Resolution with Green’s Trick

1. Put the list of asioms into clause form (CNF).
2. Negate the theorem, convert it to CNF, and add the **Answer predicate**.
3. Until a atomic sentence with only the Answer term is produced or there is no resolvable pair of clauses, do:

   Find resolvable clauses, resolve them, and add the result to the list of clauses.
4. If a clause with only the Answer term is produced, conclude that the sequence of operations in the Answer term is the required answer.
5. If there are no resolvable clauses, conclude that the required action cannot be performed.

The Monkey-and-bananas problem

A monkey is in a room containing a chair and a bunch of bananas. The bananas are hanging from the ceiling out of reach of the monkey. What sequence of actions will allow the monkey to get the bananas?

Assume that the monkey can perform three possible actions:

1. **pushchair(x)** - Push chair to position x
2. **climbchair** - monkey climbs on top of the chair
3. **grasp** - monkey grasps the bananas

Monkey-and-bananas (Cont'd)

Let the initial state S be described by the following sentences:

$\neg$Onchair(S)	At(monkey, a, S)
$\neg$Hasbanana(S)	At(chair, b, S)

Axioms for description the effects of actions:

$\forall x \forall s[\neg \mathrm{Onchair}(s) \Rightarrow \mathrm{At}(\mathrm{chair}, x, \mathrm{pushchair}(x,s))]$

For all x & s, if the monkey is not on the chair in state s, then the chair will be at positon x in the state attained by applying the operator pushchair(x) to state s.

$\forall s\ \mathrm{Onchair}(\mathrm{Climbchair}(s))$

For all s, the monkey will be on the chair in the state attained by applying the operator climbchair to state s.

$\forall s\ [\mathrm{Onchair}(s)\ \Lambda\ \mathrm{At}(\mathrm{box}, c, s) \Rightarrow \mathrm{Hasbanana}(\mathrm{grasp}(s))]$

For all s, if the monkey is on the chair and the chair is at c in state s, then the monkey will have the bananas in the state attained by applying the operator grasp to state s.

Monkey-and-bananas (Cont'd)

Frame axiom:

$\forall x \forall s[\mathrm{At}(\mathrm{chair}, x, s) \Rightarrow \mathrm{At}(\mathrm{chair}, x, \mathrm{climbchair}(x,s))]$

The position of the chair does not change when the monkey climbs on the chair.

The query to be answered:

$\exists\ s_f\ [\mathrm{Hasbanana}(s_f)]$

Negating the theorem:

$\forall\ s_f\ [\neg \mathrm{Hasbanana}(s_f)]$

In conjunctive normal form:

$$\neg \mathrm{Onchair}(S) \quad (1)$$

$$\mathrm{Onchair}(s_2)\ V\ \mathrm{At}(\mathrm{chair}, x, \mathrm{pushchair}(x, s_2)) \quad (2)$$

$$\mathrm{Onchair}(\mathrm{climbchair}(s_3)) \quad (3)$$

$$\neg \mathrm{Onchair}(s_4)\ V\ \neg \mathrm{At}(\mathrm{chair}, c, s_4)\ V\ \mathrm{Hasbanana}(\mathrm{grasp}(s_4)) \quad (4)$$

$$\neg \mathrm{At}(\mathrm{chair}, x, s_5)\ V\ \mathrm{At}(\mathrm{chair}, x, \mathrm{climbchair}(s_5)) \quad (5)$$

$$\neg \mathrm{Hasbanana}(s_f) \quad (6)$$

Monkey-and-bananas (Cont'd)

(4)
¬Onchair(s_4) V
¬At(chair , c, s_4) V
Hasbananas(grasp(s_4 **))**

(3)
¬Onchair(climbchair(s_3 **))**

(5)
¬At(chair , x, s_5) V
At(chair , x, climbchair (s_5))

(2)
Onchair (s_2) V
At(chair , x, pushchair(x, s_2 **))**

(1)
¬Onchair(S)

(6)
¬Hasbananas(s_f)

(7)
¬Onchair(s_7) V
¬At(chair , c, s_7)

(8)
¬At(chair , c,
climbchair(s_8 **))**

(9)
¬At(chair , c, s_9)

(10)
Onchair(s_{10})

(11)
Nil

Monkey-and-bananas (Cont'd)

(4)
¬Onchair(s_4) V
¬At(chair , c, s_4) V
Hasbananas(grasp(s_4))

(3)
¬Onchair(climbchair(s_3))

(5)
¬At(chair , x, s_5) V
At(chair , x, climbchair(s_5))

(2)
Onchair(s_2) V
At(chair , x, pushchair(x, s_2))

(1)
¬Onchair(S)

(6)
¬Hasbananas(s_f) V
Answer(s_f**)**

(7)
¬Onchair(s_7) V
¬At(chair , c, s_7) V
Answer(grasp(s_7 **))**

(8)
¬At(chair , c,
climbchair(s_8)) V
Answer(grasp
(climbchair(s_8 **))**

(9)
¬At(chair , c, s_9) V
Answer(grasp
(climbchair(s_9 **))**

(10)
Onchair(s_{10}) V
Answer(grasp
(climbchair
(pushchair ,c, s_{10}**)))**

(11)
Answer(grasp
(climbchair
(pushchair ,c, S)))