PROJECT REPORT

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CS6364 – ARTIFICIAL INTELLIGENCE
PROJECT REPORT

PROJECT DESCRIPTION:
The objective of this project is to prove if a goal statement follows from a given set of statements.
Given a storyline, the important axioms from that storyline will be derived.
These axioms will then be converted to First order logic form and then to Clause Normal form(CNF).
Using the Clause Normal Form statements we will be able to prove whether a goal statement is provable or not with the help of an automatic theorem prover like Prover9.

Prover9 applies the inference rules and resolution refutation principles to automatically prove theorems.

STORY:

Every wizard studies in hogwarts .Every muggle studies in UTD.
Any wizard whom Ginny loves is a quidditch star. Any wizard who does not study does not pass. Any wizard who does not pass does not play and any wizard who does not play cannot be a quidditch star. Anyone who is a muggle does not play quidditch. All non-magic users are good and anyone who studies in UTD is good. Anyone who is a wizard uses Magic. Anyone who is muggle cannot use Magic. No Magic user is a Muggle. Anyone who is evil is scared of the Dumbledore. Anyone who is bad and hated by all wizards is evil. Voldemort studied in Hogwarts. Voldemort is bad. Anyone who kills a wizard is hated by all wizards.

Harry, Ron, Dumbledore, Voldemort, lily, James are wizards. James and lily are the father and mother of harry. Voldemort killed lily and James.

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AXIOMS:

1. Every wizard studies in hogwarts.
2. Every muggle studies in UTD.
3. Every muggle loves AI.
4. Any wizard whom ginny loves is a quidditch star.
5. Any wizard who does not study does not pass.
6. Any wizard who does not pass does not play.
7. Any wizard who does not play cannot be a quidditch star.
8. Anyone who is a muggle does not play quidditch.
9. All non-magic users are good.
10. Anyone who studies in UTD is good
11. anyone who is good is brilliant.
12. Anyone who is a wizard uses Magic.
13. Anyone who is muggle cannot use Magic.
14. Anyone who is a Magic user is not a Muggle.
15. Anyone who kills a wizard is hated by all wizards.
16. Anyone hated by all wizards is Evil.
17. Anyone who is evil is scared of the wizard Dumbledore.
18. Every wizard hates Voldemort.
19. Every father and mother loves all their children.
20. Harry, Ron, Dumbledore, Voldemort, lily, James are wizards.
21. James and lily are harry's father and mother.
22. James and lily are wizards.
23. Voldemort killed James and lily.

Predicates Used:

wizard(X) :	X is a Wizard.
hogwarts(X):	X studies in Hogwarts.
muggle(X):	X is a Muggle.
utd(X):	X studies in UTD.
loves(X, Y):	X loves Y.
quidditch(X):	X is a Quidditch star.
study(X):	X studies.
pass(X):	X passes his class.
play(X):	X plays quidditch.
good(X):	X is Good.
magic(X):	X uses Magic.

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hates(X,Y):   X hates Y.
Evil(X):   X is Evil.
Scared(X, Y)   X is Scared of Y.
kills(X,Y)   X kills Y.
Father(X,Y)   X is the father of Y.
Mother(X, Y)   X is the mother of Y.
brilliant(X)   X is brilliant

First Order Logic Translation:
all x (wizard(x) -> hogwarts(x)).
all x (muggle(x) -> utd(x)).
all x (muggle(x) -> loves(x, ai)).
all x (wizard(x) & loves(ginny, x) -> quidditch(x)).
all x (wizard(x) & -study(x) -> -pass(x)).
all x (wizard(x) & -pass(x) -> -play(x)).
all x (wizard(x) & - play(x) -> -quidditch(x)).
all x (muggle(x) -> -play(x)).

all x (utd(x) -> good(x)).
all x (wizard(x) -> magic(x)).
all x (muggle(x) -> -magic(x)).
all x(magic(x) -> -muggle(x)).
all x exists y (kills(x, y) & wizard(y) -> all z (wizard(z) & hates(z, x))).
all x all y (hates(y, x) & wizard(y) -> evil(x)).
all x (evil(x) -> scared(x, dumbledore)).

all x (wizard(x) -> hates(x, voldemort)).
all x all y (father(x, y) -> loves(x,y)).
all x all y (mother(x, y) -> loves(x,y)).
father(james, harry).
mother(lily, harry).
wizard(dumbledore).
wizard(harry).
wizard(voldemort).
wizard(james).
wizard(lily).
wizard(ron).
kills(voldemort, james).
kills(voldemort, lily).

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Clause Normal Form Translation:
-wizard(x) | hogwarts(x).
-muggle(x) | utd(x).
-muggle(x) | loves(x,ai).
-wizard(x) | -loves(ginny,x) | quidditch(x).
-wizard(x) | study(x) | -pass(x).
-wizard(x) | pass(x) | -play(x).
-wizard(x) | play(x) | -quidditch(x).
-muggle(x) | -play(x).
-utd(x) | good(x).
-wizard(x) | magic(x).
-muggle(x) | -magic(x).
-magic(x) | -muggle(x).
-kills(x,f1(x)) | -wizard(f1(x)) | wizard(y).
-kills(x,f1(x)) | -wizard(f1(x)) | hates(y,x).
-hates(x,y) | -wizard(x) | evil(y).
-evil(x) | scared(x,dumbledore).
-wizard(x) | hates(x,voldemort).
-father(x,y) | loves(x,y).
-mother(x,y) | loves(x,y).
father(james,harry).
mother(lily,harry).
wizard(dumbledore).
wizard(harry).
wizard(x).
wizard(james).
wizard(lily).
wizard(ron).
kills(voldemort,james).
kills(voldemort,lily).

Questions:
1. **If ginny loves harry does is he a quidditch star?**
    FOL: loves(ginny, harry) -> quidditch(harry).
    CNF: -loves(ginny, harry) | quidditch(harry).
    negation: loves(ginny, harry) & -quidditch(harry).

OUTPUT Proved:

% -------- Comments from original proof --------

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% Proof 1 at 0.00 (+ 0.00) seconds.
% Length of proof is 9.
% Level of proof is 4.
% Maximum clause weight is 0.
% Given clauses 0.

4 (all x (wizard(x) & loves(ginny,x) -> quidditch(x))) # label(non_clause). [assumption].
19 -loves(ginny,harry) | quidditch(harry) # label(non_clause) # label(goal). [goal].
21 -wizard(x) | -loves(ginny,x) | quidditch(x). [clausify(4)].
23 loves(ginny,harry). [deny(19)].
36 -wizard(harry) | quidditch(harry). [resolve(23,a,21,b)].
37 -quidditch(harry). [deny(19)].
38 -wizard(harry). [resolve(36,b,37,a)].
40 wizard(harry). [assumption].
45 $F. [resolve(38,a,40,a)].

For negation of goal (Resolution Refutation) : Exit: Exhausted

==================== end of clauses for search =============

================ SEARCH ==================================

% Starting search at 0.00 seconds.

================ STATISTICS ===========================

Given=0. Generated=0. Kept=0. proofs=0.
Usable=0. Sos=0. Demods=0. Limbo=0, Disabled=36. Hints=0.
Weight_deleted=0. Literals_deleted=0.
Forward_subsumed=0. Back_subsumed=0.
Sos_limit_deleted=0. Sos_displaced=0. Sos_removed=0.
New_demodulators=0 (0 lex), Back_demodulated=0. Back_unit_deleted=0.
Demod_attempts=0. Demod_rewrites=0.
Res_instance_prunes=0. Para_instance_prunes=0. Basic_paramod_prunes=0.
Nonunit_fsub_feature_tests=0. Nonunit_bsub_feature_tests=0.
Megabytes=0.02.
User_CPU=0.00, System_CPU=0.01, Wall_clock=0.

==================== end of statistics ====================

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=================== end of search ========================

SEARCH FAILED

Exiting with failure.

Process 8584 exit (sos_empty) Wed Apr 25 11:50:21 2018

2. **If harry does not study then ginny does not love harry.**
   FOL;study(harry) -> -loves(ginny, harry).
   CNF: study(harry) | -loves(ginny, harry).
   Negation: -study(harry) & loves(ginny, harry).

OUTPUT PROVED:
=================== PROOF ========================

% Proof 1 at 0.00 (+ 0.00) seconds.
% Length of proof is 14.
% Level of proof is 6.
% Maximum clause weight is 2.
% Given clauses 0.

1 study(harry) | -loves(ginny,harry) # label(non_clause) # label(goal). [goal].
3 -wizard(x) | -loves(ginny,x) | quidditch(x). [assumption].
5 loves(ginny,harry). [deny(1)].
6 -study(harry). [deny(1)].
7 -wizard(x) | study(x) | -pass(x). [assumption].
8 -wizard(harry) | -pass(harry). [resolve(6,a,7,b)].
9 -wizard(x) | pass(x) | -play(x). [assumption].
10 -wizard(harry) | -wizard(harry) | -play(harry). [resolve(8,b,9,b)].
11 -wizard(x) | play(x) | -quidditch(x). [assumption].
24 -wizard(harry) | -wizard(harry) | -wizard(harry) | -quidditch(harry).
[resolve(10,c,11,b)].

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25 -wizard(harry) | quidditch(harry). [resolve(5,a,3,b)].
28 wizard(x). [assumption].
29 -wizard(harry) | -wizard(harry) | -wizard(harry) | -wizard(harry).
[resolve(24,d,25,b)].
30 $F. [copy(29),merge(b),merge(c),merge(d),unit_del(a,28)].

================= end of proof =========================

==================STATISTICS =======================

Given=0. Generated=7. Kept=3. proofs=1.
Usable=0. Sos=0. Demods=0. Limbo=3, Disabled=40. Hints=0.
Weight_deleted=0. Literals_deleted=0.
Forward_subsumed=3. Back_subsumed=0.
Sos_limit_deleted=0. Sos_displaced=0. Sos_removed=0.
New_demodulators=0 (0 lex), Back_demodulated=0. Back_unit_deleted=0.
Demod_attempts=0. Demod_rewrites=0.
Res_instance_prunes=0. Para_instance_prunes=0. Basic_paramod_prunes=0.
Nonunit_fsub_feature_tests=0. Nonunit_bsub_feature_tests=0.
Megabytes=0.02.
User_CPU=0.00, System_CPU=0.00, Wall_clock=0.

===================== end of statistics ==================

===================== end of search ==================

THEOREM PROVED

Exiting with 1 proof.

Process 5487 exit (max_proofs) Tue Apr 24 20:05:56 2018

For negation of goal (Resolution Refutation) : Exit: Exhausted

===================== end of clauses for search ============

===================== SEARCH =======================

PROJECT REPORT

% Starting search at 0.00 seconds.

======================STATISTICS =====================

Given=0. Generated=0. Kept=0. proofs=0.
Usable=0. Sos=0. Demods=0. Limbo=0, Disabled=36. Hints=0.
Weight_deleted=0. Literals_deleted=0.
Forward_subsumed=0. Back_subsumed=0.
Sos_limit_deleted=0. Sos_displaced=0. Sos_removed=0.
New_demodulators=0 (0 lex), Back_demodulated=0. Back_unit_deleted=0.
Demod_attempts=0. Demod_rewrites=0.
Res_instance_prunes=0. Para_instance_prunes=0. Basic_paramod_prunes=0.
Nonunit_fsub_feature_tests=0. Nonunit_bsub_feature_tests=0.
Megabytes=0.02.
User_CPU=0.00, System_CPU=0.00, Wall_clock=0.

===================== end of statistics ===============

===================== end of search ===================

SEARCH FAILED

Exiting with failure.

Process 8625 exit (sos_empty) Wed Apr 25 11:55:17 2018

3. if Josh is a muggle then josh is a non magic user.
FOL: muggle(josh) -> -magic(josh).
CNF: -muggle(josh) | magic(josh).
Negation: muggle(josh) & -magic(josh).

OUTPUT Proved:

===================== PROOF =========================

% Proof 1 at 0.00 (+ 0.00) seconds.
% Length of proof is 6.
% Level of proof is 3.
% Maximum clause weight is 0.
% Given clauses 0.

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1 -muggle(josh) | magic(josh) # label(non_clause) # label(goal). [goal].
16 -magic(josh). [deny(1)].
17 -wizard(x) | magic(x). [assumption].
30 -wizard(josh). [resolve(16,a,17,b)].
33 wizard(x). [assumption].
37 $F. [resolve(30,a,33,a)].

============================ end of proof
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============================= STATISTICS
============================

Given=0. Generated=1. Kept=0. proofs=1.
Usable=0. Sos=0. Demods=0. Limbo=0, Disabled=42. Hints=0.
Weight_deleted=0. Literals_deleted=0.
Forward_subsumed=0. Back_subsumed=0.
Sos_limit_deleted=0. Sos_displaced=0. Sos_removed=0.
New_demodulators=0 (0 lex), Back_demodulated=0. Back_unit_deleted=0.
Demod_attempts=0. Demod_rewrites=0.
Res_instance_prunes=0. Para_instance_prunes=0. Basic_paramod_prunes=0.
Nonunit_fsub_feature_tests=0. Nonunit_bsub_feature_tests=0.
Megabytes=0.02.
User_CPU=0.00, System_CPU=0.00, Wall_clock=0.

====================== end of statistics ==================

======================= end of search ==================

THEOREM PROVED

Exiting with 1 proof.

Process 8646 exit (max_proofs) Wed Apr 25 11:58:06 2018

For negation of goal (Resolution Refutation) : Exit: Exhausted

====================== SEARCH ========================

PROJECT REPORT

% Starting search at 0.00 seconds.

===================== STATISTICS =====================

Given=0. Generated=0. Kept=0. proofs=0.
Usable=0. Sos=0. Demods=0. Limbo=0, Disabled=34. Hints=0.
Weight_deleted=0. Literals_deleted=0.
Forward_subsumed=0. Back_subsumed=0.
Sos_limit_deleted=0. Sos_displaced=0. Sos_removed=0.
New_demodulators=0 (0 lex), Back_demodulated=0. Back_unit_deleted=0.
Demod_attempts=0. Demod_rewrites=0.
Res_instance_prunes=0. Para_instance_prunes=0. Basic_paramod_prunes=0.
Nonunit_fsub_feature_tests=0. Nonunit_bsub_feature_tests=0.
Megabytes=0.02.
User_CPU=0.00, System_CPU=0.00, Wall_clock=0.

===================== end of statistics =================

===================== end of search ===================

SEARCH FAILED

Exiting with failure.

Process 8671 exit (sos_empty) Wed Apr 25 12:00:47 2018

4. If josh is a muggle then josh is brilliant.
FOL: muggle(josh) -> brilliant(josh).
CNF: -muggle(josh) | brilliant(josh).
negation: muggle(josh) & -brilliant(josh).

OUTPUT Proved:
===================== PROOF =====================

PROJECT REPORT

% Proof 1 at 0.00 (+ 0.00) seconds.
% Length of proof is 8.
% Level of proof is 4.
% Maximum clause weight is 0.
% Given clauses 0.

1 muggle(josh) -> brilliant(josh) # label(non_clause) # label(goal). [goal].
2 muggle(josh). [deny(1)].
6 -muggle(x) | -magic(x). [assumption].
16 -magic(josh). [resolve(2,a,6,a)].
17 -wizard(x) | magic(x). [assumption].
30 -wizard(josh). [resolve(16,a,17,b)].
33 wizard(x). [assumption].
37 $F. [resolve(30,a,33,a)].

======================= end of proof =====================

============================= STATISTICS
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Given=0. Generated=1. Kept=0. proofs=1.
Usable=0. Sos=0. Demods=0. Limbo=0, Disabled=43. Hints=0.
Weight_deleted=0. Literals_deleted=0.
Forward_subsumed=0. Back_subsumed=0.
Sos_limit_deleted=0. Sos_displaced=0. Sos_removed=0.
New_demodulators=0 (0 lex), Back_demodulated=0. Back_unit_deleted=0.
Demod_attempts=0. Demod_rewrites=0.
Res_instance_prunes=0. Para_instance_prunes=0. Basic_paramod_prunes=0.
Nonunit_fsub_feature_tests=0. Nonunit_bsub_feature_tests=0.
Megabytes=0.02.
User_CPU=0.00, System_CPU=0.00, Wall_clock=0.

============================= end of statistics
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==================== end of search =====================

THEOREM PROVED

Exiting with 1 proof.

PROJECT REPORT

Process 8688 exit (max_proofs) Wed Apr 25 12:02:44 2018

For negation of goal (Resolution Refutation) : Exit: Exhausted

5. Is voldemort evil?
CNF: evil(voldemort).
Negation: -evil(voldemort).
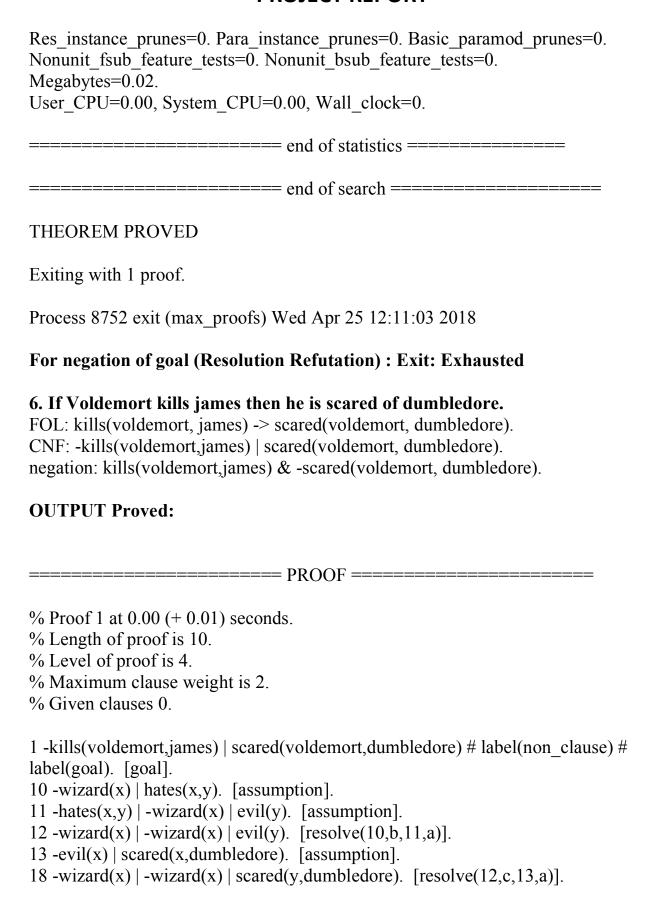

======================= PROOF ===========================

% Proof 1 at 0.00 (+ 0.00) seconds.
% Length of proof is 8.
% Level of proof is 3.
% Maximum clause weight is 2.
% Given clauses 0.

1 evil(voldemort) # label(non_clause) # label(goal). [goal].
9 -wizard(x) | hates(x,y). [assumption].
10 -hates(x,y) | -wizard(x) | evil(y). [assumption].
11 -wizard(x) | -wizard(x) | evil(y). [resolve(9,b,10,a)].
13 -evil(c1). [deny(1)].
20 wizard(x). [assumption].
21 -wizard(x) | -wizard(x). [resolve(11,c,13,a)].
22 $F. [copy(21),merge(b),unit_del(a,20)].

======================= end of proof ===================

======================= STATISTICS =====================

Given=0. Generated=7. Kept=3. proofs=1.
Usable=0. Sos=0. Demods=0. Limbo=3, Disabled=35. Hints=0.
Weight_deleted=0. Literals_deleted=0.
Forward_subsumed=3. Back_subsumed=0.
Sos_limit_deleted=0. Sos_displaced=0. Sos_removed=0.
New_demodulators=0 (0 lex), Back_demodulated=0. Back_unit_deleted=0.
Demod_attempts=0. Demod_rewrites=0.

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Res_instance_prunes=0. Para_instance_prunes=0. Basic_paramod_prunes=0.
Nonunit_fsub_feature_tests=0. Nonunit_bsub_feature_tests=0.
Megabytes=0.02.
User_CPU=0.00, System_CPU=0.00, Wall_clock=0.

======================= end of statistics ===============

======================= end of search ====================

THEOREM PROVED

Exiting with 1 proof.

Process 8752 exit (max_proofs) Wed Apr 25 12:11:03 2018

For negation of goal (Resolution Refutation) : Exit: Exhausted

6. If Voldemort kills james then he is scared of dumbledore.
FOL: kills(voldemort, james) -> scared(voldemort, dumbledore).
CNF: -kills(voldemort,james) | scared(voldemort, dumbledore).
negation: kills(voldemort,james) & -scared(voldemort, dumbledore).

OUTPUT Proved:

======================= PROOF ======================

% Proof 1 at 0.00 (+ 0.01) seconds.
% Length of proof is 10.
% Level of proof is 4.
% Maximum clause weight is 2.
% Given clauses 0.

1 -kills(voldemort,james) | scared(voldemort,dumbledore) # label(non_clause) #
label(goal). [goal].
10 -wizard(x) | hates(x,y). [assumption].
11 -hates(x,y) | -wizard(x) | evil(y). [assumption].
12 -wizard(x) | -wizard(x) | evil(y). [resolve(10,b,11,a)].
13 -evil(x) | scared(x,dumbledore). [assumption].
18 -wizard(x) | -wizard(x) | scared(y,dumbledore). [resolve(12,c,13,a)].

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19 -scared(c1,dumbledore). [deny(1)].
22 wizard(x). [assumption].
23 -wizard(x) | -wizard(x). [resolve(18,c,19,a)].
24 $F. [copy(23),merge(b),unit_del(a,22)].

===================== end of proof =====================

===================== STATISTICS =====================

Given=0. Generated=7. Kept=3. proofs=1.
Usable=0. Sos=0. Demods=0. Limbo=3, Disabled=36. Hints=0.
Weight_deleted=0. Literals_deleted=0.
Forward_subsumed=3. Back_subsumed=0.
Sos_limit_deleted=0. Sos_displaced=0. Sos_removed=0.
New_demodulators=0 (0 lex), Back_demodulated=0. Back_unit_deleted=0.
Demod_attempts=0. Demod_rewrites=0.
Res_instance_prunes=0. Para_instance_prunes=0. Basic_paramod_prunes=0.
Nonunit_fsub_feature_tests=0. Nonunit_bsub_feature_tests=0.
Megabytes=0.02.
User_CPU=0.00, System_CPU=0.01, Wall_clock=0.

===================== end of statistics =====================

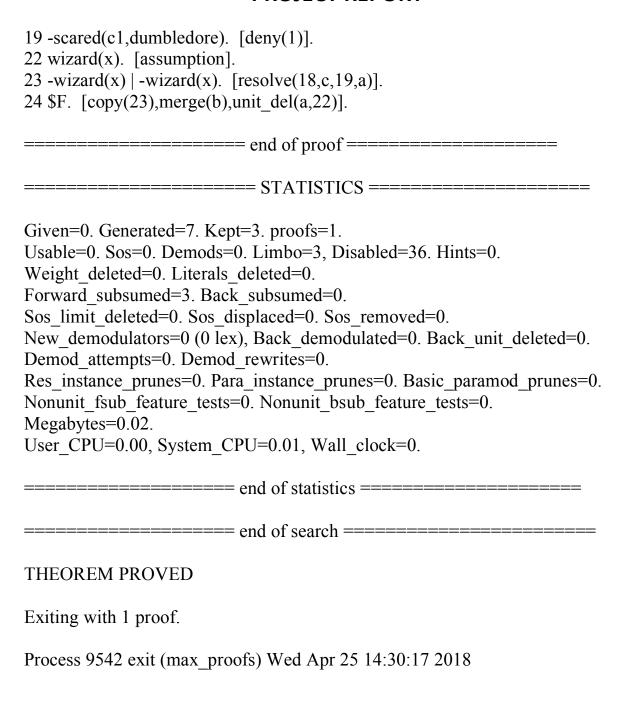===================== end of search =====================

THEOREM PROVED

Exiting with 1 proof.

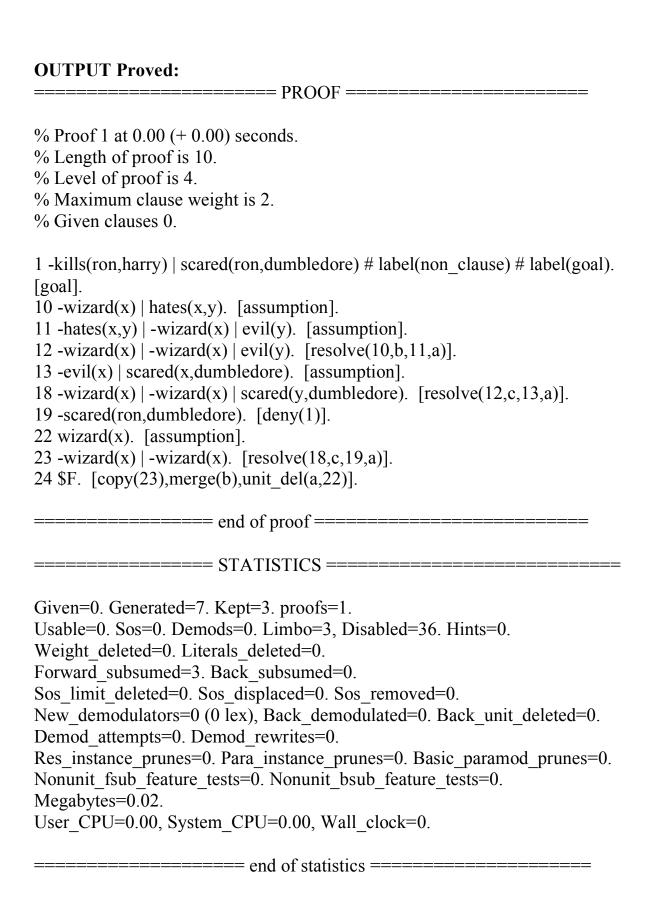Process 9542 exit (max_proofs) Wed Apr 25 14:30:17 2018

For negation of goal (Resolution Refutation) : Exit: Exhausted

7. If Ron kills harry then he is scared of dumbledore.
FOL: kills(ron, harry) -> scared(ron, dumbledore).
CNF: -kills(ron,harry) | scared(ron, dumbledore).
negation: kills(ron,harry) & -scared(ron, dumbledore).

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OUTPUT Proved:

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% Proof 1 at 0.00 (+ 0.00) seconds.
% Length of proof is 10.
% Level of proof is 4.
% Maximum clause weight is 2.
% Given clauses 0.

1 -kills(ron,harry) | scared(ron,dumbledore) # label(non_clause) # label(goal). [goal].
10 -wizard(x) | hates(x,y). [assumption].
11 -hates(x,y) | -wizard(x) | evil(y). [assumption].
12 -wizard(x) | -wizard(x) | evil(y). [resolve(10,b,11,a)].
13 -evil(x) | scared(x,dumbledore). [assumption].
18 -wizard(x) | -wizard(x) | scared(y,dumbledore). [resolve(12,c,13,a)].
19 -scared(ron,dumbledore). [deny(1)].
22 wizard(x). [assumption].
23 -wizard(x) | -wizard(x). [resolve(18,c,19,a)].
24 $F. [copy(23),merge(b),unit_del(a,22)].

================= end of proof =============================

================ STATISTICS ===============================

Given=0. Generated=7. Kept=3. proofs=1.
Usable=0. Sos=0. Demods=0. Limbo=3, Disabled=36. Hints=0.
Weight_deleted=0. Literals_deleted=0.
Forward_subsumed=3. Back_subsumed=0.
Sos_limit_deleted=0. Sos_displaced=0. Sos_removed=0.
New_demodulators=0 (0 lex), Back_demodulated=0. Back_unit_deleted=0.
Demod_attempts=0. Demod_rewrites=0.
Res_instance_prunes=0. Para_instance_prunes=0. Basic_paramod_prunes=0.
Nonunit_fsub_feature_tests=0. Nonunit_bsub_feature_tests=0.
Megabytes=0.02.
User_CPU=0.00, System_CPU=0.00, Wall_clock=0.

==================== end of statistics ====================

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================== end of search ========================

THEOREM PROVED

Exiting with 1 proof.

Process 9578 exit (max_proofs) Wed Apr 25 14:34:22 2018

For negation of goal (Resolution Refutation) : Exit: Exhausted

================== end of clauses for search =============

================ SEARCH =================================

% Starting search at 0.00 seconds.

================ STATISTICS ==============================

Given=0. Generated=0. Kept=0. proofs=0.
Usable=0. Sos=0. Demods=0. Limbo=0, Disabled=34. Hints=0.
Weight_deleted=0. Literals_deleted=0.
Forward_subsumed=0. Back_subsumed=0.
Sos_limit_deleted=0. Sos_displaced=0. Sos_removed=0.
New_demodulators=0 (0 lex), Back_demodulated=0. Back_unit_deleted=0.
Demod_attempts=0. Demod_rewrites=0.
Res_instance_prunes=0. Para_instance_prunes=0. Basic_paramod_prunes=0.
Nonunit_fsub_feature_tests=0. Nonunit_bsub_feature_tests=0.
Megabytes=0.02.
User_CPU=0.00, System_CPU=0.00, Wall_clock=0.

================== end of statistics ====================

================== end of search ========================

SEARCH FAILED

Exiting with failure.

PROJECT REPORT

Process 9588 exit (sos_empty) Wed Apr 25 14:35:16 2018

INFERENCE:
From the above CNF statements we can check if a goal statement in provable or not using Prover9 using inference rules and resolution refutation principles.
The Exit:Exhausted warning provided by Prover9 indicates the unsatisfiability of a given goal statement.