

Classical Planning Exercise

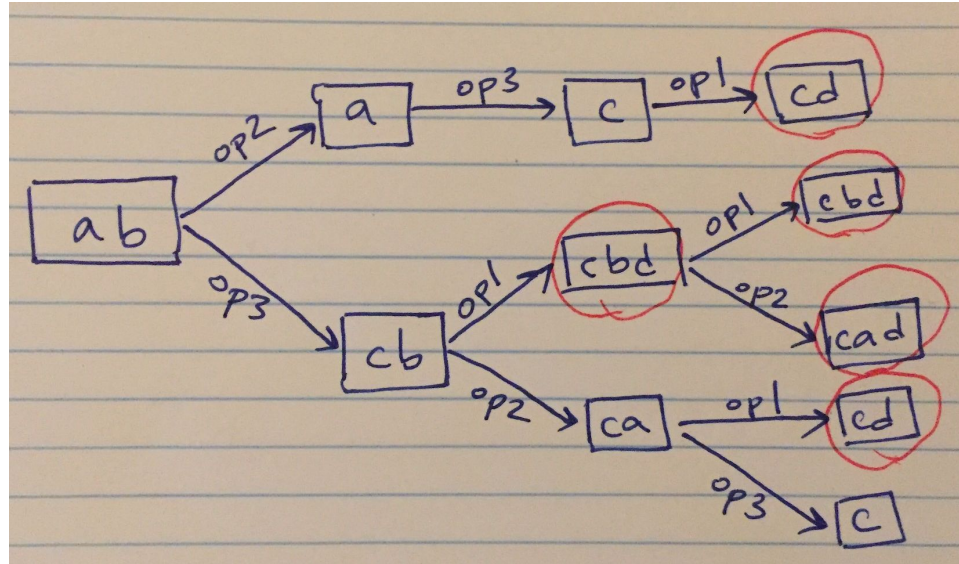
Consider a planning domain with 4 literals a, b, c, d and 3 operations op1, op2, op3. The corresponding preconditions, positive effects, and negative effects are outlined below:

	op1	op2	op3
preconditions	c	b	a
add (pos effects)	d	a	c
del (neg effects)	a	b	a

Assuming an initial state of **ab** and a goal of **cd**:

- Perform forward planning and find the optimal solution. Show the planning tree, up to three levels.
- Perform backward planning and find the optimal solution. Show the planning tree, up to three levels.
- Show the *first level* ($S_0 A_0 S_1$) of the planning graph for this problem.

Part a: Forward Planning

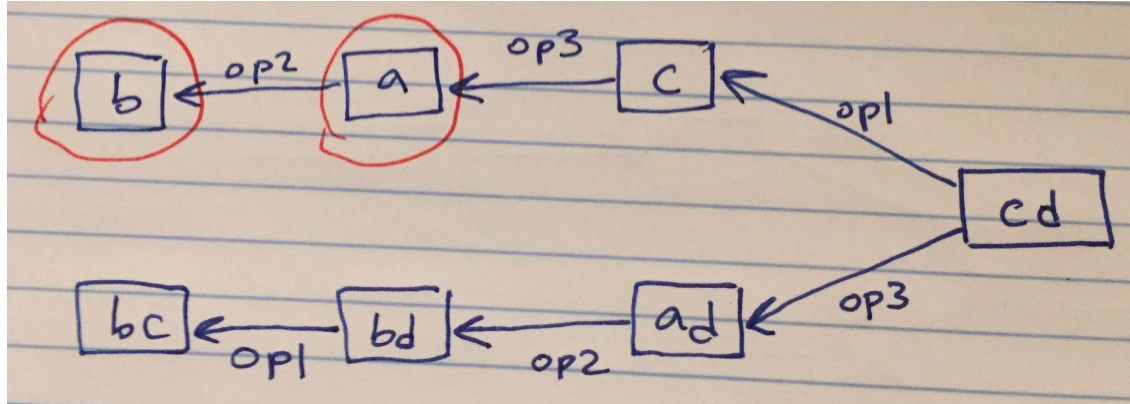


	op1	op2	op3
pre	c	b	a
add	d	a	c
del	a	b	a

The planning tree is given above. States that satisfy the goal are circled in red. The optimal solution is op3 followed by op1.

Note that in order to satisfy the goal, a state needs to include all the literals comprising that goal.

Part b: Backward Planning

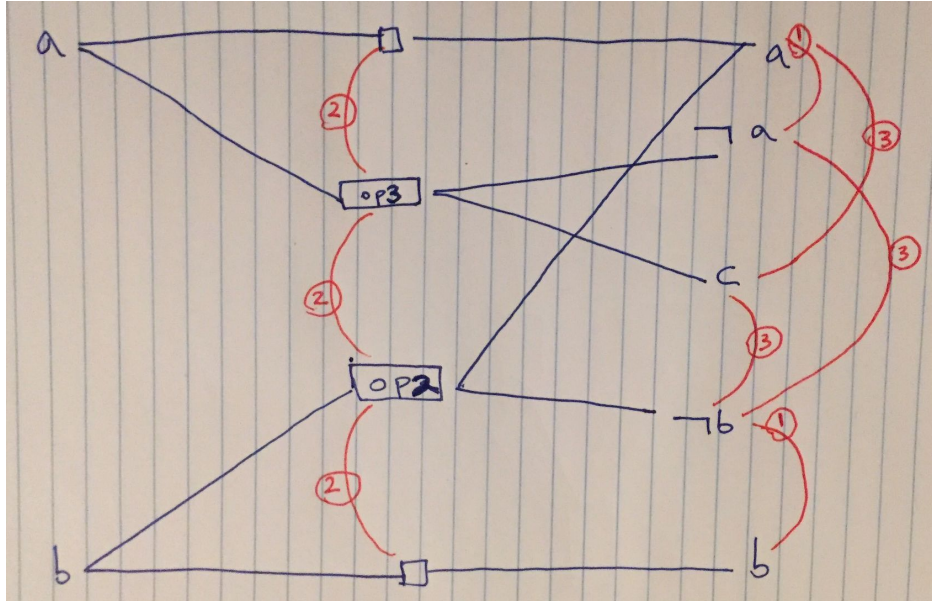


	op1	op2	op3
pre	c	b	a
add	d	a	c
del	a	b	a

The planning tree is given above. States that satisfy the initial state are circled in red. The optimal solution (going forward) is op3 followed by op1.

Note that in order to satisfy the initial state, a state must not include any literals that do not already appear in the initial state. (Eg. a, b, ab are valid states, but abc or c are not.)

Part c: Planning Graph



	op1	op2	op3
pre	c	b	a
add	d	a	c
del	a	b	a

We begin with the initial state a, b . We add $op2$ and $op3$, as their preconditions are met at the initial state. We then add persistence actions corresponding to the literals comprising the initial state. We then proceed to adding mutex links in three stages (each mutex link in the diagram is marked according to its stage). **Stage 1:** We first add mutex links between literals and their opposing literals (eg. a and $\neg a$). **Stage 2:** Next, we add mutex links between all operations that have inconsistent effects, inconsistent preconditions, or operations for which the effects of one undoes the preconditions of the other. **Stage 3:** Finally, we add mutex links between all literals for which, as the textbook describes, “each possible pair of actions that could achieve the two literals is mutually exclusive.”