1. Progression

Init → Pq → O1 → Pqr → O2 → Pqrs → Goal

Level 1

1b

Initial State

Pq → O1 → Pqr → O2 → Goal

Pqrs

rs

Pqrs

1c - Set of partial plans to resolve the Flaw "P"

Initial Plan

P Q O

AO

OC: P @ A_q, Q @ A_q, R @ A_q, S @ A_q

A: {A_q, A_q}

P Q RS

AO

CL: {3}

UL: {3}

O = Orderings

OC = Open Conditions

A = Actions

CL = Causal Links

UL = Unsafe Links
Set of partial plans resolving "P"

a) OC = \{@R@A_1, R@A_2, S@A_2\}
O = \{A_0 < A_3\}
A = \{A_0, A_3\}
CL = \{A_0 \rightarrow A_3\}
UL = \{3\}

b) OC = \{@R@A_2, R@A_2, S@A_2, R@O_5, S@O_3\}
O = \{O_5 < A_3\}
A = \{A_0, O_5, A_2\}
CL = \{O_5 \rightarrow A_3\}
UL = \{3\}

c) OC = \{Q@A_3, R@A_2, S@A_2, R@O_4, S@O_3\}
O = \{O_4 < A_3\}
A = \{A_0, O_4, A_3\}
CL = \{O_4 \rightarrow A_3\}
UL = \{3\}
1c (cont.). Show entire branch.

0: \[ \begin{array}{c}
\text{QR} \\
\text{PQ} \\
\text{A}_0 \\
\text{R}_{\text{S}} \\
\text{A}_x
\end{array} \]

(Initial Plan already shown)

1: \[ \begin{array}{c}
\text{QR} \\
\text{PQ} \\
\text{A}_0 \\
\text{R}_{\text{S}} \\
\text{A}_x
\end{array} \]

OC: \{ \text{Q} \rightarrow \text{A}_x, \text{R} \rightarrow \text{A}_x, \text{S} \rightarrow \text{A}_x \}

OC: \{ \text{Q} \rightarrow \text{A}_x, \text{R} \rightarrow \text{A}_x, \text{S} \rightarrow \text{A}_x \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x, \text{A}_0 \rightarrow \text{A}_x \}

UL: \{3\}

2: \[ \begin{array}{c}
\text{QR} \\
\text{PQ} \\
\text{A}_0 \\
\text{R}_{\text{S}} \\
\text{A}_x
\end{array} \]

OC: \{ \text{R} \rightarrow \text{A}_x, \text{S} \rightarrow \text{A}_x \}

OC: \{ \text{R} \rightarrow \text{A}_x, \text{S} \rightarrow \text{A}_x \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x, \text{A}_0 \rightarrow \text{A}_x \}

UL: \{3\}

3: \[ \begin{array}{c}
\text{QR} \\
\text{PQ} \\
\text{A}_0 \\
\text{R}_{\text{S}} \\
\text{A}_x
\end{array} \]

OC: \{ \text{R} \rightarrow \text{A}_x, \text{Q} \rightarrow \text{O}_2 \}

OC: \{ \text{R} \rightarrow \text{A}_x, \text{Q} \rightarrow \text{O}_2 \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x, \text{O}_2 \rightarrow \text{A}_x \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x, \text{O}_2 \rightarrow \text{A}_x \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x, \text{O}_2 \rightarrow \text{A}_x \}

UL: \{3\}

4: \[ \begin{array}{c}
\text{QR} \\
\text{PQ} \\
\text{A}_0 \\
\text{R}_{\text{S}} \\
\text{A}_x
\end{array} \]

OC: \{ \text{P} \rightarrow \text{O}_1, \text{Q} \rightarrow \text{O}_2 \}

OC: \{ \text{P} \rightarrow \text{O}_1, \text{Q} \rightarrow \text{O}_2 \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x, \text{O}_2 \rightarrow \text{A}_x, \text{O}_1 \rightarrow \text{A}_x \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x, \text{O}_2 \rightarrow \text{A}_x, \text{O}_1 \rightarrow \text{A}_x \}

OC: \{ \text{A}_0 \rightarrow \text{A}_x, \text{O}_2 \rightarrow \text{A}_x, \text{O}_1 \rightarrow \text{A}_x \}

UL: \{3\}

Next step would be to resolve the threat posting an ordering constraint.
5. Solving the unsafe link:

\[ OC = \{ P \Rightarrow Q, Q \Rightarrow O2, O1 \} \]
\[ O = \{ A0 \leq A1, O2 \leq A1, O1 \leq O2 \} \]
\[ A = \{ A0, O1, O2, A2 \} \]
\[ CL = \{ A0 \rightarrow P \Rightarrow A1, A0 \rightarrow Q \Rightarrow A1, O2 \rightarrow S \Rightarrow A1, O1 \rightarrow R \Rightarrow A1 \} \]
\[ UL = \{ 3 \} \]

6. A

\[ OC = \{ Q \Rightarrow O2, O3 \} \]
\[ O = \{ A0 \leq A1, O2 \leq A1, O1 \leq O2 \} \]
\[ A = \{ A0, O1, O2, A2 \} \]
\[ CL = \{ A0 \rightarrow P \Rightarrow A1, A0 \rightarrow Q \Rightarrow A1, O2 \rightarrow S \Rightarrow A1, O1 \rightarrow R \Rightarrow A1 \} \]
\[ UL = \{ 3 \} \]

7. Final Plan

\[ OC = \{ 3 \} \]
\[ O = \{ A0 \leq A1, O2 \leq A1, O1 \leq O2 \} \]
\[ A = \{ A0, O1, O2, A2 \} \]
\[ CL = \{ A0 \rightarrow P \Rightarrow A1, A0 \rightarrow Q \Rightarrow A1, O2 \rightarrow S \Rightarrow A1, O1 \rightarrow R \Rightarrow A1 \} \]
\[ UL = \{ 3 \} \]
In the 196 ground actions there are many duplicates, which can be eliminated.

There will be a total 99 ground actions left after removing all duplicates.

In fact there will be a total of 196 actions before and 100 actions after removing duplicates respectively if we include the action with only negative preconditions and no effects.

The argument for including it is that the action sequence consisting only of the lifted action in the all-false state is a valid plan; if we eliminate that grounding, then there is no valid ground plan corresponding to it.

This would be important in conformat planning – Will

<table>
<thead>
<tr>
<th>Choices for A</th>
<th>Choices for B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(~P1(a)) (~P2(a)) (~R(a)) (~M(a)) (~N(a))</td>
<td>(~P1(a)) (~P2(b)) (~R(b)) (~M(b)) (~N(b))</td>
</tr>
<tr>
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This would be important in conformat planning – Will
Choices are independent of each other; 100 choices
Solution II.2

\[ P_1(x) \lor P_2(x) \]
\[ \neg M(u) \land \neg N(u) \lor u \land z \]
\[ x = z \]

\[ J(x) \]

\[ W(z) \]

\[ \neg M(u) \land \neg N(u) \lor u \land z \]
\[ x = z \]

Init

\[ P_1(a) \]
\[ J(a) \]

\[ \text{Success!} \]

\[ \text{s = \{x = a\} consistent with } x = z \]
\[ S_5, s \subseteq \text{Init} \]

\[ U((P_1(a), J(a)), (P_1(x), J(x))) \]

\[ \text{Success!} \]

\[ \text{FAILURE!} \]

\[ S_5 \]

\[ S_1 \]

\[ S_2 \]

\[ S_3 \]

\[ S_4 \]

\[ S_5 \]

\[ \text{Goal} \]

\[ Q(z) \]

\[ W(z) \]

\[ \text{FAILURE!} \]

\[ \text{FAILURE!} \]

\[ U((P_1(x), J(x)), (P_1(x), J(x))) \]

\[ \text{S_5, s \subseteq Init} \]
Plan Space Solution II.3

Plan 1

Plan Queue

R(y) => W(y)

Plan 2

Eventually Fails

Plan 3
Plan Space Solution II.3 Cont...

- Selecting only one trace (Plan 1). Resolving open condition $W(z)@G$ with $O2$

- Resolving now open condition $J(x)$ by inserting a causal link to $I$
- Resolving now open condition $P_1(x) \lor P_2(x)$ by inserting a causal link to $I$

Consistent with $x = z$, $u \neq z$

$P_1(a) \quad s = \{x = a\}$

$O_1$

$P_1(x) \lor P_2(x) \Rightarrow O_1$

~$M(u) \land \sim N(u) \Rightarrow O_1$

$x = z$, $u \neq z$

$J(x) \quad s = \{x = a\}$

$O_2$

$J(x) \Rightarrow O_2$

$x = z$

$Q(z)$

$R(y) \Rightarrow W(y)$

$Q(z) @ G$

$W(z) @ G$

Algorithm stops, we do not have more open conditions to satisfy. Conjunct $\sim M(u) \land \sim N(u)$ gets satisfied by CWA from $I$. Constraints are also consistent, and we do not have any unsafe links.