Assignment - 2 AI

Q-4

Initial axioms

Predicates used → at (obj, loc) – true iff a physical object obj is at place loc.

in-city (loc, city) – true iff a place loc is in the city city.

in (pkg, veh) – true iff the package pkg is in a vehicle veh.

$$Init^0 = at(p1, LA)^0 \wedge at(p2, LA)^0 \wedge at(a, LA)^0 \wedge$$
$$at(t, PA)^0 \wedge in\text{-}city(LA, L)^0 \wedge$$
$$in\text{-}city(PA, P)^0 \wedge in\text{-}city(N, P)^0 \wedge$$
$$in\text{-}city(S, P)^0 \wedge \neg in(p1, a)^0 \wedge \neg in(p_2, a)^0$$
$$\wedge \neg at(p_1, N)^0 \wedge \neg at(p_2, S)^0 \wedge \neg at(p_1, S)^0 \wedge$$
$$\neg at(p_2, N)^0 \wedge \neg in(p_1, t)^0 \wedge \neg in(p2, t)^0$$

Here p1 → package1   P → Paris
      p2 → package2   L → London
      a → airplane
      t → truck
      LA → London airport
      PA → Paris airport
      N → North
      S → South

Goal Axioms

$$Goal^t = at(p_1, N)^t \land at(p_2, S)^t \land \text{~~in~~}$$
$$\land \text{ in-city}(S, P)^t \land \text{in-city}(N, P)^t$$

Fluents :- $at(p_1, LA), at(p_2, LA), at(a, LA),$
$at(t, PA), \text{in-city}(LA, L), \text{in-city}(PA, P)$
$\text{in-city}(N, P), \text{in-city}(S, P), in(p_1, a),$
$in(p_2, a), at(p_1, N), at(p_2, S), in(p_1, t),$
$in(p_2, t), at(p_2, N), at(p_1, S)$

Actions : Propositionalizing it.

Tload (p_8, x) : Truck loading package(p) at location (x)

Precond: $at(p, x) \land Empty(t) \land at(t, x) \land$
$\qquad \qquad \qquad \qquad \neg in(p, t)$

Effect: $in(p, t) \land \neg Empty(t) \land at(t, x) \land$
$\qquad \qquad \qquad \qquad \qquad at(p, x)$

Here :- Empty (t) → means truck is empty

Tunload (p, x) : Truck unloading package(p) at location (x)

Precond: $at(t, x) \land in(p, t) \land \neg Empty(t) \land at(p, x)$
Effect: $\neg in(p, t) \land Empty(t) \land at(t, x) \land at(p, x)$

A.load (p,x): Airplane loading package (p) at location (x),

Precond: $at(p,x) \wedge Empty(a) \wedge at(a,x) \wedge \neg in(p,a)$

Effect: $in(p,a) \wedge \neg Empty(a) \wedge at(a,x) \wedge at(p,x)$

Here:- Empty(a) → means airplane is Empty.

A.unload (p,x): Airplane unloading package (p) at location (x)

Precond: $at(a,x) \wedge in(p,a) \wedge \neg Empty(a) \wedge at(p,x)$

Effect: $\neg in(p,a) \wedge Empty(a) \wedge at(a,x) \wedge at(p,x)$

A.move (x,y): Airplane flies from x to y

Precond: $at(a,x)$
Effect: $at(a,y) \wedge \neg at(a,x)$

T.move (x,y,z): Truck moves from x to y in a city z.

Precond: $at(t,x) \wedge in\text{-}city(x,z) \wedge in\text{-}city(y,z)$
Effect: $at(t,y) \wedge \neg at(t,x)$

Now we will make successor state axioms based on
$F^{t+1} \Longleftrightarrow Action Causes F^t \vee (F^t \wedge \neg Action Causes Not F^t)$

Successor State Axioms

$$at(p_1, LA)' \Leftrightarrow (at(p_1, LA)^{\circ} \wedge in(p_1, a)^{\circ} \wedge \neg Amove(LA, PA)^{\circ})$$
$$\vee (at(p_1, LA)^{\circ} \wedge \neg in(p_1, a)^{\circ} \wedge Aload(p_1, LA)^{\circ})$$
$$\vee (at(p_1, LA)^{\circ} \wedge \neg in(p_1, a)^{\circ} \wedge \neg Aload(p_1, LA)^{\circ})$$
$$\vee (Amove(PA, LA)^{\circ} \wedge in(p_1, a)^{\circ} \wedge \neg Empty(a)^{\circ})$$
$$\vee (at(a, LA)^{\circ} \wedge Aunload(p_1, LA)^{\circ})$$

$$at(p_2, LA)' \Leftrightarrow (at(p_2, LA)^{\circ} \wedge in(p_2, a)^{\circ} \wedge \neg Amove(LA, PA)^{\circ})$$
$$\vee (at(p_2, LA)^{\circ} \wedge \neg in(p_2, a)^{\circ} \wedge Aload(p_2, LA)^{\circ})$$
$$\vee (at(p_2, LA)^{\circ} \wedge \neg in(p_2, a)^{\circ} \wedge \neg Aload(p_2, LA)^{\circ})$$
$$\vee (Amove(PA, LA)^{\circ} \wedge in(p_2, a)^{\circ} \wedge \neg Empty(a)^{\circ})$$
$$\vee (at(a, LA)^{\circ} \wedge Aunload(p_2, LA)^{\circ})$$

$$at(a, LA)' \Leftrightarrow (at(a, LA)^{\circ} \wedge \neg Amove(LA, PA)^{\circ})$$
$$\vee (at(a, PA)^{\circ} \wedge Amove(PA, LA)^{\circ})$$

$$at(t, PA)' \Leftrightarrow (at(t, PA)^{\circ} \wedge \neg Tmove(PA, N, P)^{\circ})$$
$$\vee (at(t, PA)^{\circ} \wedge \neg Tmove(PA, S, P)^{\circ})$$
$$\vee (at(t, PA)^{\circ} \wedge Tmove(N, PA, P)^{\circ})$$
$$\vee (at(t, PA)^{\circ} \wedge Tmove(S, PA, P)^{\circ})$$

$$in\text{-}city(LA, L)' \Leftrightarrow in\text{-}city(LA, L)^{\circ}$$
$$in\text{-}city(PA, P)' \Leftrightarrow in\text{-}city(PA, P)^{\circ}$$
$$in\text{-}city(N, P)' \Leftrightarrow in\text{-}city(N, P)^{\circ}$$

$$\text{in-city}(S,P)' \Leftrightarrow \text{in-city}(S,P)^\circ$$

$$\text{in}(p_1,a)' \Leftrightarrow (\text{in}(p_1,a)^\circ \wedge \neg A\text{unload}(p_1,LA)^\circ)$$
$$\vee (\text{in}(p_1,a)^\circ \wedge \neg A\text{unload}(p_1,PA)^\circ)$$
$$\vee (A\text{move}(LA,PA)^\circ \wedge \text{in}(p_1,a)^\circ)$$
$$\vee (A\text{move}(PA,LA)^\circ \wedge \text{in}(p_1,a)^\circ)$$
$$\vee (A\text{load}(p_1,LA)^\circ \wedge \text{at}(p_1,LA)^\circ)$$
$$\vee (A\text{load}(p_1,PA)^\circ \wedge \text{at}(p_1,PA)^\circ)$$

$$\text{in}(p_2,a)' \Leftrightarrow (\text{in}(p_2,a)^\circ \wedge \neg A\text{unload}(p_2,LA)^\circ)$$
$$\vee (\text{in}(p_2,a)^\circ \wedge \neg A\text{unload}(p_2,PA)^\circ)$$
$$\vee (A\text{move}(LA,PA)^\circ \wedge \text{in}(p_2,a)^\circ)$$
$$\vee (A\text{move}(PA,LA)^\circ \wedge \text{in}(p_2,a)^\circ)$$
$$\vee (A\text{load}(p_2,LA)^\circ \wedge \text{at}(p_2,LA)^\circ)$$
$$\vee (A\text{load}(p_2,PA)^\circ \wedge \text{at}(p_2,PA)^\circ)$$

$$\text{in}(p_1,t)' \Leftrightarrow (\text{in}(p_1,t)^\circ \wedge \neg T\text{unload}(p_1,PA)^\circ)$$
$$\vee (\text{in}(p_1,t)^\circ \wedge \neg T\text{unload}(p_1,N)^\circ)$$
$$\vee (\text{in}(p_1,t)^\circ \wedge \neg T\text{unload}(p_1,S)^\circ)$$
$$\vee (\text{at}(p_1,PA)^\circ \wedge T\text{load}(p_1,PA)^\circ)$$
$$\vee (\text{at}(p_1,N)^\circ \wedge T\text{load}(p_1,N)^\circ)$$
$$\vee (\text{at}(p_1,S)^\circ \wedge T\text{load}(p_1,S)^\circ)$$
$$\vee (\text{in}(p_1,t)^\circ \wedge T\text{move}(PA,N,P)^\circ)$$
$$\vee (\text{in}(p_1,t)^\circ \wedge T\text{move}(PA,S,P)^\circ)$$
$$\vee (\text{in}(p_1,t)^\circ \wedge T\text{move}(N,PA,P)^\circ)$$
$$\vee (\text{in}(p_1,t)^\circ \wedge T\text{move}(S,PA,P)^\circ)$$ Teacher's Signature ----------- $$\vee (\text{in}(p_1,t)^\circ \wedge T\text{move}(N,S,P)^\circ)$$
$$\vee (\text{in}(p_1,t)^\circ \wedge T\text{move}(S,N,P)^\circ)$$

$$in(p2,t)' \Leftrightarrow (in(p2,t)° \land \lnot Tunload(p2,PA)°)$$
$$\lor (in(p2,t)° \land \lnot Tunload(p2,N)°)$$
$$\lor (in(p2,t)° \land \lnot Tunload(p2,S)°)$$
$$\lor (at(p2,PA)° \land Tload(p2,PA)°)$$
$$\lor (at(p2,N)° \land Tload(p2,N)°)$$
$$\lor (at(p2,S)° \land Tload(p2,S)°)$$
$$\lor (in(p2,t)° \land Tmove(PA,N,P)°)$$
$$\lor (in(p2,t)° \land Tmove(N,PA,P)°)$$
$$\lor (in(p2,t)° \land Tmove(S,PA,P)°)$$
$$\lor (in(p2,t)° \land Tmove(PA,S,P)°)$$
$$\lor (in(p2,t)° \land Tmove(N,S,P)°)$$
$$\lor (in(p2,t)° \land Tmove(S,N,P)°)$$

$$at(p1,N)' \Leftrightarrow (at(p1,N)° \land in(p1,t)° \land \lnot Tmove(N,PA,P)°)$$
$$\lor (at(p1,N)° \land in(p1,t)° \land \lnot Tmove(N,S,P)°)$$
$$\lor (at(p1,N)° \land \lnot in(p1,t)° \land Tload(p1,N)°)$$
$$\lor (at(p1,N)° \land \lnot in(p1,t)° \land \lnot Tload(p1,N)°)$$
$$\lor (Tmove(S,N,P)° \land in(p1,t)° \land \lnot Tempty(t)°)$$
$$\lor (Tmove(PA,N,P)° \land in(p1,t)° \land \lnot Tempty(t)°)$$
$$\lor (at(t,N)° \land Tunload(p1,N)°)$$

$$at(p2,N)' \Leftrightarrow (at(p2,N)° \land in(p2,t)° \land \lnot Tmove(N,PA,P)°)$$
$$\lor (at(p2,N)° \land in(p2,t)° \land \lnot Tmove(N,S,P)°)$$
$$\lor (at(p2,N)° \land \lnot in(p2,t)° \land Tload(p2,N)°)$$
$$\lor (at(p2,N)° \land \lnot in(p2,t)° \land \lnot Tload(p2,N)°)$$
$$\lor (Tmove(S,N,P)° \land in(p2,t)° \land \lnot Tempty(t)°)$$
Teacher's Signature -------------------
$$\lor (Tmove(PA,N,P)° \land in(p2,t)° \land \lnot Tempty(t)°)$$
$$\lor (at(t,N)° \land Tunload(p2,N)°)$$

$$at(p1,s)' \Leftrightarrow (at(p1,s)° \wedge in(p1,t)° \wedge \neg move(S,PA,P)°)$$
$$\vee (at(p1,s)° \wedge \neg in(p1,t)° \wedge \neg move(S,N,P)°)$$
$$\vee (at(p1,s)° \wedge \neg in(p1,t)° \wedge load(p1,s)°)$$
$$\vee (at(p1,s)° \wedge \neg in(p1,t)° \wedge \neg load(p1,s)°)$$
$$\vee (move(N,S,P)° \wedge in(p1,t)° \wedge \neg empty(t)°)$$
$$\vee (move(PA,S,P)° \wedge in(p1,t)° \wedge \neg empty(t)°)$$
$$\vee (at(t,s)° \wedge \neg unload(p1,s)°)$$

$$at(p2,s)' \Leftrightarrow (at(p2,s)° \wedge in(p2,t)° \wedge \neg move(S,PA,P)°)$$
$$\vee (at(p2,s)° \wedge in(p2,t)° \wedge \neg move(S,N,P)°)$$
$$\vee (at(p2,s)° \wedge \neg in(p2,t)° \wedge load(p2,s)°)$$
$$\vee (at(p2,s)° \wedge \neg in(p2,t)° \wedge \neg load(p2,s)°)$$
$$\vee (move(N,S,P)° \wedge in(p2,t)° \wedge \neg empty(t)°)$$
$$\vee (move(PA,S,P)° \wedge in(p2,t)° \wedge \neg empty(t)°)$$
$$\vee (at(t,s)° \wedge \neg unload(p2,s)°)$$

Precondition Axioms

$$load(p1,PA)° \Rightarrow at(p1,PA)° \wedge at(t,PA)° \wedge empty(t)° \wedge \neg in(p1,t)°$$

$$load(p1,N)° \Rightarrow at(p1,N)° \wedge at(t,N)° \wedge empty(t)° \wedge \neg in(p1,t)°$$

$$load(p1,s)° \Rightarrow at(p1,s)° \wedge at(t,s)° \wedge empty(t)° \wedge \neg in(p1,t)°$$

$Tload\ (p1,S)' \Rightarrow at\ (p1,S)' \wedge Empty(t)' \wedge at\ (t,S)' \wedge$
$$\neg in\ (p1,t)'$$

$Tload\ (p1,N)' \Rightarrow at\ (p1,N)' \wedge Empty\ (t)' \wedge at\ (t,N)'$
$$\wedge \neg in\ (p1,t)'$$

$Tload\ (p1,PA)' \Rightarrow at\ (p1,PA)' \wedge Empty\ (t)' \wedge at\ (t,PA)'$
$$\wedge \neg in\ (p1,t)'$$

$Tload\ (p2,PA)^0 \Rightarrow at\ (p2,PA)^0 \wedge Empty\ (t)^0 \wedge at\ (t,PA)^0 \wedge$
$$\neg in\ (p2,t)^0$$

$Tload\ (p2,S)^0 \Rightarrow at\ (p2,S)^0 \wedge Empty\ (t)^0 \wedge at\ (t,S)^0 \wedge$
$$\neg in\ (p2,t)^0$$

$Tload\ (p2,N)^0 \Rightarrow at\ (p2,N)^0 \wedge Empty\ (t)^0 \wedge at\ (t,N)^0 \wedge$
$$\neg in\ (p2,t)^0$$

$Tload\ (p2,PA)' \Rightarrow at\ (p2,PA)' \wedge Empty\ (t)' \wedge at\ (t,PA)'$
$$\wedge \neg in\ (p2,t)'$$

$Tload\ (p2,N)' \Rightarrow at\ (p2,N)' \wedge Empty(t)' \wedge at\ (t,N)'$
$$\wedge \neg in\ (p2,t)'$$

$Tload\ (p2,S)' \Rightarrow at\ (p2,S)' \wedge Empty\ (t)' \wedge at\ (t,S)' \wedge$
$$\neg in\ (p2,t)'$$

$Tunload\ (p1,PA)^0 \Rightarrow at\ (t,PA)^0 \wedge at\ (p1,PA)^0 \wedge \neg Empty(t)^0$
$$\wedge in\ (p1,t)^0$$

$Tunload\ (p1,N)^0 \Rightarrow at\ (t,N)^0 \wedge at\ (p1,N)^0 \wedge \neg Empty(t)^0 \wedge$
$$in\ (p1,t)^0$$

$Tunload\ (p1,S)^0 \Rightarrow at\ (t,S)^0 \wedge at\ (p1,S)^0 \wedge \neg Empty(t)^0 \wedge$
$$in\ (p1,t)^0$$

$Tunload\ (p1,PA)' \Rightarrow at\ (t,PA)' \wedge at\ (p1,PA)' \wedge \neg Empty(t)'$
$$\wedge in\ (p1,t)'$$

$Tunload\ (p1,N)' \Rightarrow at\ (t,N)' \wedge at\ (p1,N)' \wedge \neg Empty(t)'$
$$\wedge in\ (p1,t)'$$

$Tunload(p1,S)^1 \Rightarrow at(t,S)^1 \wedge at(p1,S)^1 \wedge \neg Empty(t)^1 \wedge in(p1,t)^1$

$Tunload(p2,PA)^0 \Rightarrow at(t,PA)^0 \wedge at(p2,PA)^0 \wedge \neg Empty(t)^0 \wedge in(p2,t)^0$

$Tunload(p2,N)^0 \Rightarrow at(t,N)^0 \wedge at(p2,N)^0 \wedge \neg Empty(t)^0 \wedge in(p2,t)^0$

$Tunload(p2,S)^0 \Rightarrow at(t,S)^0 \wedge at(p2,S)^0 \wedge \neg Empty(t)^0 \wedge in(p2,t)^0$

$Tunload(p2,PA)^1 \Rightarrow at(t,PA)^1 \wedge at(p2,PA)^1 \wedge \neg Empty(t)^1 \wedge in(p2,t)^1$

$Tunload(p2,N)^1 \Rightarrow at(t,N)^1 \wedge at(p2,N)^1 \wedge \neg Empty(t)^1 \wedge in(p2,t)^1$

$Tunload(p2,S)^1 \Rightarrow at(t,S)^1 \wedge at(p2,S)^1 \wedge \neg Empty(t)^1 \wedge in(p2,t)^1$

$Aload(p1,LA)^0 \Rightarrow at(a,LA)^0 \wedge at(p1,LA)^0 \wedge Empty(a)^0 \wedge \neg in(p1,a)^0$

$Aload(p1,PA)^0 \Rightarrow at(a,PA)^0 \wedge at(p1,PA)^0 \wedge Empty(a)^0 \wedge \neg in(p1,a)^0$

$Aload(p1,LA)^1 \Rightarrow at(a,LA)^1 \wedge at(p1,LA)^1 \wedge Empty(a)^1 \wedge \neg in(p1,a)^1)$

$Aload(p1,PA)^1 \Rightarrow at(a,PA)^1 \wedge at(p1,PA)^1 \wedge Empty(a)^1 \wedge \neg in(p1,a)^1)$

$Aload(p2,LA)^0 \Rightarrow at(a,LA)^0 \wedge at(p2,LA)^0 \wedge Empty(a)^0 \wedge \neg in(p2,a)^0)$

$Aload(p2,PA)^0 \Rightarrow at(a,PA)^0 \wedge at(p2,PA)^0 \wedge Empty(a)^0 \wedge \neg in(p2,a)^0)$

$Aload(p2,LA)^1 \Rightarrow at(a,LA)^1 \wedge at(p2,LA)^1 \wedge Empty(a)^1 \wedge \neg in(p2,a)^1)$

$Aload\ (p2, PA)' \Rightarrow at(a, PA)' \wedge at(p2, PA)' \wedge Empty(a)' \wedge$
$$\neg in(p2, a)')$$

$Amove\ (LA, PA)^0 \Rightarrow at\ (a, LA)^0$

$Amove\ (PA, LA)^0 \Rightarrow at(a, PA)^0$

$Amove\ (LA, PA)' \Rightarrow at\ (a, LA)'$

$Amove\ (PA, LA)' \Rightarrow at\ (a, PA)'$

$Tmove\ (N, PA, P)^0 \Rightarrow at(t, N)^0 \wedge in\text{-}city\ (N, P)^0 \wedge in\text{-}city\ (PA, P)^0$

$Tmove\ (PA, N, P)^0 \Rightarrow at\ (t, PA)^0 \wedge in\text{-}city\ (PA, P)^0 \wedge in\text{-}city(N, P)^0$

$Tmove\ (N, S, P)^0 \Rightarrow at\ (t, N)^0 \wedge in\text{-}city\ (N, P)^0 \wedge in\text{-}city\ (S, P)^0$

$Tmove\ (S, N, P)^0 \Rightarrow at\ (t, S)^0 \wedge in\text{-}city\ (S, P)^0 \wedge in\text{-}city\ (N, P)^0$

$Tmove\ (S, PA, P)^0 \Rightarrow at\ (t, S)^0 \wedge in\text{-}city\ (S, P)^0 \wedge in\text{-}city\ (PA, P)^0$

$Tmove\ (PA, S, P)^0 \Rightarrow at\ (t, PA)^0 \wedge in\text{-}city\ (PA, P)^0 \wedge in\text{-}city\ (S, P)^0$

$Tmove\ (N, PA, P)' \Rightarrow at\ (t, N)' \wedge in\text{-}city\ (N, P)' \wedge in\text{-}city(PA, P)'$

$Tmove\ (PA, N, P)' \Rightarrow at\ (t, PA)' \wedge in\text{-}city\ (PA, P)' \wedge in\text{-}city\ (N, P)'$

$Tmove\ (N, S, P)' \Rightarrow at\ (t, N)' \wedge in\text{-}city\ (N, P)' \wedge in\text{-}city\ (S, P)'$

$Tmove\ (S,N,P)' \Rightarrow at(t,S)' \wedge in\text{-}city(S,P)' \wedge in\text{-}city(N,P)'$

$Tmove\ (S,PA,P)' \Rightarrow at(t,S)' \wedge in\text{-}city(S,P)' \wedge in\text{-}city(PA,P)'$

$Tmove\ (PA,S,P)' \Rightarrow at(t,PA)' \wedge in\text{-}city(PA,P)' \wedge in\text{-}city(S,P)'$

$Aunload\ (p1,LA)^o \Rightarrow at(a,LA)^o \wedge in(p1,a)^o \wedge \neg empty(a)^o \wedge$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad at(p1,LA)^o$

$Aunload\ (p1,PA)^o \Rightarrow at(a,PA)^o \wedge at(p1,PA)^o \wedge \neg empty(a)^o \wedge$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad in(p1,a)^o$

$Aunload\ (p1,LA)' \Rightarrow at(a,LA)' \wedge at(p1,LA)' \wedge \neg empty(a)' \wedge$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad in\neg at(p1,a)'$

$Aunload\ (p1,PA)' \Rightarrow at(a,PA)' \wedge at(p1,PA)' \wedge \neg empty(a)' \wedge$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad in(p1,a)'$

$Aunload\ (p2,LA)^o \Rightarrow at(a,LA)^o \wedge at(p2,LA)^o \wedge \neg empty(a)^o$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad \wedge in(p2,a)^o$

$Aunload\ (p2,PA)^o \Rightarrow at(a,PA)^o \wedge at(p2,PA)^o \wedge \neg empty(a)^o$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad \wedge in(p2,a)^o$

$Aunload\ (p2,LA)' \Rightarrow at(a,LA)' \wedge at(p2,LA)' \wedge \neg empty(a)'$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad \wedge in(p2,a)'$

$Aunload\ (p2,PA)' \Rightarrow at(a,PA)' \wedge at(p2,PA)' \wedge \neg empty(a)'$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad \wedge in(p2,a)'$

Action-Exclusion Axioms

Excl:

$\Rightarrow$ ㄱAload $(p1, LA)^0$ v ㄱAload $(p2, LA)^0$

$\Rightarrow$ ㄱAload $(p1, PA)^0$ v ㄱAload $(p2, PA)^0$

$\Rightarrow$ ㄱAload $(p1, LA)^1$ v ㄱAload $(p2, LA)^1$

$\Rightarrow$ ㄱAload $(p1, PA)^1$ v ㄱAload $(p2, PA)^1$

$\Rightarrow$ ㄱAload $(p1, LA)^0$ v ㄱAload $(p1, PA)^0$

$\Rightarrow$ ㄱAload $(p2, LA)^0$ v ㄱAload $(p2, PA)^0$

$\Rightarrow$ ㄱAload $(p1, LA)^1$ v ㄱAload $(p1, PA)^1$

$\Rightarrow$ ㄱAload $(p2, LA)^0$ v ㄱAload $(p2, PA)^1$

$\Rightarrow$ ㄱAmove $(LA, PA)^0$ v ㄱAmove $(PA, LA)^0$

$\Rightarrow$ ㄱAmove $(LA, PA)^1$ v ㄱAmove $(PA, LA)^1$

$\Rightarrow$ ㄱTload $(p1, PA)^0$ v ㄱTload $(p2, PA)^0$

$\Rightarrow$ ㄱTload $(p1, N)^0$ v ㄱTload $(p2, N)^0$

$\Rightarrow$ ㄱTload $(p1, S)^0$ v ㄱTload $(p2, S)^0$

$\Rightarrow$ ㄱTload $(p1, PA)^1$ v ㄱTload $(p2, PA)^1$

$\Rightarrow$ ㄱTload $(p1, N)^1$ v ㄱTload $(p2, N)^1$

$\Rightarrow$ ㄱTload $(p1, S)^1$ v ㄱTload $(p2, S)^1$

$\Rightarrow$ ㄱTload $(p1, PA)^0$ v ㄱTload $(p1, N)^0$ v ㄱTload $(p1, S)^0$

$\Rightarrow$ ㄱTload $(p2, PA)^0$ v ㄱTload $(p2, N)^0$ v ㄱTload $(p2, S)^0$

$\Rightarrow$ ㄱTload $(p1, PA)^1$ v ㄱTload $(p1, N)^1$ v ㄱTload $(p1, S)^1$

$\Rightarrow$ ㄱTload $(p2, PA)^1$ v ㄱTload $(p2, N)^1$ v ㄱTload $(p2, S)^1$

$\Rightarrow$ ㄱTmove $(PA, N, P)^0$ v ㄱTmove $(PA, S, P)^0$ v ㄱTmove $(N, S, P)^0$ v
ㄱTmove $(S, N, P)^0$ v ㄱTmove $(N, PA, P)^0$
v ㄱTmove $(S, PA, P)^0$

$\Rightarrow \lnot Tmove(N,S,P)' \lor \lnot Tmove(S,N,P)' \lor \lnot Tmove(N,PA,P)'$
$\lor \lnot Tmove(PA,N,P)' \lor \lnot Tmove(S,PA,P)' \lor \lnot Tmove$
$(PA,S,P)'$

$\Rightarrow \lnot Aunload(p1,LA)^{\circ} \lor \lnot Aunload(p2,LA)^{\circ}$

$\Rightarrow \lnot Aunload(p2,PA)^{\circ} \lor \lnot Aunload(p1,PA)^{\circ}$

$\Rightarrow \lnot Aunload(p1,LA)' \lor \lnot Aunload(p2,LA)'$

$\Rightarrow \lnot Aunload(p2,PA)' \lor \lnot Aunload(p1,PA)'$

$\Rightarrow \lnot Aunload(p1,LA)^{\circ} \lor \lnot Aunload(p1,PA)^{\circ}$

$\Rightarrow \lnot Aunload(p2,PA)^{\circ} \lor \lnot Aunload(p2,LA)^{\circ}$

$\Rightarrow \lnot Aunload(p1,LA)' \lor \lnot Aunload(p1,PA)'$

$\Rightarrow \lnot Aunload(p2,PA)' \lor \lnot Aunload(p2,LA)'$

$\Rightarrow \lnot Tunload(p1,PA)^{\circ} \lor \lnot Tunload(p2,PA)^{\circ}$

$\Rightarrow \lnot Tunload(p1,N)^{\circ} \lor \lnot Tunload(p2,N)^{\circ}$

$\Rightarrow \lnot Tunload(p1,S)^{\circ} \lor \lnot Tunload(p2,S)^{\circ}$

$\Rightarrow \lnot Tunload(p1,PA)' \lor \lnot Tunload(p2,PA)'$

$\Rightarrow \lnot Tunload(p1,N)' \lor \lnot Tunload(p2,N)'$

$\Rightarrow \lnot Tunload(p1,S)' \lor \lnot Tunload(p2,S)'$

$\Rightarrow \lnot Tunload(p1,PA)^{\circ} \lor \lnot Tunload(p1,N)^{\circ} \lor \lnot Tunload(p1,S)^{\circ}$

$\Rightarrow \lnot Tunload(p2,PA)^{\circ} \lor \lnot Tunload(p2,S)^{\circ} \lor \lnot Tunload(p2,N)^{\circ}$

$\Rightarrow \lnot Tunload(p1,PA)' \lor \lnot Tunload(p1,N)' \lor \lnot Tunload(p1,S)'$

$\Rightarrow \lnot Tunload(p2,PA)' \lor \lnot Tunload(p2,S)' \lor \lnot Tunload(p2,N)'$