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Task1

(a) For all the rows where KB is true, S1 is true

So $KB \models S1$

(b) There is atleast one row where KB is not true (not (KB) is true) where S1 is true (not (S1) is false).

So $not(KB) \not\models not(S1)$

Task2

Given, First Case :- When A is true, B is false, C is false, D is true
Second Case :- When A is false, B is false, C is true, D is false

First Case :- $A \wedge \neg B \wedge \neg C \wedge D$
Second Case :- $\neg A \wedge \neg B \wedge C \wedge \neg D$

The Sentence that Satisfies the two Cases is
$\neg(A \wedge \neg B \wedge \neg C \wedge D) \wedge \neg(\neg A \wedge \neg B \wedge C \wedge \neg D)$

Applying Demorgans law :-

$(\neg A \vee B \vee C \vee \neg D) \wedge (A \vee B \vee \neg C \vee D)$

This is in CNF Form

Task-3

$A \Leftrightarrow B$
$B \Rightarrow C$
$P \Rightarrow A$
$C \wedge E \Rightarrow F$

~~E~~
D

Convert to HORN FORM

$A \Rightarrow B$
$B \Rightarrow A$
$B \Rightarrow C$
$D \Rightarrow A$
$C \wedge E \Rightarrow F$
E
D

(i) forward chaining

$\frac{D,\ D \Rightarrow A}{A}$ $\frac{C,\ E,\ C \wedge E \Rightarrow F}{F}$

$\frac{A,\ A \Rightarrow B}{B}$

$\frac{B,\ B \Rightarrow C}{C}$

So $KB \models F$

(ii) Backward Chaining

| F |

Consider $C \wedge E \Rightarrow F$

| C |
| F |

Consider $B \Rightarrow C$

| B |
| C |
| F |

Consider $A \Rightarrow B$

| A |
| B |
| C |
| F |

Consider $D \Rightarrow A$

So

$D, \quad D \Rightarrow A$

A

| ~~A~~ |
| B |
| C |
| F |

$A, \quad A \Rightarrow B$

B

| ~~B~~ |
| C |
| F |

$$\frac{B,\ B \Rightarrow C}{C}$$

$\not C$
F

$$\frac{C,\ E,\ C \wedge E \Rightarrow F}{F}$$

$\not F$

So, $KB \not\models F$

Convert to CNF

$(\neg A \vee B) \wedge (\neg B \vee A)$

$(\neg B \vee C)$

$(\neg D \vee A)$

$(\neg C \vee \neg E \vee F)$

E

D

(iii) Resolution

CNF KB ∧ ¬α:

(¬A ∨ B) (¬B ∨ A) (¬B ∨ C) (¬D ∨ A)

(¬C ∨ ¬E ∨ F) E D ¬F

¬C ∨ ¬E ∨ F ¬F

¬C ∨ ¬E

¬B ∧ A ∨ B

¬A

¬C ∨ ¬E E

¬C

¬A ¬D ∨ A

¬D

¬C ¬B ∨ C

¬B

¬D D

□

So KB ⊨ F

Task-4

(a) Constants

John, Mary, May 1

predicates

Rain(X) : It rains on X

Gives 10,000(x, y) : X gives 10,000 to y

MovesLawn(X) : X moves lawn

Contract

Rain(May 1) $\Rightarrow$ Gives 10,000 (John, Mary)

Gives 10,000 (John, Mary) $\Rightarrow$ MovesLawn(Mary)

(b) Events

$\neg$ Rain(May 1) $\wedge$ Gives 10K (John, Mary)

$\wedge$ MovesLawn (Mary)

(c) For the sequence of events to be true,

$R\_M\_1 = F$, $G\_J\_M = T$, $M\_M = F$

for this model,
contract is true,
so contract is not violated.

(d) Symbols

Rain(May-1) : R_M_1
Rain(John) : R_J
Rain(Mary) : R_M
Gives lok(May1, John) : G_M1_J
Gives lok(May1, Mary) : G_M1_M
Gives lok(May1, May1) : G_M1_M1
Gives lok(Mary, John) : G_M_J
Gives lok(Mary, Mary) : G_M_M
Gives lok(Mary, May1) : G_M_M1
Gives lok(John, Mary) : G_J_M
Gives lok(John, John) : G_J_J
Gives lok(John, May1) : G_J_M1
MovesLawn(May1) : M_M1
MovesLawn(Mary) : M_M
MovesLawn(John) : M_J

Contract

$R\_M\_1 \Rightarrow G\_J\_M$

$G\_J\_M \Rightarrow M\_M$

Events

$\neg R\_M\_1 \wedge G\_J\_M \wedge M\_M$

Task-5

CONSTANTS : $A_1, A_2, A_3, C_1, C_2, C_3, B$

PREDICATES:

isChild(X) : X is a child
isBoat(X) : X is a boat
onLeft(X) : X is on the left Bank
onRight(X) : X is on the Right Bank

START STATE :

$onLeft(A_1) \wedge onLeft(A_2) \wedge onLeft(A_3) \wedge$
$onLeft(C_1) \wedge onLeft(C_2) \wedge onLeft(C_3) \wedge$
$onLeft(B) \wedge isChild(C_1) \wedge isChild(C_2) \wedge$
$isChild(C_3) \wedge isBoat(B)$

GOAL STATE:

$onRight(C_1) \wedge onRight(C_2) \wedge onRight(C_3) \wedge$
$onRight(A_1) \wedge onRight(A_2) \wedge onRight(A_3)$

ACTIONS:

Move-1-L-to-R(p, b)
PRE: $onLeft(p) \wedge onLeft(b) \wedge isBoat(b)$
EFF: $onRight(p) \wedge onRight(b) \wedge not(onLeft(p)) \wedge not(onLeft(b))$

Move-1-R-to-L(p, b)
PRE: $onRight(p) \wedge onRight(b) \wedge isBoat(b)$
EFF: $onLeft(p) \wedge onLeft(b) \wedge not(onRight(p)) \wedge not(onRight(b))$

Move-2-L-to-R (p_1, p_2, b)

PRE: onLeft(p_1) $\wedge$ isChild(p_1) $\wedge$ onLeft(p_2) $\wedge$ onLeft(b) $\wedge$ isBoat(b)

EFF: onRight(p_1) $\wedge$ onRight(p_2) $\wedge$ onRight(b) $\wedge$ not(onLeft(p_1)) $\wedge$ not(onLeft(p_2)) $\wedge$ not(onLeft(b))

Move-2-R-to-L (p_1, p_2, b)

PRE: onRight(p_1) $\wedge$ isChild(p_1) $\wedge$ onRight(p_2) $\wedge$ onRight(b) $\wedge$ isBoat(b)

EFF: onLeft(p_1) $\wedge$ onLeft(p_2) $\wedge$ onLeft(b) $\wedge$ not(onRight(p_1)) $\wedge$ not(onRight(p_2)) $\wedge$ not(onRight(b))

PLAN:

Move-2-L-to-R (c_1, A_1)
Move-1-R-to-L (c_1)
Move-2-L-to-R (c_2, A_2)
Move-1-R-to-L (c_2)
Move-2-L-to-R (c_3, A_3)
Move-1-R-to-L (c_3)
Move-2-L-to-R (c_1, c_2)
Move-1-R-to-L (c_2)
Move-2-L-to-R (c_2, c_3)

Task 6

Number of Constants : 4
Number of arguments per predicate : [1 4]
Number of predicates : 5

Total number of assignments: $[4 \times 5^1 \quad 4 \times 5^4]$

$: [20 \quad 2500]$

So number of PDPL stats

$[2^{20} \quad 2^{2500}]$

Task 7

Execution Monitoring / online Replanning

No changes as during the planning stage, we treat it as a deterministic problem.

Conditional planning

We add the possible sequence of Events to the non deterministic actions.

Move-1-L-to-R(p, b)

PRE: onLeft(p) ∧ onLeft(b) ∧ isBoat(b)

EFF: [onRight(p) ∧ onRight(b) ∧ not(onLeft(p)) ∧ not(onLeft(b))] ∨ [onLeft(p) ∧ onLeft(b)

Similar change to Move-1-R-to-L(p, b)