

### Problem 1

*Original:*  $\forall x (\forall y (A(x) \wedge B(y) \leftrightarrow C(x, y)) \Rightarrow (\exists y D(y) \wedge E(x, y)))$

*Step 1:*  $\forall x \neg \left( \forall y (\neg(A(x) \wedge B(y)) \vee C) \wedge (\neg C \vee (A(x) \wedge B(y))) \right) \vee (\exists y D(y) \wedge E(x, y))$

$\forall x (\exists y (\neg(A \wedge B) \vee C) \wedge \neg(\neg C \vee (A \wedge B))) \vee (\exists y D \wedge E)$

*Step 2:*  $\forall x (\exists y ((A \wedge B) \wedge \neg C) \wedge (\neg C \vee (A \wedge B))) \vee (\exists y D \wedge E)$

*Step 3:*  $\forall x (\exists y ((A(x) \wedge B(y)) \wedge \neg C(x, y)) \wedge (\neg C(x, y) \vee (A(x) \wedge B(y)))) \vee (\exists z D(z) \wedge E(x, z))$

*Step 4:*  $\forall x (( (A(x) \wedge B(F(x))) \wedge \neg C(x, F(x))) \wedge (\neg C(x, F(x)) \vee (A(x) \wedge B(F(x)))) \vee (D(G(x)) \wedge E(x, G(x)))$

*Step 5:*  $(( (A(x) \wedge B(F(x))) \wedge \neg C(x, F(x))) \wedge (\neg C(x, F(x)) \vee (A(x) \wedge B(F(x)))) \vee (D(G(x)) \wedge E(x, G(x)))$

$(( (A(x) \wedge B(F(x))) \wedge \neg C(x, F(x))) \wedge ((\neg C \wedge A) \vee (\neg C \wedge B))) \vee (D(G(x)) \wedge E(x, G(x)))$

*Step 6:*  $(A(x) \vee D(G(x))) \wedge (A(x) \vee E(x, G(x))) \wedge (B(F(x)) \vee D(G(x))) \wedge (B(F(x)) \vee E(x, G(x))) \wedge (\neg C(x, F(x)) \vee D(G(x))) \wedge (\neg C(x, F(x)) \vee E(x, G(x)))$

*Final:*

$(A(x) \vee D(G(x))) \wedge (A(x) \vee E(x, G(x))) \wedge (B(F(x)) \vee D(G(x))) \wedge (B(F(x)) \vee E(x, G(x))) \wedge (\neg C(x, F(x)) \vee D(G(x))) \wedge (\neg C(x, F(x)) \vee E(x, G(x)))$

### Problem 2

1.  $A(cat) \vee C(x, y)$

2.  $\neg B(x, y) \vee C(x, y)$

3.  $\neg A(x) \vee B(hippo, x)$

4.  $\forall x \neg B(hippo, x) \vee B(x, F(x))$

5.  $\forall y \neg C(cat, y)$

$x/\alpha$

3.  $(\neg A(\alpha) \vee B(hippo, \alpha)) \wedge$  4.  $(\neg B(hippo, \alpha) \vee B(\alpha, F(\alpha)))$

Becomes 6.  $(\neg A(\alpha) \vee B(\alpha, F(\alpha)))$

$y/F(\alpha)$

6.  $(\neg A(\alpha) \vee B(\alpha, F(\alpha))) \wedge$  2.  $(\neg B(\alpha, F(\alpha)) \vee C(\alpha, F(\alpha)))$

Becomes 7.  $(\neg A(\alpha) \vee C(\alpha, F(\alpha)))$

$\alpha/cat$

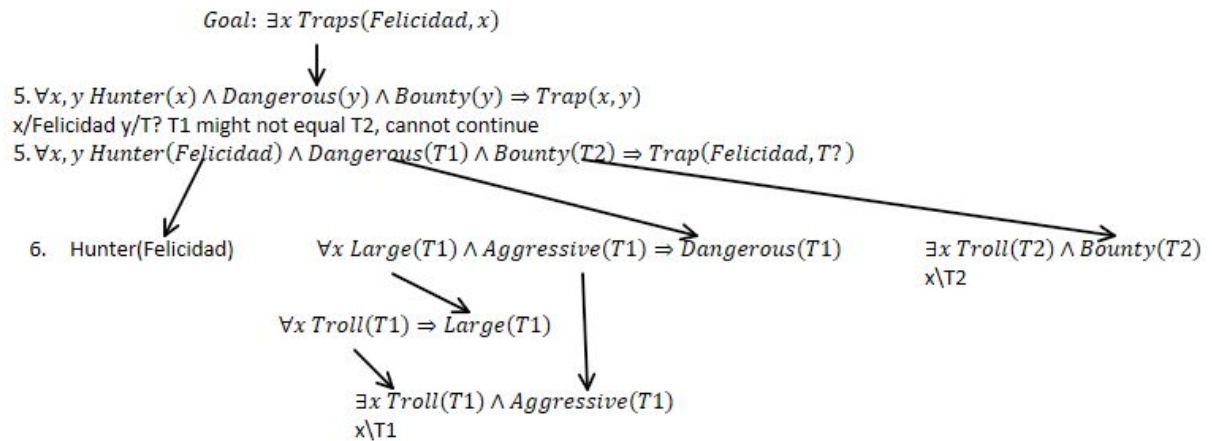
1.  $A(cat) \vee C(cat, F(cat)) \wedge$  7.  $(\neg A(cat) \vee C(cat, F(cat)))$

Becomes 8.  $C(cat, F(cat))$

*Final:* 5.  $\neg C(cat, cat) \wedge$  8.  $C(cat, cat)$

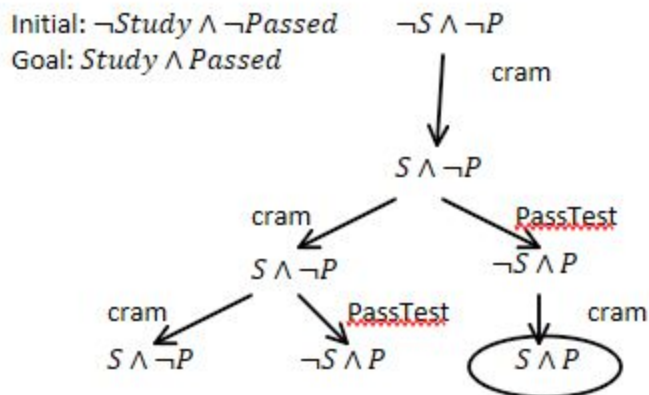
This is a contradiction, so  $\neg \alpha$  is not entailed and  $\alpha$  is entailed

### Problem 3

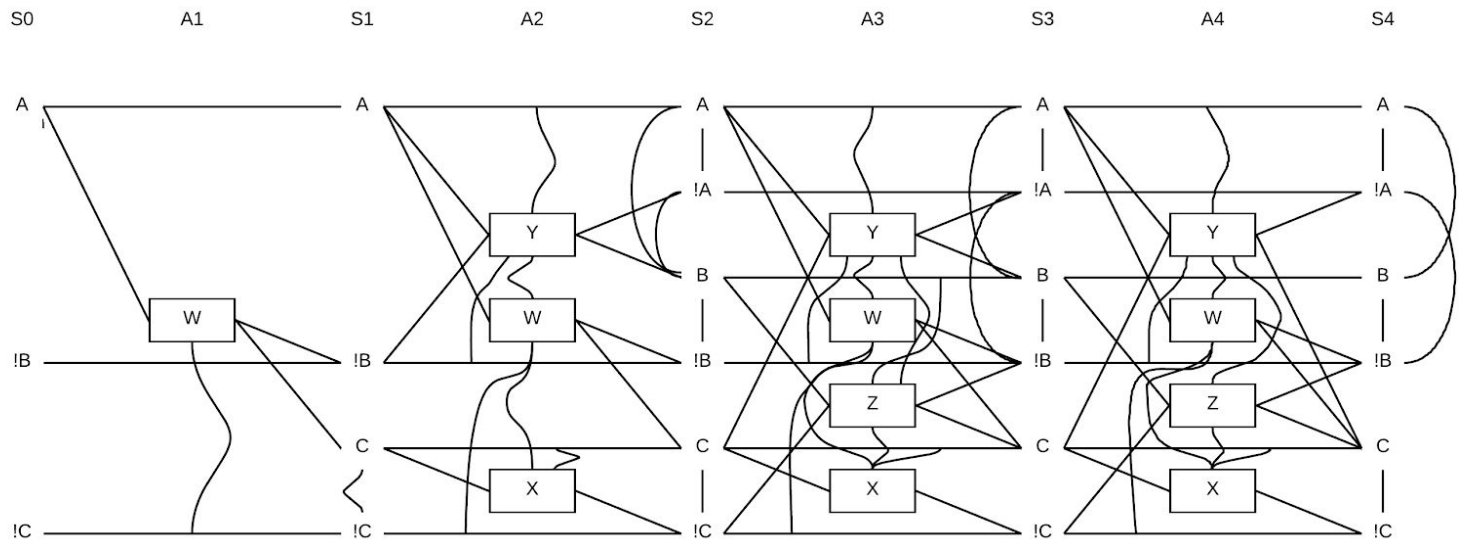


We cannot determine whether it is true or not.  
 The aggressive troll might not be the troll with a bounty  
 We cannot unify a value for x that makes it true.

### Problem 4



## Problem 5



A3, S3 and A4,S4 are the same, they have converged