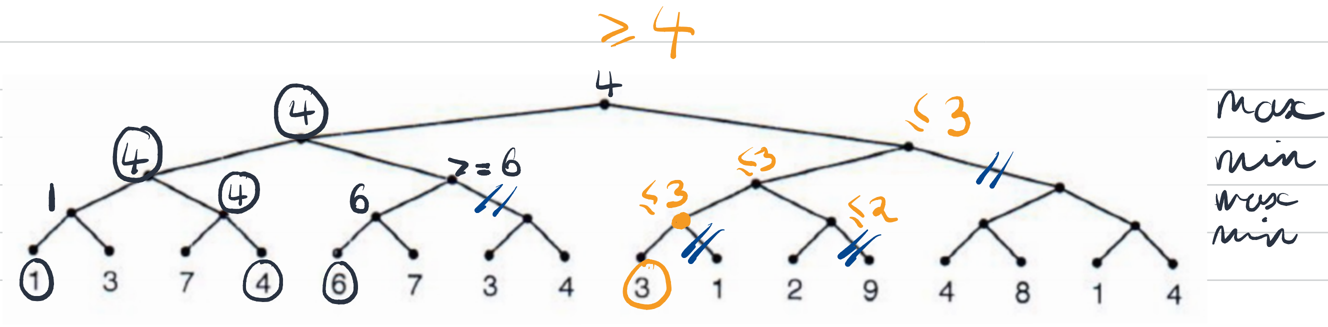
WME

A, C, F, Z

A, C, F

A, C

(d)

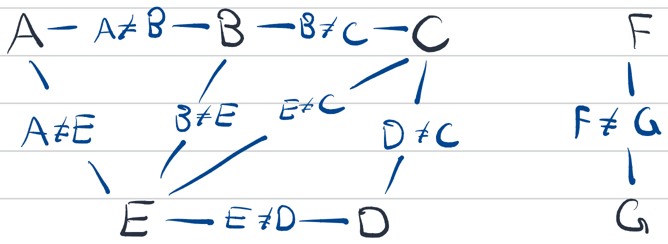


Move left, expecting utility of 4.

(e) —

4. (a) —

(b) (i) All variables have domain {low, medium, high}



(ii)

A	B	C	D	E	F	G	Step
l,m,h	l,m,h	l,m,h	l,m,h	l,m,h	l,m,h	l,m,h	MRV = any, DH = E, LCV = any (L)
m,h	m,h	m,h	m,h	L	l,m,h	l,m,h	MRV = A,B,C,D, DH = B, C, LCV = any (m)
h	m	h	m,h	L	l,m,h	l,m,h	MRV = A, C, DH = C, LCV = h
h	m	h	m	L	l,m,h	l,m,h	MRV/DH = A, D, LCV = h
h	m	h	m	L	l,m,h	l,m,h	MRV = D, LCV = m
h	m	h	m	L	l,m,h	l,m,h	MRV/DH = F, G, LCV = any (L)
h	m	h	m	L	L	m,h	MRV = G, LCV = any (m)
h	m	h	m	L	L	m	all assigned

(c) • Instantiate the tree of A, B, C, ..., O with each value of P, cutset is {P}
• The union of solutions of trees are the possible assignments.

• Without $= d^n = 3^{16} = 43046721$
• With $= d^c(n-c)d^2 = 3^1(16-1)3^2 = 405$

↑ cutset = {P}

(d) (i) h_4 – since the search will take less time due to less branches being explored

(ii) $\max(h_4, h_6)$ – since the same branching factor, for each node choose heuristic value that is closest to actual value which (if admissable) is the max of the two

$\max(h_4(a), h_6(a))$

where $a \in$ nodes

5. (a)

(b) $P(A) = 0.001$

$P(H) = \frac{1}{300}$

$P(H \mid A) = 0.9$

$$P(A \mid H) = \frac{P(H \mid A) \times P(A)}{P(H)} = \frac{0.9 \times 0.001}{1/300} = 0.27 = 27\%$$

(c) $P(X \mid D) = 0.98$ $\quad P(Y \mid D) = 0.85$

$P(X \mid \neg D) = 0.08$ $\quad P(Y \mid \neg D) = 0.03$

$P(D) = 0.01$

$$P(D \mid X) = \frac{P(X \mid D) \times P(D)}{P(X)} = \frac{P(X \mid D) \times P(D)}{(P(X \mid D) \times P(D)) + (P(X \mid \neg D) \times P(\neg D))}$$

$$= \frac{0.98 \times 0.01}{(0.98 \times 0.01) + (0.08 \times 0.99)} \approx 0.1101$$

$$P(D \mid Y) = \frac{P(Y \mid D) \times P(D)}{P(Y)} = \frac{P(Y \mid D) \times P(D)}{(P(Y \mid D) \times P(D)) + (P(Y \mid \neg D) \times P(\neg D))}$$

$$= \frac{0.85 \times 0.01}{(0.85 \times 0.01) + (0.03 \times 0.99)} \approx 0.2225$$

Therefore pick test Y since $P(D \mid Y) > P(D \mid X)$

(d)

a	b	c	$a \to b$	$\neg b \to c$	c	KB	a
T	T	T	T	T	T	T	T
T	T	F	T	T	F	F	T
T	F	T	F	T	T	F	T
T	F	F	F	F	F	F	T
F	T	T	T	T	T	T	F
F	T	F	T	T	F	F	F
F	F	T	T	T	T	T	F
F	F	F	T	F	F	F	F

← when a = F, b = T, c = T
KB = T but a = F

therefore not valid

(e) ?

(f)
- Pick a variable and new value at random
- If it is an improvement adopt it.
- Else adopt with probability:

$$e^{\frac{(h(n') - h(n))}{T}}$$ ← for maximising

where n = current assignment
n' = new assignment
T = temperature

- Temperature can be reduced over time.