Answer Extraction in the Resolution Process

In the simple example,

Axioms: $(\forall x)(Bird(x) \rightarrow Flies(x))$
$Bird(Tweety)$
Goal: $Flies(Tweety)$

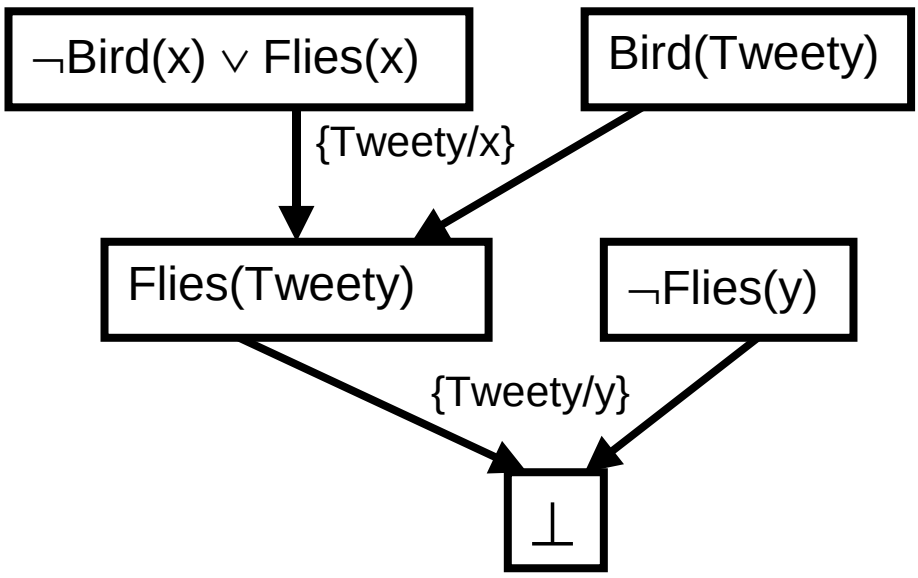
it is easy to establish the goal by using resolution.

However, we must predetermine who it is who does not fly.

Suppose that we replace the above goal by the more general one which states that someone flies.

Goal: $(\exists y)Flies(y)$

In that case, the proof process tells us who it is via the binding of y.

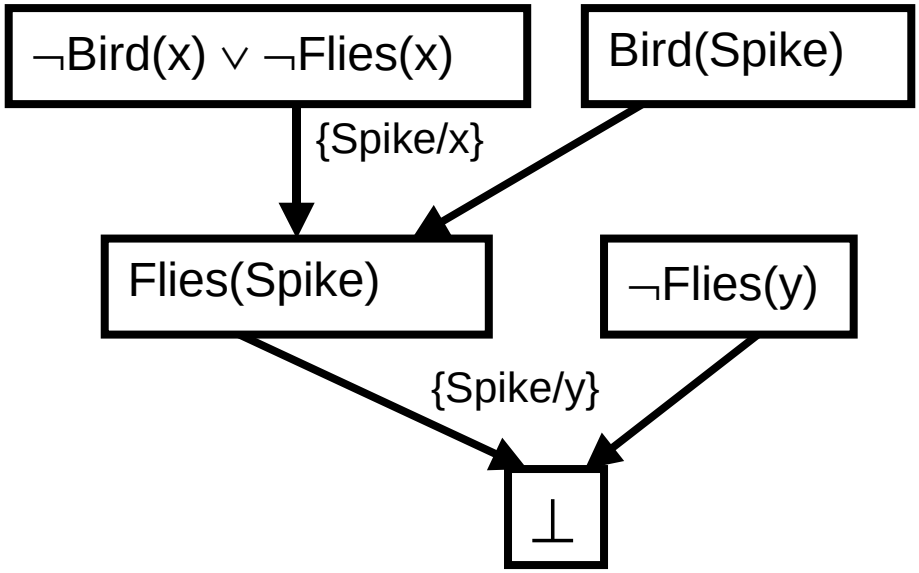


Note that this will give only one instance of a solution.

If the fact that Spike is also a bird is added to the set of hypotheses

Bird(Spike)

then a separate proof is required to determine that Spike can fly.



Thus, to find all answers, one must generate all proofs (or do a special intelligent analysis of the problem).

Note that since inference in first-order logic is undecidable, it is not always possible to search for all answers.

However, in some cases, more generic answers may be generated in one proof.

Example:

A grandparent is a parent of a parent.
$(\forall x)(\forall y)(\forall z)$
$((Parent(x,y) \wedge Parent(y,z)) \rightarrow Grandparent(x,z))$

Everyone has a parent.
$(\forall y)(\exists x)(Parent(x,y))$

Goal: Everyone has a grandparent.
$(\forall x)(\exists y)(Grandparent(y,x))$

Here is the clausal database:

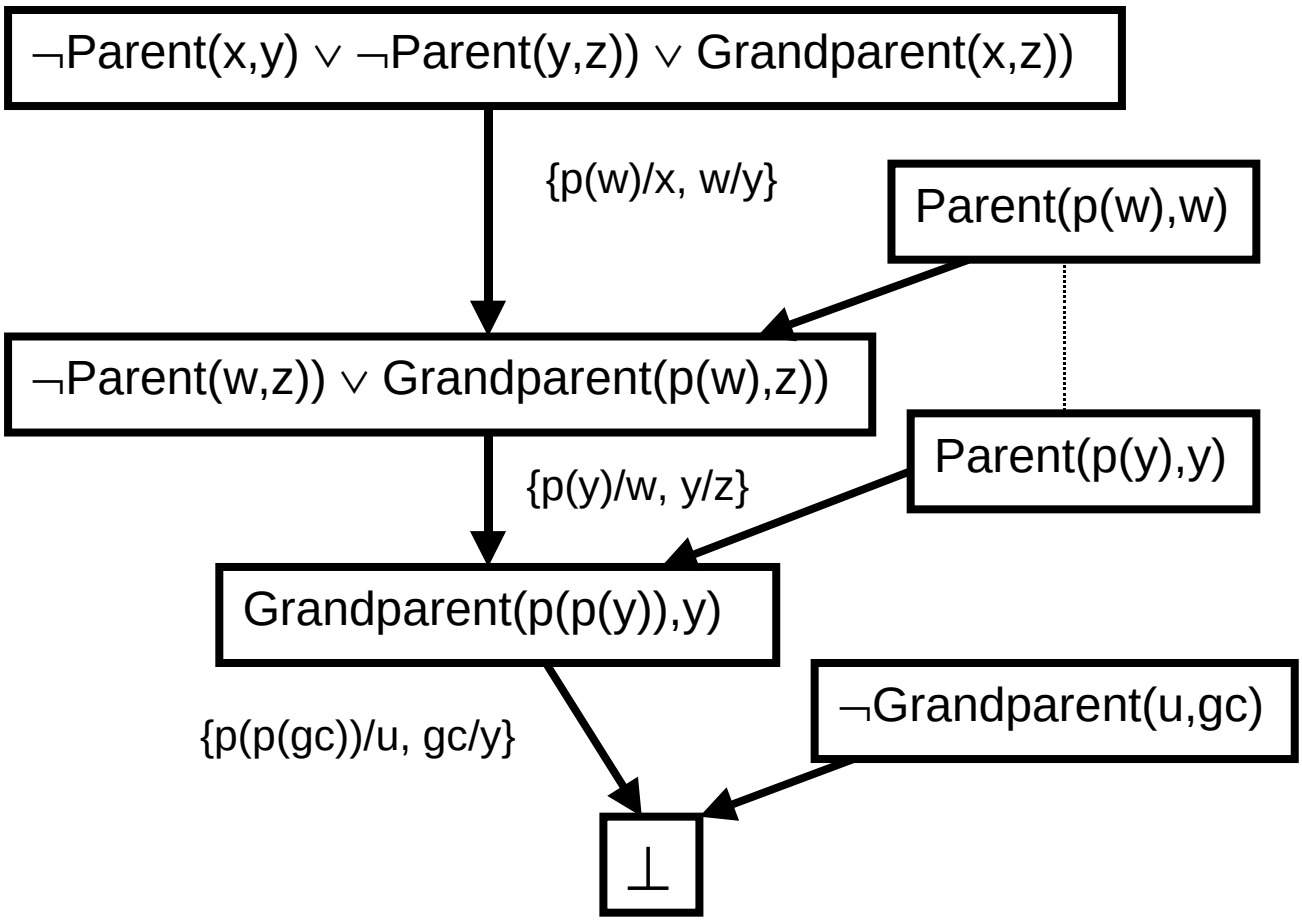
$\neg Parent(x,y) \vee \neg Parent(y,z)) \vee Grandparent(x,z))$

$Parent(p(w),w)$

$\neg Grandparent(u,gc)$

The following proof shows the answer extraction.

The grandparent of grandchild gc is p(p(gc)).



Note also that it was necessary to rename the variables the clause Parent(p(w),w) during a second use of this clause. This is no problem, since universally quantified variables in clauses may always be renamed.

For more information:

Information on answer extraction is generally to be found in texts on Artificial Intelligence, rather than in texts on logic.

The textbooks of Nilsson are perhaps the best sources.

Nilsson, Nils J., *Problem-Solving Methods in Artificial Intelligence,* McGraw-Hill, 1971.

Nilsson, Nils J., *Principles of Artificial Intelligence*, Tioga, 1980.

Genereseth, Michael R., and Nilsson, Nils J., *Logical Foundations of Artificial Intelligence*, Morgan-Kaufmann, 1987.

Warning: The last book in this list uses very non-standard notation and scoping rules for logical formulas, and the notation for substitutions is reversed from the more usual form given in these notes and the course text.

The classical reference

Chang, Chin-Liang, and Lee, Richard Char-Tung, *Symbolic Logic and Mechanical Theorem Proving,* Academic Press, 1973.

also contains some information answer extraction, which they identify with “Class B” queries.