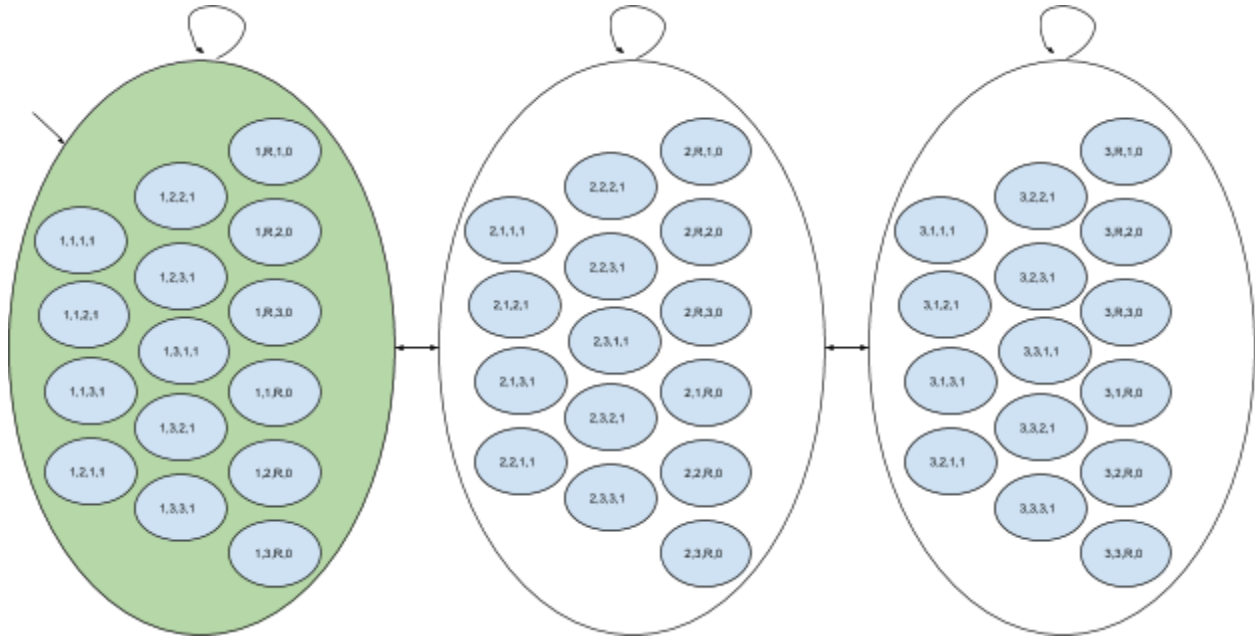
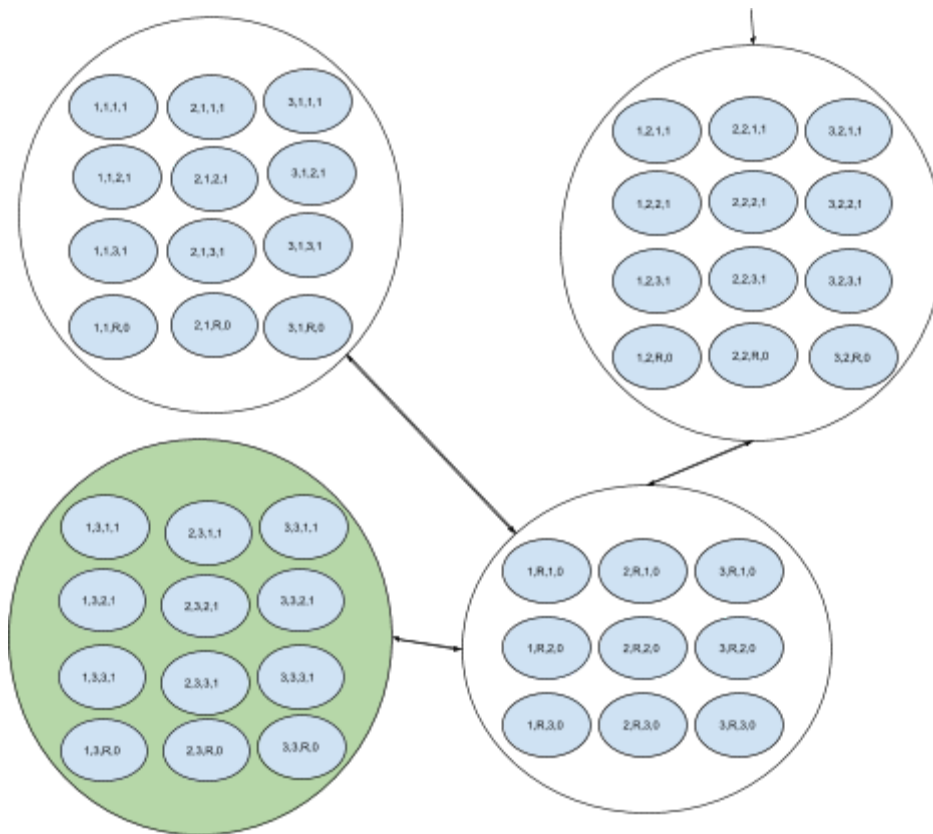
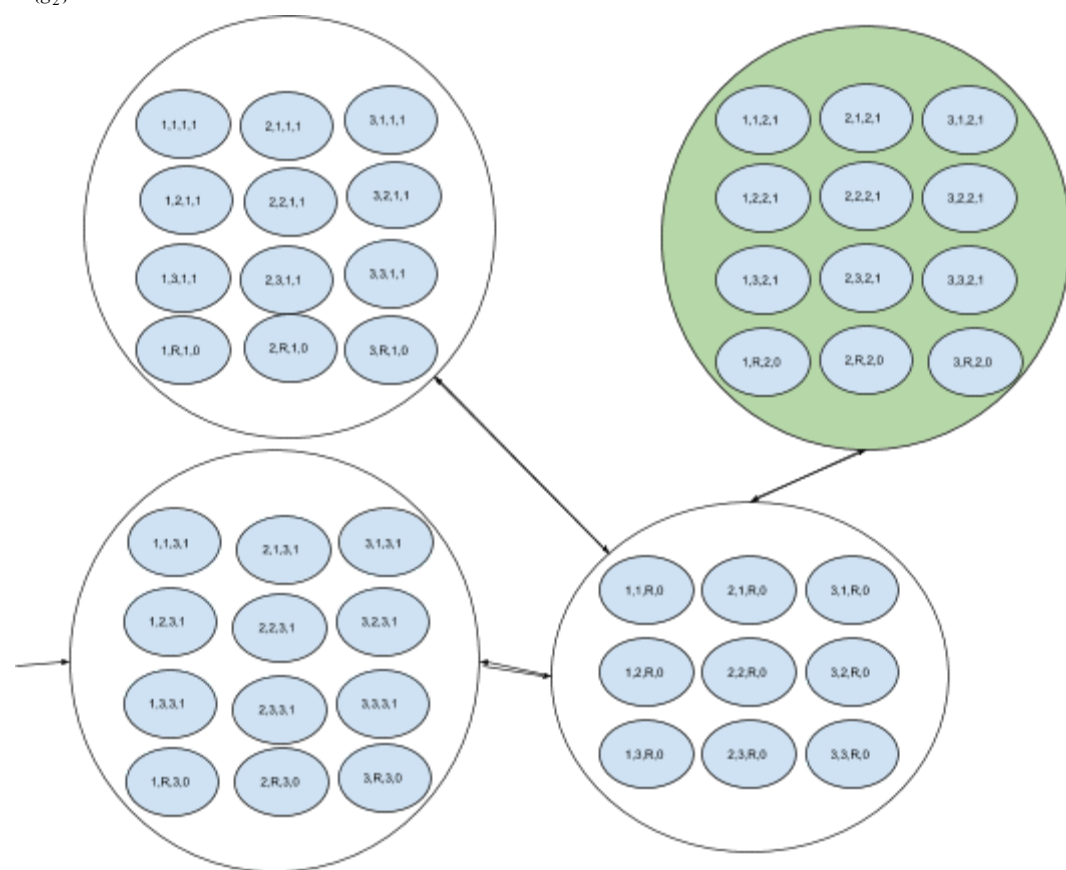
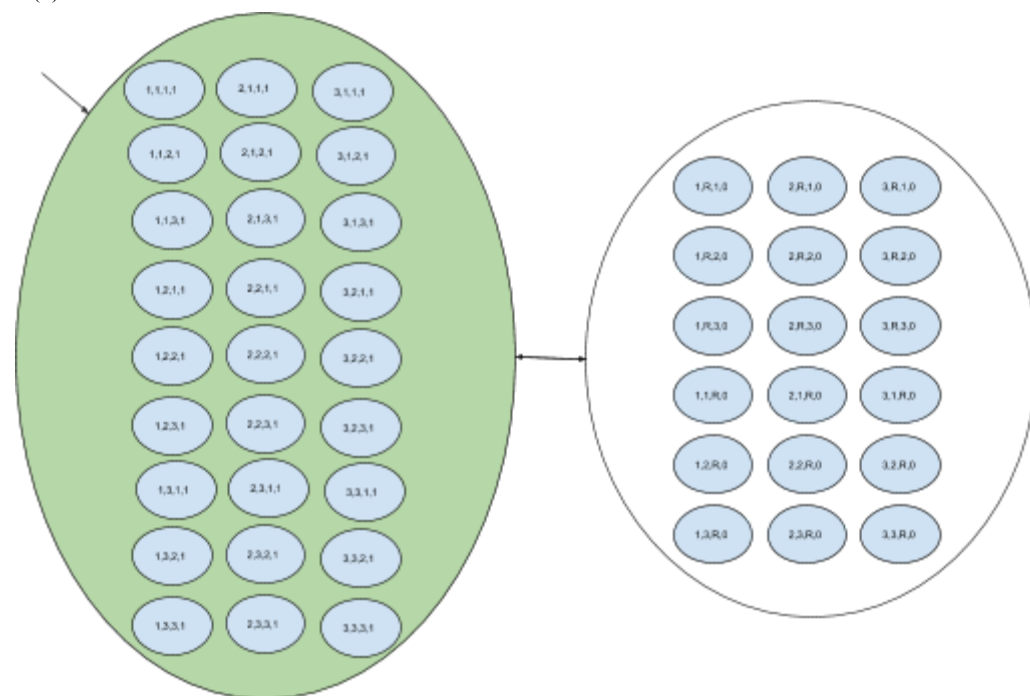


Exercise 13**(i) Atomic projections** $\pi_{\{r\}} :$  $\pi_{\{g_1\}} :$ 

$\pi_{\{g_2\}} :$



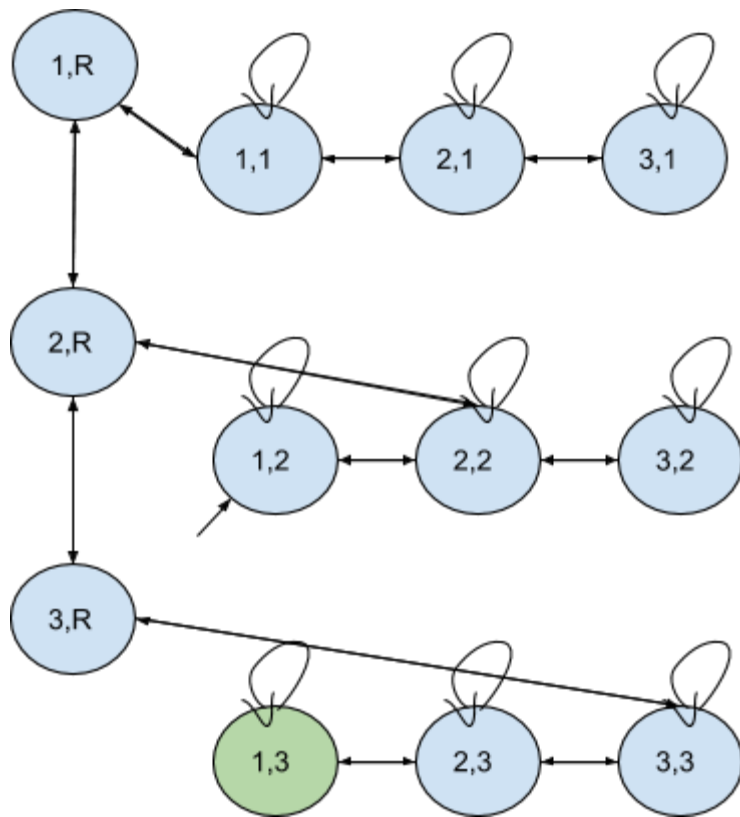
$\pi_{\{c\}} :$



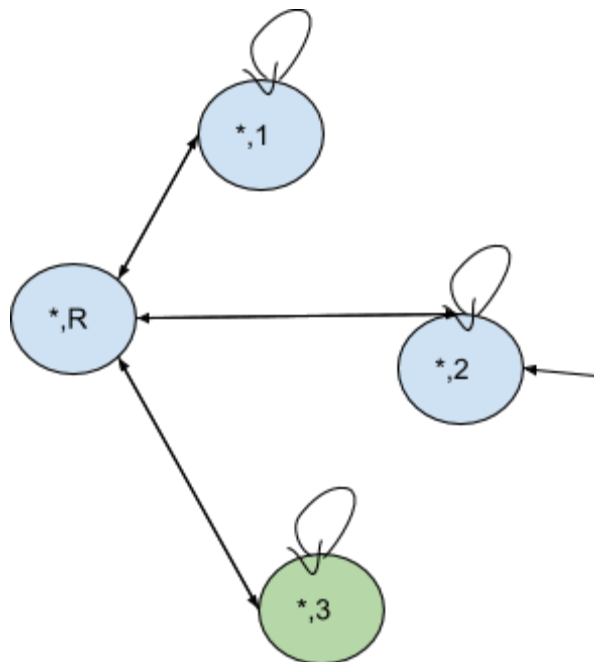
(ii) Merge-and-Shrink abstraction

R and g1

Merge:

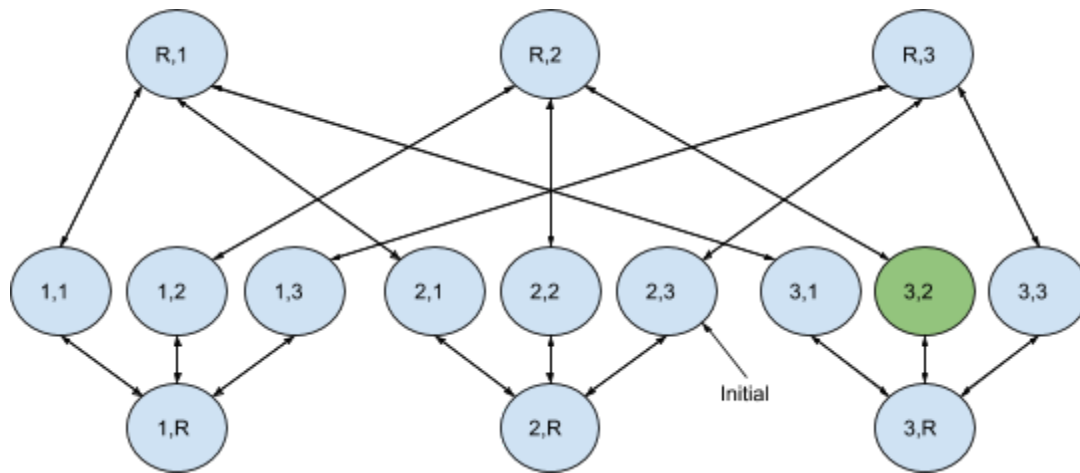


Shrink:



Result and g2:

Merge:



Heuristic value for the initial state = 4

Exercise 14

(i) Necessary subgoals

$$\begin{aligned}
 N &= \{g1=3, g2=2, r=1\} \vee \{g1=3, g2=2\} \\
 N &= N \cup \{r=3, g1=R, c=0\} \cup \{r=2, g2=R\} \\
 &= \{g1=3, g2=2, r=3, g1=R, c=0, r=2, g2=R\}
 \end{aligned}$$

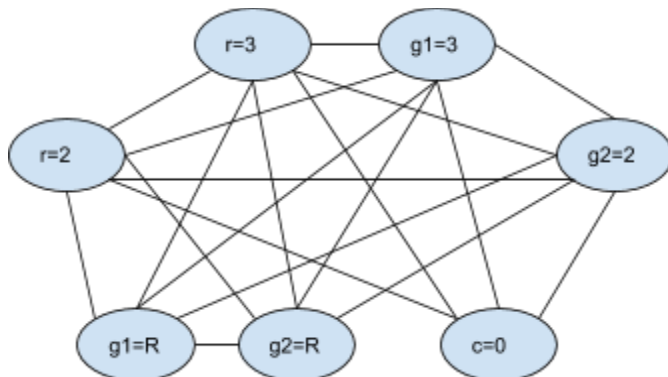
(ii)

Facts of Π :

r=1	No, it is in the initial state.
r=2	Yes, there is no delete relaxed plan without this fact.
r=3	Yes, there is no delete relaxed plan without this fact.
g1=1	No, there is a delete relaxed plan without this fact.
g1=2	No, it is in the initial state.
g1=3	Yes, this is part of the goal.
g1=R	Yes, there is no delete relaxed plan without this fact.
g2=1	No, there is a delete relaxed plan without this fact.
g2=2	Yes, this is part of the goal.
g2=3	No, it is in the initial state.
g2=R	Yes, there is no delete relaxed plan without this fact.
c=0	Yes, there is no delete relaxed plan without this fact.
c=1	No, it is in the initial state.

(iii) Induced action landmarks:

r=2: {drive(1,2)}
 r=3: {drive(2,3)}
 g1=3: {putdown(1,3)}
 g1=R: {puton(1,1), puton(1,2), puton(1,3)}
 g2=2: {putdown(2,2)}
 g2=R: {puton(2,1), puton(2,2), puton(2,3)}
 c=0: {puton(1,1), puton(1,2), puton(1,3), puton(2,1), puton(2,2), puton(2,3)}



Cliques: {r=2, r=3, g1=3, g2=2, g2=r, g1=R}, {c=0, r=2, r=3, g1=3, g2=2}

$$h^C(I) = 6$$

Exercise 15

- (i) Each optimal plan consists of one increment actions for each variable, Heuristic value return for initial state is 8.

Heuristic	at	V_{Ad}	V_{Br}	V_{Pe}	V_{Da}
$h^{\{Sy, Br\}}(I) = 1$	Br	F	T	F	F
$h^{\{Br, Sy\}}(I) = 1$	Sy	F	T	F	F
$h^{\{Sy, Ad\}}(I) = 1$	Ad	T	T	F	F
$h^{\{Ad, Pe\}}(I) = 1$	Pe	T	T	T	F
$h^{\{Pe, Ad\}}(I) = 1$	Ad	T	T	T	F
$h^{\{Ad, Da\}}(I) = 1$	Da	T	T	T	T
$h^{\{Da, Ad\}}(I) = 1$	Ad	T	T	T	T
$h^{\{Ad, Sy\}}(I) = 1$	Sy	T	T	T	T

Variables: Minimize unit cost instead of each action to return.

Objective Function:

$$h^*(I) = 8$$

- (ii) **Landmarks:** $D(at) = \{Sy\}$, $D(at) = \{Br\}$, $D(at) = \{Ad\}$, $D(at) = \{Da\}$,
 $vAd = T$, $vBr = T$, $vPe = T$, $vDa = T$

$$h^*(I) = 4$$