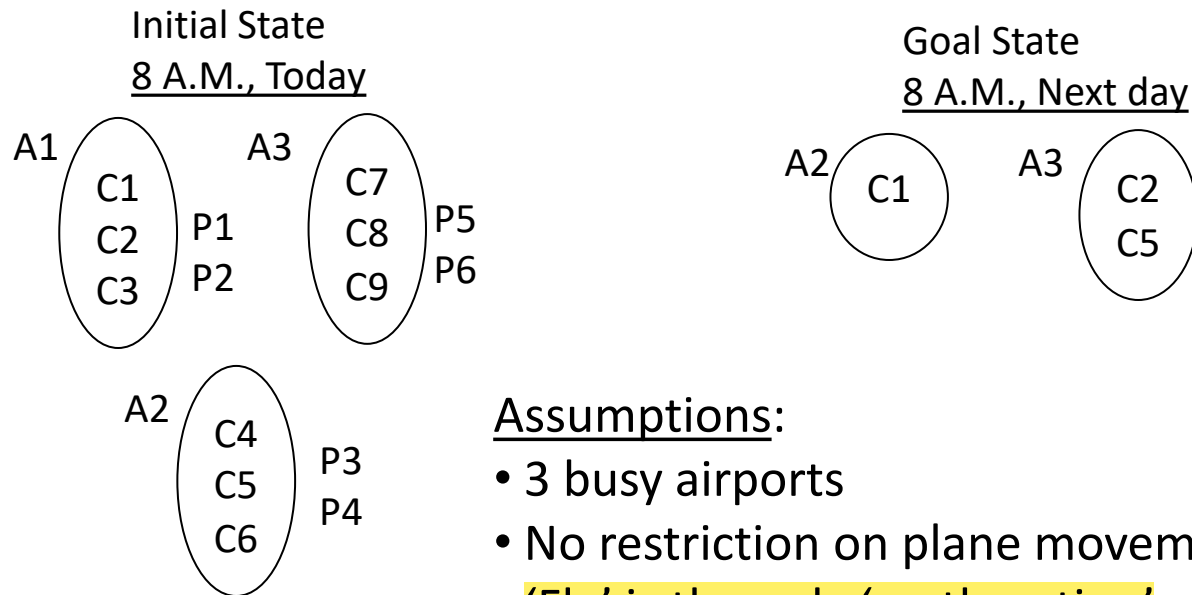


## Chapter 4. Planning Problems

### Topic 4.1. Air-Cargo Transportation Problem as a Planning Problem

#### A) Representation of the problem

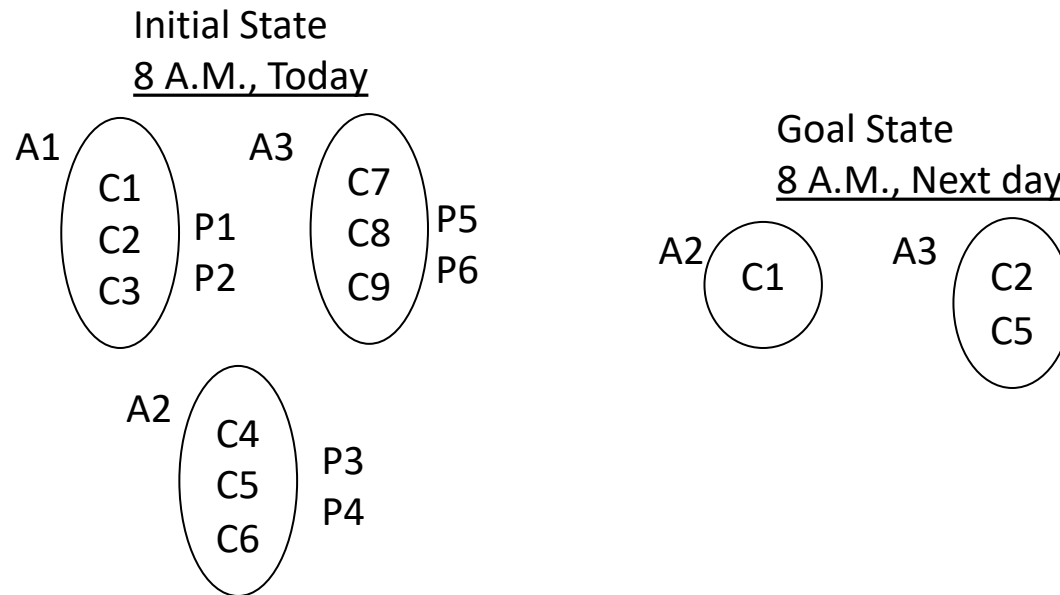
##### a) Schematic representation



#### Assumptions:

- 3 busy airports
- No restriction on plane movement
- 'Fly' is the only 'costly action'
- Any plane can reach another port directly or via the 3<sup>rd</sup> by the given time

## b) Representation in Planning Domain Definition Language (PDDL)



Initial State (IS):

$\text{Airport}(A1) \wedge \text{Airport}(A2) \wedge \text{Airport}(A3) \wedge \text{Cargo}(C1) \wedge \text{Cargo}(C2) \wedge \dots$   
 $\wedge \text{Cargo}(C9) \wedge \text{Plane}(P1) \wedge \text{Plane}(P2) \wedge \dots \wedge \text{Plane}(P6) \wedge \text{At}(A1, C1) \wedge$   
 $\text{At}(A1, C2) \wedge \dots \wedge \text{At}(A3, C9) \wedge \text{At}(A1, P1) \wedge \text{At}(A1, P2) \wedge \dots \wedge \text{At}(A3, P6)$

Goal State (GS):

$\text{At}(A2, C1) \wedge \text{At}(A3, C2) \wedge \text{At}(A3, C5) \wedge \text{Airport}(A2) \wedge \text{Airport}(A3) \wedge$   
 $\text{Cargo}(C1) \wedge \text{Cargo}(C2) \wedge \text{Cargo}(C5)$

c) Action Schemas:

i) Action: Load(c, p, a)

Precondition:  $\text{Cargo}(c) \wedge \text{Plane}(p) \wedge \text{Airport}(a) \wedge \text{At}(a, c) \wedge \text{At}(a, p)$

Effect:  $\neg \text{At}(a, c) \wedge \text{In}(p, c)$

ii) Action: Unload(c, p, a)

Precondition:  $\text{Cargo}(c) \wedge \text{Plane}(p) \wedge \text{Airport}(a) \wedge \text{At}(a, p) \wedge \text{In}(p, c)$

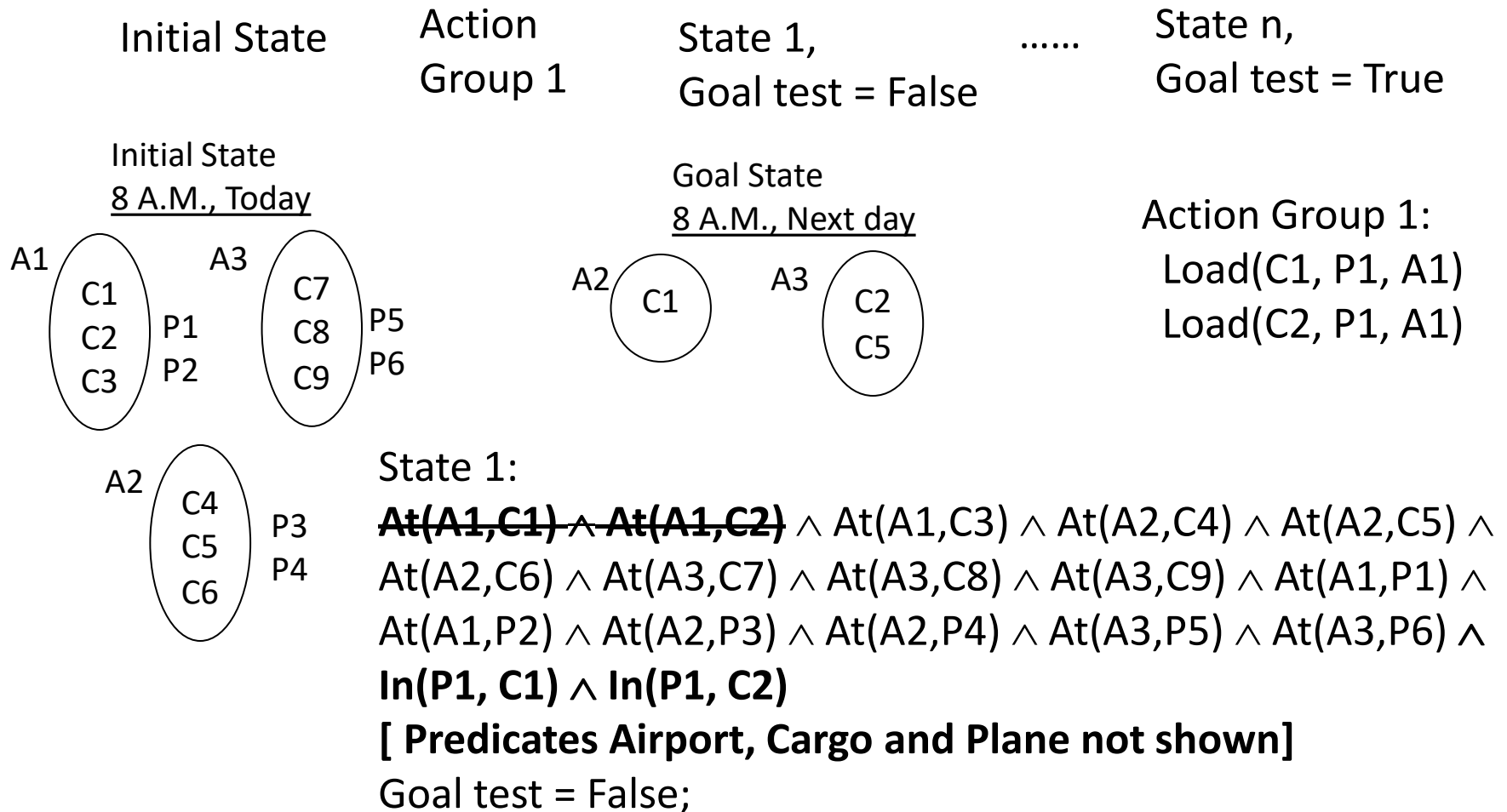
Effect:  $\text{At}(a, c) \wedge \neg \text{In}(p, c)$

iii) Action: Fly(p, from, to)

Precondition:  $\text{Plane}(p) \wedge \text{Airport}(\text{from}) \wedge \text{Airport}(\text{to}) \wedge \text{At}(\text{from}, p)$

Effect:  $\neg \text{At}(\text{from}, p) \wedge \text{At}(\text{to}, p)$

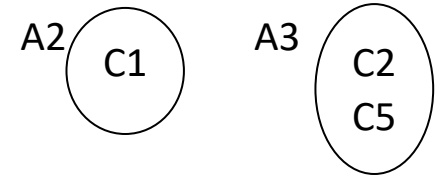
## B) Construction of a plan through Forward State Space Search



State ..... :

~~At(A1,C1) ∧ At(A1,C2)~~ ∧ At(A1,C3) ∧ At(A2,C4) ∧ At(A2,C5) ∧  
At(A2,C6) ∧ At(A3,C7) ∧ At(A3,C8) ∧ At(A3,C9) ∧ At(A1,P1) ∧  
At(A1,P2) ∧ At(A2,P3) ∧ At(A2,P4) ∧ At(A3,P5) ∧ At(A3,P6) ∧  
**In(P1, C1) ∧ In(P1, C2)**

Goal State  
8 A.M., Next day



Goal Test = .....

Action Group2:

Fly(P1, A1, A2)

Action Group 3:

Unload(C1, P1, A2)

Load(C5, P1, A2)

Action Group 4:

Fly(P1, A2, A3)

Action Group 5:

Unload(C2, P1, A3)

Unload(C5, P1, A3)

**Plan:** Action Group1, Action Group 2, ... , Action Group 5; Optimal?