# <u>Negative Writes</u>
# <u>Version 2</u>

Updated 2Aug2017

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<u>**Algorithm**</u> *NegativeWrites*

1. Input a raw Datalog Program ***P***.
2. Copy ***P*** into ***P'*** such that all negated subgoals ***s*** are replaced by positive subgoals "***not_s***"
3. Run ***P*** without rewrites. Per IDB rule, populate a ***domains*** EDB with schema ***(ruleName,attributeID,value)***, where each ***ruleName*** corresponds to a particular IDB relation, attributeID is a member of ***{ 0,1,2, ... , N }*** corresponding to the index of the attribute in the ruleName schema, and value is a raw value appearing at that index of that IDB relation, as determined by the results of executing ***P*** without any rewrites.
4. FOR ***i*** in range(0, len( ***P'*** ) ) :
    a. ***r = P'[ i ]*** // get the current rule
    b. FOR EACH subgoal ***s*** in ***r*** :
        i. IF ***s*** is a negative subgoal AND an IDB :
            1. Interpret the collection of rules defining ***s*** in ***P'*** as a CQ.
            2. Apply DeMorgan's Law and simplify into a DNF.
            3. Interpret the DNF as a set of Datalog rules, following the strict definition of OR, ***(a OR b) == ( NOT a AND b ) OR ( a AND NOT b ) OR ( a AND b )***.
            4. Insert the new rules at the end of ***P'*** to ensure any new negated subgoals introduced by the rewrites are appropriately processed.
5. Output ***P'***.

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# Examples

## Example 1 :

(Example 1)

$\boldsymbol{P}$ :

$a(X,Y) \ :- \ b(X,Y), \neg r(X,Y)$
$r(X,Y) \ :- \ s(X,Y), u(Y)$

CQ interpretation :
$\forall X \in s_{att1}, Y \in s_{att2} \cup u_{att1}, (X,Y) \in s \wedge (Y) \in u$

Negation :
$\exists X \in s_{att1}, Y \in s_{att2} \cup u_{att1} \ni (X,Y) \notin s \vee (Y) \notin u$
$\equiv [\exists X \in s_{att1}, Y \in s_{att2} \ni (X,Y) \notin s] \vee [\exists Y \in u_{att1} \ni (Y) \notin u]$
$\equiv [\exists X \in s_{att1}, Y \in s_{att2} \ni (X,Y) \in \neg s] \vee [\exists Y \in u_{att1} \ni (Y) \in \neg u]$

Truth Table Analysis :
Let $A := \neg s(X,Y), B := \neg u(Y)$.

| A | B | $A \vee B$ | $CorrespondingFmla$ |
|---|---|---|---|
| 0 | 0 | 0 | |
| 0 | 1 | 1 | $s(X,Y), \neg u(Y)$ |
| 1 | 0 | 1 | $\neg s(X,Y), u(Y)$ |
| 1 | 1 | 1 | $\neg s(X,Y), \neg u(Y)$ |

Corresponding NegativeWrite rewrite :
$a(X,Y) \ :- \ b(X,Y), not\_r(X,Y)$
$r(X,Y) \ :- \ s(X,Y), u(Y)$
$not\_r(X,Y) \ :- \ \neg s(X,Y), u(Y), dom\_a\_att1(X), dom\_a\_att2(Y)$
$not\_r(X,Y) \ :- \ s(X,Y), \neg u(Y), dom\_a\_att1(X), dom\_a\_att2(Y)$
$not\_r(X,Y) \ :- \ \neg s(X,Y), \neg u(Y), dom\_a\_att1(X), dom\_a\_att2(Y)$

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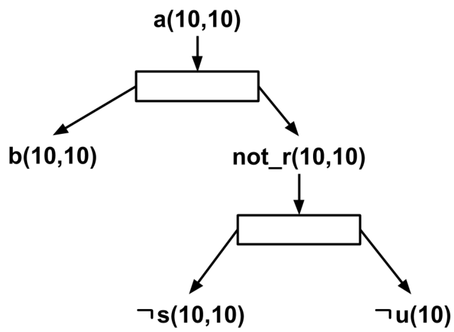
a
10 10
--------------------
b
10 10
--------------------
r
1 2
--------------------
s
1 2
3 4
5 6
--------------------
u
2 8
--------------------

dom_a_att1
10
--------------------
dom_a_att2
10



## Example 2 :

(Example 2)
$\boldsymbol{P}$ :

$$
\begin{aligned}
a(X,Y) &\;:-\; b(X,Y), \neg r(X,Y) \\
r(X,Y) &\;:-\; s(X,Y), \neg u(Y)
\end{aligned}
$$

CQ interpretation :
$\forall X \in s_{att1}, Y \in u_{att1}, (X) \in s \wedge (Y) \in u$

Negation :
$\exists X \in s_{att1}, Y \in u_{att1} \ni (X) \notin s \vee (Y) \notin u$
$\equiv [\exists X \in s_{att1} \ni (X) \notin s] \vee [\exists Y \in u_{att1} \ni (Y) \notin u]$
$\equiv [\exists X \in s_{att1} \ni (X) \in \neg s] \vee [\exists Y \in u_{att1} \ni (Y) \in \neg u]$

Truth Table Analysis :
Let $A := \neg s(X), B := \neg u(Y)$.

| A | B | $A \vee B$ | $CorrespondingFmla$ |
|---|---|---|---|
| 0 | 0 | 0 | |
| 0 | 1 | 1 | $s(X), \neg u(Y)$ |
| 1 | 0 | 1 | $\neg s(X), u(Y)$ |
| 1 | 1 | 1 | $\neg s(X), \neg u(Y)$ |

Corresponding NegativeWrite rewrite :

$$
\begin{aligned}
a(X,Y) &\;:-\; b(X,Y), not\_r(X,Y) \\
r(X,Y) &\;:-\; s(X,Y), u(Y) \\
not\_r(X,Y) &\;:-\; \neg s(X), u(Y), dom\_a\_att1(X), dom\_a\_att2(Y) \\
not\_r(X,Y) &\;:-\; s(X), \neg u(Y), dom\_a\_att1(X), dom\_a\_att2(Y) \\
not\_r(X,Y) &\;:-\; \neg s(X), \neg u(Y), dom\_a\_att1(X), dom\_a\_att2(Y)
\end{aligned}
$$

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a
10 10

--------------------

b
10 10

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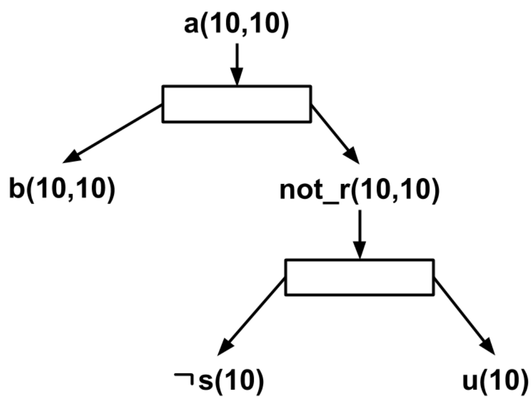
r
1 10
1 5
1 4
3 10
3 5
3 4
5 10
5 5
5 4

--------------------

s
1

3
5
--------------------
u
10
5
4
--------------------
dom_a_att1
10
--------------------
dom_a_att2
10



## Example 3 :

(Example 3)

$\boldsymbol{P}$ :

$$
\begin{aligned}
a(X,Y) &:- \ b(X,Y), \neg r(X,Y) \\
r(X,Y) &:- \ s(X,Z), t(Z,Y)
\end{aligned}
$$

CQ interpretation :

$\forall X \in s_{att1}, Y \in t_{att2}, \exists Z \in s_{att2} \cup t_{att1} \ni (X,Z) \in s \wedge (Z,Y) \in t$

Negation :

$\exists X \in s_{att1}, Y \in t_{att2} \ni \forall Z \in s_{att2} \cup t_{att1}, (X,Z) \notin s \vee (Z,Y) \notin t$

$\equiv \forall Z \in s_{att2} \cup t_{att1}, [\exists X \in s_{att1} \ni (X,Z) \notin s] \vee [\exists Y \in t_{att2} \ni (Z,Y) \notin t]$

$\equiv \forall Z \in s_{att2} \cup t_{att1}, [\exists X \in s_{att1} \ni (X,Z) \in \neg s] \vee [\exists Y \in t_{att2} \ni (Z,Y) \in \neg t]$

Truth Table Analysis :

Let $A := \neg s(X,Z), B := \neg t(Z,Y)$.

| A | B | $A \vee B$ | $CorrespondingFmla$ |
|---|---|---|---|
| 0 | 0 | 0 | |
| 0 | 1 | 1 | $s(X,Z), \neg t(Z,Y)$ |
| 1 | 0 | 1 | $\neg s(X,Z), t(Z,Y)$ |
| 1 | 1 | 1 | $\neg s(X,Z), \neg t(Z,Y)$ |

Corresponding NegativeWrite rewrite :

$$
\begin{aligned}
a(X,Y) &:- \ b(X,Y), not\_r(X,Y) \\
r(X,Y) &:- \ s(X,Z), t(Z,Y) \\
not\_r(X,Y) &:- \ \neg s(X,Z), t(Z,Y), dom\_a\_att1(X), dom\_a\_att2(Y) \\
not\_r(X,Y) &:- \ s(X,Z), \neg t(Z,Y), dom\_a\_att1(X), dom\_a\_att2(Y) \\
not\_r(X,Y) &:- \ \neg s(X,Z), \neg t(Z,Y), dom\_a\_att1(X), dom\_a\_att2(Y)
\end{aligned}
$$

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a

10 10

--------------------

b

10 10

--------------------

r

10 2

--------------------

s

1 2

10 3

5 6

--------------------

t

1 2

5 8

4 2

--------------------

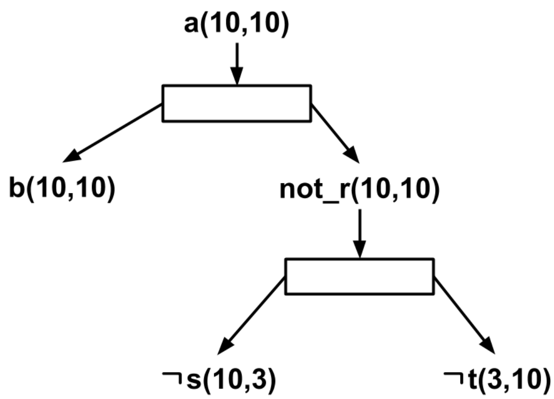
dom_a_att1

10

--------------------

dom_a_att2

10



**Example 4 :**

(Example 4)

$\boldsymbol{P}$ :

$$
\begin{aligned}
a(X,Y) &\ :-\ b(X,Y), \neg r(X,Y) \\
r(X,Y) &\ :-\ s(X,Y), \neg u(Y)
\end{aligned}
$$

CQ interpretation :

$\forall X \in s_{att1}, Y \in s_{att2} \cup u_{att1}, (X,Y) \in s \wedge (Y) \notin u$

Negation :

$\exists X \in s_{att1}, Y \in s_{att2} \cup u_{att1} \ni (X,Y) \notin s \vee (Y) \in u$

$[\exists X \in s_{att1}, \exists Y \in s_{att2} \ni (X,Y) \notin s] \vee [\exists Y \in u_{att1} \ni (Y) \notin u]$

$[\exists X \in s_{att1}, \exists Y \in s_{att2} \ni (X,Y) \in \neg s] \vee [\exists Y \in u_{att1} \ni (Y) \in \neg u]$

Truth Table Analysis :

Let $A := \neg s(X,Z), B := u(Y)$.

| A | B | $A \vee B$ | $CorrespondingFmla$ |
|---|---|---|---|
| 0 | 0 | 0 | |
| 0 | 1 | 1 | $s(X,Z), u(Z,Y)$ |
| 1 | 0 | 1 | $\neg s(X,Z), \neg u(Z,Y)$ |
| 1 | 1 | 1 | $\neg s(X,Z), u(Y)$ |

Corresponding NegativeWrite rewrite :

$$
\begin{aligned}
a(X,Y) &\ :-\ b(X,Y), not\_r(X,Y) \\
r(X,Y) &\ :-\ s(X,Y), u(Y) \\
not\_r(X,Y) &\ :-\ s(X,Y), u(Y), dom\_a\_att1(X), dom\_a\_att2(Y) \\
not\_r(X,Y) &\ :-\ \neg s(X,Y), \neg u(Y), dom\_a\_att1(X), dom\_a\_att2(Y) \\
not\_r(X,Y) &\ :-\ \neg s(X,Y), u(Y), dom\_a\_att1(X), dom\_a\_att2(Y)
\end{aligned}
$$

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a

10 10

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b

10 10

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r

5 10

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s

1 2

3 4

10 10

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u

1

3

10

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dom_a_att1

10

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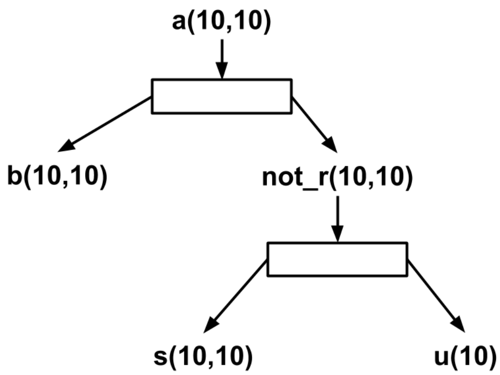
dom_a_att2

10

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