Example 101: canonical examples for overbinding w.r.t. order

Here, the second lower prooftree shows what huang would produce.

Ex 101a

$$\dfrac{\dfrac{\overset{\Sigma}{P(u,f(u))\lor Q(u)} \qquad \overset{\Pi}{\neg Q(a)}}{P(a,f(a))}\;u\mapsto a \qquad \overset{\Pi}{\neg P(x,y)}}{\square}\;x\mapsto a, y\mapsto f(a)$$

$$\dfrac{\dfrac{\bot \qquad \top}{Q(a)}\;u\mapsto a \qquad \top}{P(a,f(a))\lor Q(a)}\;x\mapsto a, y\mapsto f(a) \qquad\qquad \dfrac{\dfrac{\bot \qquad \top}{\forall x_1 Q(x_1)} \qquad \top}{\forall x_1\exists x_2(P(x_1,x_2)\lor Q(x_1))}$$

Direct overbinding would not work without merging same variables!: $\forall x_1\forall x_2\exists x_3(P(x_2,x_3)\lor Q(x_1))$
counterexample: $Q\sim\{0\}, P\sim\{(1,0)\}$
Direct overbinding would work when considering original dependencies as highlighted above

Ex 101b – other resolution order

$$\dfrac{\dfrac{\overset{\Sigma}{P(u,f(u))\lor Q(u)} \qquad \overset{\Pi}{\neg P(x,y)}}{Q(u))}\;y\mapsto f(u), x\mapsto u \qquad \overset{\Pi}{\neg Q(a)}}{\square}\;u\mapsto a$$

$$\dfrac{\dfrac{\bot \qquad \top}{P(u,f(u))}\;x\mapsto f(u), x\mapsto u \qquad \top}{P(a,f(a))\lor Q(a)}\;u\mapsto a \qquad\qquad \dfrac{\dfrac{\bot \qquad \top}{\exists x_1 P(u,x_1)} \qquad \top}{\forall x_1\exists x_2(P(x_1,x_2)\lor Q(x_1))}\;u\mapsto a$$

Ex 101c – Π and Σ swapped

$$\dfrac{\dfrac{\overset{\Pi}{P(u,f(u))\lor Q(u)} \qquad \overset{\Sigma}{\neg P(x,y)}}{Q(u))}\;y\mapsto f(u), x\mapsto u \qquad \overset{\Sigma}{\neg Q(a)}}{\square}\;u\mapsto a$$

$$\dfrac{\dfrac{\top \qquad \bot}{\neg P(u,f(u))}\;x\mapsto f(u), x\mapsto u \qquad \bot}{\neg P(a,f(a))\land\neg Q(a)}\;u\mapsto a \qquad\qquad \dfrac{\dfrac{\top \qquad \bot}{\forall x_2\neg P(u,x_2)} \qquad \bot}{\exists x_1\forall x_2(\neg P(x_1,x_2)\land\neg Q(x_1))}$$

Ex 101d – Π and Σ swapped, other resolution order

$$\dfrac{\dfrac{\overset{\Pi}{P(u,f(u))\lor Q(u)} \qquad \overset{\Sigma}{\neg Q(a)}}{P(a,f(a))}\;u\mapsto a \qquad \overset{\Sigma}{\neg P(x,y)}}{\square}\;x\mapsto a, y\mapsto f(a)$$

$$\dfrac{\dfrac{\top \qquad \bot}{\neg Q(a)}\, y \mapsto a \qquad\qquad \bot}{\neg Q(a) \land \neg P(a, f(a))}\, x \mapsto a, y \mapsto f(a) \qquad\qquad \dfrac{\dfrac{\top \qquad \bot}{\exists x_1 \neg Q(x_1)} \qquad \bot}{\exists x_1 \forall x_2 (\neg P(x_1, x_2) \land \neg Q(x_1))}$$

102 – similar to 101 but with intra-clause-set inferences

Ex 102a

$$\dfrac{\dfrac{P(f(x)) \overset{\Sigma}{\lor} Q(f(x), z) \qquad \overset{\Pi}{\neg P(y)}}{Q(f(x), z)} \quad \dfrac{\neg Q(x_1, \overset{\Sigma}{y}) \lor R(y) \qquad \overset{\Pi}{\neg R(g(z_1))}}{\neg Q(x_1, g(z_1))}\, y \mapsto g(z_1), x_1 \mapsto f(x)}{\square}\, x_1 \mapsto f(x), z \mapsto g(z_1)$$

$$\dfrac{\dfrac{\bot \qquad \top}{P(f(x))} \quad \dfrac{\bot \qquad \top}{R(g(z_1))}\, y \mapsto g(z_1), x_1 \mapsto f(x)}{P(f(x)) \lor R(g(z_1))}\, x_1 \mapsto f(x), z \mapsto g(z_1) \qquad\qquad \dfrac{\dfrac{\bot \qquad \top}{\exists x_1 P(x_1)} \quad \dfrac{\bot \qquad \top}{\forall x_2 R(x_2)}}{\exists x_1 \forall x_2 (P(x_1) \lor R(x_2)) \quad \text{(order irrelevant!)}}$$

Ex 102b

$$\dfrac{\dfrac{P(f(x)) \overset{\Sigma}{\lor} Q(f(x), z) \qquad \overset{\Pi}{\neg P(y)}}{Q(f(x), z)} \quad \dfrac{\neg Q(f(\overset{\Sigma}{y}), z_1) \lor R(y) \qquad \overset{\Pi}{\neg R(a)}}{\neg Q(f(a), z_1)}\, y \mapsto a}{\square}\, x \mapsto a, z \mapsto z_1$$

$$\dfrac{\dfrac{\bot \qquad \top}{P(f(x))} \quad \dfrac{\bot \qquad \top}{R(a)}\, y \mapsto a}{P(f(a)) \lor R(a)}\, x \mapsto a, z \mapsto z_1 \qquad\qquad \dfrac{\dfrac{\bot \qquad \top}{\exists x_1 P(x_1)} \quad \dfrac{\bot \qquad \top}{\forall x_2 R(x_2)}\, y \mapsto a}{\forall x_2 \exists x_1 (P(x_1) \lor R(x_2))}\, x \mapsto a, z \mapsto z_1$$

direct:

$$\dfrac{\dfrac{\bot \qquad \top}{\exists x_1 P(x_1)}\, x_1 \sim f(x) \quad \dfrac{\bot \qquad \top}{\forall x_2 R(x_2)}\, x_2 \sim a}{\exists x_1 \forall x_2 (P(x_1) \lor R(x_2))}\, \text{order irrelevant!}$$

Ex 102b' with Q grey

$$\dfrac{\dfrac{\overset{\Sigma}{P(f(x)) \vee Q(f(x), z)} \qquad \overset{\Pi}{\neg P(y)}}{Q(f(x), z)} \qquad \dfrac{\overset{\Sigma}{\neg Q(f(y), z_1) \vee R(y)} \qquad \overset{\Pi}{\neg R(a)}}{\neg Q(f(a), z_1)}\; y \mapsto a}{\square}\; x \mapsto a, z_1 \mapsto z$$

$$\dfrac{\dfrac{\bot \qquad \top}{P(f(x))} \qquad \dfrac{\bot \qquad \top}{R(a)}\; y \mapsto a}{(\neg Q(f(a), z) \wedge P(f(a))) \vee (Q(f(a), z) \wedge R(a))}\; x \mapsto a, z_1 \mapsto z$$

Huang:

$$\dfrac{\dfrac{\bot \qquad \top}{\exists x_2 P(x_2)} \qquad \dfrac{\bot \qquad \top}{\forall x_1 R(x_1)}\; y \mapsto a}{\forall x_1 \exists x_2 (\neg Q(x_2, z) \wedge P(x_2)) \vee (Q(x_2, z) \wedge R(x_1))}\; x \mapsto a, z_1 \mapsto z$$

direct:

$$\dfrac{\dfrac{\dfrac{\dfrac{\bot \qquad \top}{\exists x_2 P(x_2)}\; x_2 \sim f(x) \qquad \dfrac{\bot \qquad \top}{\forall x_1 R(x_1)}\; x_1 \sim a}{\forall x_1 \exists x_2 \exists x_3 (\neg Q(x_3, z) \wedge P(x_2)) \vee (Q(x_3, z) \wedge R(x_1))}\; x_3 \sim f(a); x_2 \parallel x_3, x_1 < x_3}{\text{OR: } \exists x_2 \forall x_1 \exists x_3 (\neg Q(x_3, z) \wedge P(x_2)) \vee (Q(x_3, z) \wedge R(x_1))}}{\text{OR: } \exists x_1 \exists x_3 \forall x_2 (\neg Q(x_3, z) \wedge P(x_2)) \vee (Q(x_3, z) \wedge R(x_1))}$$

Huang-Version passt weil man für existenzielle quantoren eh gleichen term einsetzt
TODO: algo-formulierung hier überprüfen

Example 103: variables in interpolant get unified and order might have to be changed

103a: length changes but old version is still valid, despite huang's algorithm doing a sort

$$\cfrac{\cfrac{\cfrac{\overset{\Sigma}{Q(f(x)) \lor P(y) \lor R(x)} \qquad \overset{\Pi}{\neg Q(y_1)}}{P(y) \lor R(x)}\; y_1 \mapsto f(x) \qquad \overset{\Pi}{\neg P(h(g(a)))}}{R(x)}\; y \mapsto h(g(a)) \qquad \overset{\Pi}{\neg R(g(g(a)))}}{\Box}\; x \mapsto g(g(a))$$

$$\cfrac{\cfrac{\cfrac{\bot \qquad \top}{Q(f(x))}\; y_1 \mapsto f(x) \qquad \top}{Q(f(x)) \lor P(h(g(a)))}\; y \mapsto h(g(a)) \qquad \top}{Q(f(g(g(a)))) \lor P(h(g(a))) \lor R(g(g(a)))}\; x \mapsto g(g(a)) \qquad\qquad \cfrac{\cfrac{\cfrac{\bot \qquad \top}{\exists x_1 Q(x_1)} \qquad \top}{\exists x_1 \forall x_2 (Q(x_1) \lor P(x_2))} \qquad \top}{X}$$

X:
Huang's algo gives:
$\forall x_2 \forall x_3 \exists x_1 (Q(x_1) \lor P(x_2) \lor R(x_3))$
Direct overbinding gives: $x_3 < x_1$, rest arbitrary, hence:
$\forall x_3 \exists x_1 \forall x_2 (Q(x_1) \lor P(x_2) \lor R(x_3))$ <- this you do not get with huang
$\forall x_2 \forall x_3 \exists x_1 (Q(x_1) \lor P(x_2) \lor R(x_3))$
$\forall x_3 \forall x_2 \exists x_1 (Q(x_1) \lor P(x_2) \lor R(x_3))$

103b: length changes "uniformly"

$$\cfrac{\cfrac{\cfrac{\overset{\Sigma}{Q(f(f(x))) \lor P(f(x)) \lor R(x)} \qquad \overset{\Pi}{\neg Q(y_1)}}{P(f(x)) \lor R(x)}\; y_1 \mapsto f(f(x)) \qquad \overset{\Pi}{\neg P(y_2)}}{R(x)}\; y_2 \mapsto f(x) \qquad \overset{\Pi}{\neg R(g(a))}}{\Box}\; x \mapsto g(a)$$

$$\cfrac{\cfrac{\cfrac{\bot \qquad \top}{Q(f(f(x)))}\; y_1 \mapsto f(f(x)) \qquad \top}{Q(f(f(x))) \lor P(f(x))}\; y_2 \mapsto f(x) \qquad \top}{Q(f(f(g(a)))) \lor P(f(g(a))) \lor R(g(a))}\; x \mapsto g(a) \qquad\qquad \cfrac{\cfrac{\cfrac{\bot \qquad \top}{\exists x_1 Q(x_1)} \qquad \top}{\exists x_2 \exists x_1 (Q(x_1) \lor P(x_2))} \qquad \top}{\forall x_3 \exists x_2 \exists x_1 (Q(x_1) \lor P(x_2) \lor R(x_3))}$$

Huang and direct overbinding somewhat coincide as $x_2 < x_1$ in both cases, and $x_3 < x_1$ and $x_3 < x_2$

103c: Failed attempt: different variables, accidentally the same terms appear but no logical connection

$$\dfrac{\overset{\Sigma}{P(a,x)} \qquad \dfrac{\overset{\Sigma}{\neg Q(a)} \qquad \overset{\Pi}{\neg P(y,f(z)) \vee Q(z)}}{\neg P(y,f(a))}\; z \mapsto a}{\Box}\; y \mapsto a, x \mapsto f(a)$$

$$\dfrac{\bot \qquad \dfrac{\bot \qquad \top}{\neg Q(a)}\; z \mapsto a}{P(a,f(a)) \wedge \neg Q(a)}\; y \mapsto a, x \mapsto f(a) \qquad\qquad \dfrac{\bot \qquad \dfrac{\bot \qquad \top}{\exists x_1 \neg Q(x_1)}}{\exists x_1 \forall x_2 (P(x_1,x_2) \wedge \neg Q(x_1))}$$

order required for Π

direct:

$$\dfrac{\dfrac{\bot \qquad \dfrac{\bot \qquad \top}{\exists x_1 \neg Q(x_1)}\; x_1 \sim a}{\exists x_1 \exists x_2 \forall x_3 (P(x_2,x_3) \wedge \neg Q(x_1))}\; x_2 \sim a, x_3 \sim f(a); x_1 < x_3}{\text{OR: } \exists x_1 \forall x_3 \exists x_2 (P(x_2,x_3) \wedge \neg Q(x_1))}$$

invariant:

$$\dfrac{\dfrac{\exists x_2 (P(x_2,x) \vee \bot) \qquad \dfrac{\exists x_1 (Q(x_1) \vee \bot) \qquad \forall x_3 ((\neg P(y,x_3) \vee Q(z)) \vee \top)}{\exists x_1 \forall x_3 \neg P(y,x_3) \vee \neg Q(x_1)}\; x_1 \sim a}{\exists x_1 \exists x_2 \forall x_3 (P(x_2,x_3) \wedge \neg Q(x_1))}\; x_2 \sim a, x_3 \sim f(a); x_1 < x_3}{\text{OR: } \exists x_1 \forall x_3 \exists x_2 (P(x_2,x_3) \wedge \neg Q(x_1))}$$

invariant in other resolution order

$$\dfrac{\dfrac{\bot \qquad \dfrac{\bot \qquad \top}{Q(z) \vee \exists x_2 \forall x_3 P(x_2,x_3)}\; x_2 \sim a, x_3 \sim f(z)}{\exists x_1 \exists x_2 \forall x_3 (P(x_2,x_3) \wedge \neg Q(x_1))}\; x_1 \sim a; x_1 < x_3}{\text{OR: } \exists x_1 \forall x_3 \exists x_2 (P(x_2,x_3) \wedge \neg Q(x_1))}$$

invariant if Σ and Π swapped:

$$\dfrac{\dfrac{\bot \qquad \dfrac{\top \qquad \bot}{\neg P(y,f(x_1)) \vee \forall x_1 Q(x_1)}\; x_1 \sim a}{\forall x_1 \forall x_2 \exists x_3 (\neg P(x_2,x_3) \vee Q(x_1))}\; x_2 \sim a, x_3 \sim f(a); x_1 < x_3}{\text{OR: } \forall x_1 \exists x_3 \forall x_2 (\neg P(x_2,x_3) \vee Q(x_1))}$$

SECOND ATTEMPT:

$$\dfrac{\overset{\Sigma}{P(a)} \qquad \dfrac{\overset{\Sigma}{Q(z)} \qquad \dfrac{\overset{\Sigma}{\neg S(a)} \qquad \overset{\Pi}{\neg P(y) \vee \neg Q(f(x)) \vee S(x)}}{\neg P(y) \vee \neg Q(f(a))}\; x \mapsto a}{\neg P(y)}\; z \mapsto f(a)}{\Box}\; y \mapsto a$$

$$\dfrac{\bot \qquad \dfrac{\bot \qquad \dfrac{\bot \qquad \top}{\neg S(a)}\; x \mapsto a}{\neg S(a) \wedge Q(f(a))}\; z \mapsto f(a)}{P(a) \wedge \neg S(a) \wedge Q(f(a))}\; y \mapsto a$$

Huang:

Example: ordering on both ancestors where the merge forces a new ordering

202a – canonical

$$
\dfrac{\dfrac{\overset{\Sigma}{P(a,x_1)} \vee R(y) \qquad \overset{\Pi}{\neg P(x, fx)}}{R(y)}\ \begin{matrix} x_1 \mapsto fa \\ x \mapsto a \end{matrix} \qquad \dfrac{\overset{\Sigma}{Q(x_2, gx_2)} \vee \neg R(u) \qquad \dfrac{\overset{\Sigma}{\neg S(a)} \qquad \overset{\Pi}{\neg Q(fz, x_3) \vee S(z)}}{\neg Q(fa, x_3)}\ z \mapsto a}{\neg R(u)}\ \begin{matrix} x_2 \mapsto fa, \\ x_3 \mapsto gfa \end{matrix}}{\Box}
$$

$$
\dfrac{\dfrac{\bot \qquad \top}{P(a, f(a))}\ \begin{matrix} x_1 \mapsto f(a) \\ x \mapsto a \end{matrix} \qquad \dfrac{\bot \qquad \dfrac{\bot \qquad \top}{\neg S(a)}\ z \mapsto a}{Q(f(a), g(f(a))) \wedge \neg S(a)}\ \begin{matrix} x_2 \mapsto f(a), \\ x_3 \mapsto g(f(a)) \end{matrix}}{P(a, f(a)) \vee (Q(f(a), g(f(a))) \wedge \neg S(a))}
$$

Huang

$$
\dfrac{\dfrac{\bot \qquad \top}{\exists x_1 \forall x_2 P(x_1, x_2))} \qquad \dfrac{\bot \qquad \dfrac{\bot \qquad \top}{\exists x_1 \neg S(x_1)}}{\exists x_1 \forall x_2 \exists x_3 Q(x_2, x_3) \wedge \neg S(x_1)}}{\exists x_1 \forall x_2 \exists x_3 P(x_1, x_2) \vee (Q(x_2, x_3)) \wedge \neg S(x_1))}
$$

direct:

$$
\dfrac{\dfrac{\bot \qquad \top}{\exists x_1 \forall x_2 P(x_1, x_2))}\ \begin{matrix} x_1 \sim a, x_2 \sim fa \\ x_1 < x_2 \end{matrix} \qquad \begin{matrix} x_3 \sim a, x_4 \sim fa, x_5 \sim gfa) \\ x_3 < x_4, x_4 < x_5 \end{matrix}\ \dfrac{\bot \qquad \dfrac{\bot \qquad \top}{\exists x_3 \neg S(x_3)}\ x_3 \sim a}{\exists x_3 \forall x_4 \exists x_5 Q(x_4, x_3) \wedge \neg S(x_3)}}{\exists x_1 \forall x_2 \exists x_5 P(x_1, x_2) \vee (Q(x_2, x_5) \wedge \neg S(x_5))}\ \begin{matrix} x_3 \mapsto x_1, x_4 \mapsto x_2 \\ x_1 < x_2, x_2 < x_5 \end{matrix}
$$

without merge in end: $(x_1 < x_2, x_3 < x_4, x_4 < x_5)$
$\exists x_1 \forall x_2 \exists x_3 \forall x_4 \exists x_5 P(x_1, x_2) \vee (Q(x_4, x_5) \wedge \neg S(x_3))$
$\exists x_3 \forall x_4 \exists x_5 \exists x_1 \forall x_2 P(x_1, x_2) \vee (Q(x_4, x_5) \wedge \neg S(x_3))$
(also interwoven ones appear to work)

202b – just a a lot of terms for random mass test

TODO

Example with transitive order constraint

203a

$$
\dfrac{\neg \overset{\Pi}{S}(x_1) \qquad \dfrac{\neg \overset{\Pi}{R}(a) \qquad \dfrac{\dfrac{R(x) \lor \overset{\Sigma}{\neg P}(f(x)) \qquad P(z) \lor \overset{\Pi}{Q}(g(z))}{R(x) \lor Q(g(f(x)))}\; z \mapsto f(x) \qquad \neg Q(y) \overset{\Sigma}{\lor} S(h(y))}{R(x) \lor S(h(g(f(x))))}\; y \mapsto g(f(x))}{S(h(g(f(a))))}\; x \mapsto a}{\square}\; x_1 \mapsto h(g(f(a)))
$$

$$
\dfrac{\top \qquad \dfrac{\top \qquad \dfrac{\dfrac{\bot \qquad \top}{\neg P(f(x))}\; z \mapsto f(x) \qquad \bot}{\neg Q(g(f(x))) \land \neg P(f(x))}\; y \mapsto g(f(x))}{\neg Q(g(f(a))) \land \neg P(f(a)) \lor R(a)}\; x \mapsto a}{\neg Q(g(f(a))) \land \neg P(f(a)) \lor R(a) \lor S(h(g(f(a))))}\; x_1 \mapsto h(g(f(a)))
$$

Huang:

$$
\dfrac{\top \qquad \dfrac{\top \qquad \dfrac{\dfrac{\bot \qquad \top}{\exists x_1 \neg P(x_1)} \qquad \bot}{\exists x_1 \forall x_2 (\neg Q(x_2) \land \neg P(x_1))}}{\forall x_0 \exists x_1 \forall x_2 (\neg Q(x_2) \land \neg P(x_1) \lor R(x_0))}}{\forall x_0 \exists x_1 \forall x_2 \exists x_3 (\neg Q(x_2) \land \neg P(x_1) \lor R(x_0) \lor S(x_3))}
$$

Direct:

$$
\dfrac{\top \qquad \dfrac{\top \qquad \dfrac{\dfrac{\bot \qquad \top}{\exists x_1 \neg P(x_1)}\; x_1 \sim f(x) \qquad \bot}{\exists x_1 \forall x_2 (\neg Q(x_2) \land \neg P(f(x)))}\; x_2 \sim g(f(x)); x_1 < x_2}{\forall x_0 \exists x_1 \forall x_2 (\neg Q(x_2) \land \neg P(x_1) \lor R(x_0))}\; x_0 \sim a; x_0 < x_1, x_0 < x_2}{\forall x_0 \exists x_1 \forall x_2 \exists x_3 (\neg Q(x_2) \land \neg P(x_1) \lor R(x_0) \lor S(x_3))}\; x_3 \sim h(g(f(a))); x_0 < x_3, x_1 < x_3, x_2 < x_3
$$

misc examples

201a

$$\dfrac{\dfrac{P(x,y) \overset{\Sigma}{\vee} \neg Q(y) \qquad \overset{\Pi}{\neg P(a, y_2)}}{\neg Q(y)}\, x \mapsto a \qquad \dfrac{Q(f(z)) \overset{\Sigma}{\vee} R(z) \qquad \overset{\Pi}{\neg R(a)}}{Q(f(a))}\, z \mapsto a}{\Box}\, y \mapsto f(a)$$

$$\dfrac{\dfrac{\bot \qquad \top}{P(a,y)}\, x \mapsto a \qquad \dfrac{\bot \qquad \top}{R(a)}\, z \mapsto a}{P(a,f(a)) \vee R(a)}\, y \mapsto f(a) \qquad\qquad \dfrac{\dfrac{\bot \qquad \top}{\forall x_1 P(x_1, y)}\, x \mapsto a \qquad \dfrac{\bot \qquad \top}{\forall x_3 R(x_3)}\, z \mapsto a}{\forall x_3 \forall x_1 \exists x_2 (P(x_1, x_2) \vee R(x_3))}\, y \mapsto f(a)$$

Huang would produce: $\forall x_1 \exists x_2 P(x_1, x_2) \vee R(x_1)$

201b

$$\dfrac{\dfrac{P(x,f(y)) \overset{\Sigma}{\vee} \neg Q(f(y)) \qquad \overset{\Pi}{\neg P(a, y_2)}}{\neg Q(f(y))}\, x \mapsto a \qquad \dfrac{Q(f(z)) \overset{\Sigma}{\vee} R(z) \qquad \overset{\Pi}{\neg R(a)}}{Q(f(a))}\, z \mapsto a}{\Box}\, y \mapsto f(a)$$

$$\dfrac{\dfrac{\bot \qquad \top}{P(a,f(y))}\, x \mapsto a \qquad \dfrac{\bot \qquad \top}{R(a)}\, z \mapsto a}{P(a,f(a)) \vee R(a)}\, y \mapsto a \qquad\qquad \dfrac{\dfrac{\bot \qquad \top}{\forall x_1 \exists x_2 P(x_1, x_2)}\, x \mapsto a \qquad \dfrac{\bot \qquad \top}{\forall x_3 R(x_3)}\, z \mapsto a}{\forall x_3 \forall x_1 \exists x_2 P(x_1, x_2) \vee R(x_3)}\, y \mapsto f(a)$$

Huang would produce: $\forall x_1 \exists x_2 P(x_1, x_2) \vee R(x_1)$