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May NNF conversion lead to an exponential increase in formula size for formulas with nested if and only if ($\Leftrightarrow$)?

Satisfiability Checking
06 SAT solving examples

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06 SAT solving examples

1 Example 1

2 Example 2

SAT solving: Example1

- We use enumeration and propagation in DPLL-style for the search, and CDCL-style conflict resolution for backtracking.
- We use watched literals (underlined in formulas) to speed up propagation.
- We use VSIDS as variable ordering heuristics and assign the value *false* to decision variables.
- In VSIDS, to order variables with the same activity value, we use the lexicographic order; in our example this will be $x_1 < x_2 < x_3 < x_4$.

Example 1

$$c_1 : (\underline{x_1} \vee \underline{x_2} \vee x_4) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (\underline{x_1} \vee \underline{\neg x_2} \vee x_4) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4})$$

Watch lists:

$x_1 :$ c_1, c_3

$\neg x_1 :$

$x_2 :$ c_1, c_2

$\neg x_2 :$ c_3

$x_3 :$ c_4

$\neg x_3 :$

$x_4 :$

$\neg x_4 :$ c_2, c_4

Activities (increment=1):

x_1 0

x_2 0

x_3 0

x_4 0

Trail:

Example 1

$$c_1 : (\underline{x_1} \vee \underline{x_2} \vee x_4) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (\underline{x_1} \vee \underline{\neg x_2} \vee x_4) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4})$$

Watch lists:

$x_1 :$ c_1, c_3
$\neg x_1 :$
$x_2 :$ c_1, c_2
$\neg x_2 :$ c_3
$x_3 :$ c_4
$\neg x_3 :$
$x_4 :$
$\neg x_4 :$ c_2, c_4
Decide $\neg x_1$

Activities
(increment=1):

x_1 0
x_2 0
x_3 0
x_4 0

Trail:

DL1: $\neg x_1 :$ NULL

Example 1

$$c_1 : (\underline{x_1} \vee \underline{x_2} \vee x_4) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (\underline{x_1} \vee \neg x_2 \vee x_4) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4})$$

Watch lists:

x_1 :	c_1, c_3
$\neg x_1$:	
x_2 :	c_1, c_2
$\neg x_2$:	c_3
x_3 :	c_4
$\neg x_3$:	
x_4 :	
$\neg x_4$:	c_2, c_4

Propagate $\neg x_1$ in

Activities (increment=1):

x_1	0
x_2	0
x_3	0
x_4	0

Trail:

DL1: $\neg x_1$: NULL

Example 1

$$c_1 : (\underline{x_1} \lor \underline{x_2} \lor x_4) \land c_2 : (\underline{x_2} \lor \underline{\neg x_4}) \land c_3 : (\underline{x_1} \lor \underline{\neg x_2} \lor x_4) \land c_4 : (\underline{x_3} \lor \underline{\neg x_4})$$

Watch lists:

$x_1 :$ c_1, c_3

$\neg x_1 :$

$x_2 :$ c_1, c_2

$\neg x_2 :$ c_3

$x_3 :$ c_4

$\neg x_3 :$

$x_4 :$

$\neg x_4 :$ c_2, c_4

Activities
(increment=1):

x_1 0

x_2 0

x_3 0

x_4 0

Trail:

DL1: $\neg x_1 :$ NULL

Propagate $\neg x_1$ in $c_1 : (\underline{x_1} \lor \underline{x_2} \lor x_4)$

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (\underline{x_1} \vee \underline{\neg x_2} \vee x_4) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4})$

Watch lists:

$x_1 :$ ~~c_1~~, c_3

$\neg x_1 :$

$x_2 :$ c_1, c_2

$\neg x_2 :$ c_3

$x_3 :$ c_4

$\neg x_3 :$

$x_4 :$ c_1

$\neg x_4 :$ c_2, c_4

Activities (increment=1):

x_1 0

x_2 0

x_3 0

x_4 0

Trail:

DL1: $\neg x_1 :$ NULL

Propagate $\neg x_1$ in $c_1 : (\underline{x_1} \vee \underline{x_2} \vee x_4) \rightarrow (x_1 \vee \underline{x_2} \vee \underline{x_4})$

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (\underline{x_1} \vee \underline{\neg x_2} \vee x_4) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4})$

Watch lists:

$x_1 : \ \cancel{c_1}, c_3$
$\neg x_1 :$
$x_2 : \ c_1, c_2$
$\neg x_2 : \ c_3$
$x_3 : \ c_4$
$\neg x_3 :$
$x_4 : \ c_1$
$\neg x_4 : \ c_2, c_4$

Activities (increment=1):

$x_1 \quad 0$
$x_2 \quad 0$
$x_3 \quad 0$
$x_4 \quad 0$

Trail:

DL1: $\neg x_1 :$ NULL

Propagate $\neg x_1$ in $\quad c_3 : (\underline{x_1} \vee \underline{\neg x_2} \vee x_4)$

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4})$

Watch lists:

$\quad x_1 : \quad \cancel{c_1}, \cancel{c_3}$
$\neg x_1 :$
$\quad x_2 : \quad c_1, c_2$
$\neg x_2 : \quad c_3$
$\quad x_3 : \quad c_4$
$\neg x_3 :$
$\quad x_4 : \quad c_1, c_3$
$\neg x_4 : \quad c_2, c_4$

Activities (increment=1):

$\quad x_1 \quad 0$
$\quad x_2 \quad 0$
$\quad x_3 \quad 0$
$\quad x_4 \quad 0$

Trail:

$\quad$ DL1: $\quad \neg x_1 :$ NULL

Propagate $\neg x_1$ in $\quad c_3 : (\underline{x_1} \vee \underline{\neg x_2} \vee x_4) \;\rightarrow\; (x_1 \vee \underline{\neg x_2} \vee \underline{x_4})$

Example 1

$$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4})$$

Watch lists:

$x_1 :$

$\neg x_1 :$

$x_2 : c_1, c_2$

$\neg x_2 : c_3$

$x_3 : c_4$

$\neg x_3 :$

$x_4 : c_1, c_3$

$\neg x_4 : c_2, c_4$

Decide $\neg x_2$

Activities
(increment=1):

$x_1 \quad 0$

$x_2 \quad 0$

$x_3 \quad 0$

$x_4 \quad 0$

Trail:

DL1: $\neg x_1$: NULL

DL2: $\neg x_2$: NULL

Example 1

$$c_1 : (x_1 \lor \underline{x_2} \lor \underline{x_4}) \land c_2 : (\underline{x_2} \lor \underline{\neg x_4}) \land c_3 : (x_1 \lor \underline{\neg x_2} \lor \underline{x_4}) \land c_4 : (\underline{x_3} \lor \underline{\neg x_4})$$

Watch lists:

x_1 :
$\neg x_1$:
x_2 : c_1, c_2
$\neg x_2$: c_3
x_3 : c_4
$\neg x_3$:
x_4 : c_1, c_3
$\neg x_4$: c_2, c_4
Propagate $\neg x_2$ in

Activities
(increment=1):

x_1 0
x_2 0
x_3 0
x_4 0

Trail:

DL1: $\neg x_1$: NULL
DL2: $\neg x_2$: NULL

Example 1

$$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4})$$

Watch lists:

x_1 :	
$\neg x_1$:	
x_2 :	c_1, c_2
$\neg x_2$:	c_3
x_3 :	c_4
$\neg x_3$:	
x_4 :	c_1, c_3
$\neg x_4$:	c_2, c_4

Activities (increment=1):

x_1	0
x_2	0
x_3	0
x_4	0

Trail:

DL1: $\neg x_1$: NULL
DL2: $\neg x_2$: NULL

Propagate $\neg x_2$ in $\quad c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4})$

Example 1

$$c_1 : (x_1 \lor \underline{x_2} \lor \underline{x_4}) \land c_2 : (\underline{x_2} \lor \underline{\neg x_4}) \land c_3 : (x_1 \lor \underline{\neg x_2} \lor \underline{x_4}) \land c_4 : (\underline{x_3} \lor \underline{\neg x_4})$$

Watch lists:

$x_1 :$

$\neg x_1 :$

$x_2 : \quad c_1, c_2$

$\neg x_2 : \quad c_3$

$x_3 : \quad c_4$

$\neg x_3 :$

$x_4 : \quad c_1, c_3$

$\neg x_4 : \quad c_2, c_4$

Activities (increment=1):

$x_1 \quad 0$

$x_2 \quad 0$

$x_3 \quad 0$

$x_4 \quad 0$

Trail:

DL1: $\neg x_1 :$ NULL

DL2: $\neg x_2 :$ NULL

$\quad x_4 : c_1$

Propagate $\neg x_2$ in $\quad c_1 : (x_1 \lor \underline{x_2} \lor \underline{x_4}) \quad \to \quad$ Assign x_4

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4})$

Watch lists:

x_1 :
$\neg x_1$:
x_2 : c_1, c_2
$\neg x_2$: c_3
x_3 : c_4
$\neg x_3$:
x_4 : c_1, c_3
$\neg x_4$: c_2, c_4

Activities (increment=1):

x_1 0
x_2 0
x_3 0
x_4 0

Trail:

DL1: $\neg x_1$: NULL
DL2: $\neg x_2$: NULL
    x_4 : c_1

Propagate $\neg x_2$ in $c_2 : (\underline{x_2} \vee \underline{\neg x_4})$

Example 1

$$c_1 : (x_1 \lor \underline{x_2} \lor \underline{x_4}) \land c_2 : (\underline{x_2} \lor \underline{\neg x_4}) \land c_3 : (x_1 \lor \underline{\neg x_2} \lor \underline{x_4}) \land c_4 : (\underline{x_3} \lor \underline{\neg x_4})$$

Watch lists:

x_1 :

$\neg x_1$:

x_2 : c_1, c_2

$\neg x_2$: c_3

x_3 : c_4

$\neg x_3$:

x_4 : c_1, c_3

$\neg x_4$: c_2, c_4

Propagate $\neg x_2$ in $\quad c_2 : (\underline{x_2} \lor \underline{\neg x_4}) \; \rightarrow \not\downarrow$ conflict!

Activities (increment=1):

x_1 0

x_2 0

x_3 0

x_4 0

Trail:

DL1: $\neg x_1$: NULL

DL2: $\neg x_2$: NULL

x_4 : c_1

Example 1

$$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4})$$

Watch lists:

$x_1 :$

$\neg x_1 :$

$x_2 : \quad c_1, c_2$

$\neg x_2 : \quad c_3$

$x_3 : \quad c_4$

$\neg x_3 :$

$x_4 : \quad c_1, c_3$

$\neg x_4 : \quad c_2, c_4$

Conflict resolution:

Activities (increment=1):

$x_1 \quad 0$

$x_2 \quad 0$

$x_3 \quad 0$

$x_4 \quad 0$

Trail:

DL1: $\neg x_1$: NULL

DL2: $\neg x_2$: NULL

$x_4 : c_1$

Example 1

$$c_1 : (x_1 \lor \underline{x_2} \lor \underline{x_4}) \land c_2 : (\underline{x_2} \lor \underline{\neg x_4}) \land c_3 : (x_1 \lor \underline{\neg x_2} \lor \underline{x_4}) \land c_4 : (\underline{x_3} \lor \underline{\neg x_4})$$

Watch lists:

$x_1 :$

$\neg x_1 :$

$x_2 : \quad c_1, c_2$

$\neg x_2 : \quad c_3$

$x_3 : \quad c_4$

$\neg x_3 :$

$x_4 : \quad c_1, c_3$

$\neg x_4 : \quad c_2, c_4$

Activities (increment=1):

$x_1 \quad 0$

$x_2 \quad 0$

$x_3 \quad 0$

$x_4 \quad 0$

Trail:

DL1: $\neg x_1 :$ NULL

DL2: $\neg x_2 :$ NULL

$\quad x_4 : c_1$

Conflict resolution: $\dfrac{(x_2 \lor \neg x_4) \quad (x_1 \lor x_2 \lor x_4)}{(x_1 \lor x_2)}$

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4}) \wedge$
$c_5 : (x_1 \vee x_2)$

Watch lists:

$x_1 :$	c_5
$\neg x_1 :$	
$x_2 :$	c_1, c_2, c_5
$\neg x_2 :$	c_3
$x_3 :$	c_4
$\neg x_3 :$	
$x_4 :$	c_1, c_3
$\neg x_4 :$	c_2, c_4

Add conflict clause

Activities
(increment=2):

x_1	1
x_2	1
x_3	0
x_4	1

Trail:

DL1: $\neg x_1 :$ NULL
DL2: $\neg x_2 :$ NULL
$\quad x_4 : c_1$

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4}) \wedge$
$c_5 : (x_1 \vee x_2)$

Watch lists:

$x_1 :$	c_5
$\neg x_1 :$	
$x_2 :$	c_1, c_2, c_5
$\neg x_2 :$	c_3
$x_3 :$	c_4
$\neg x_3 :$	
$x_4 :$	c_1, c_3
$\neg x_4 :$	c_2, c_4

Backtrack to DL1

Activities
(increment=2):

x_1	1
x_2	1
x_3	0
x_4	1

Trail:

DL1: $\neg x_1$: NULL

Example 1

$c_1 : (x_1 \lor \underline{x_2} \lor \underline{x_4}) \land c_2 : (\underline{x_2} \lor \underline{\neg x_4}) \land c_3 : (x_1 \lor \underline{\neg x_2} \lor \underline{x_4}) \land c_4 : (\underline{x_3} \lor \underline{\neg x_4}) \land$
$c_5 : (x_1 \lor \underline{x_2})$

Watch lists:

$\quad\quad x_1 : \quad c_5$

$\quad \neg x_1 :$

$\quad\quad x_2 : \quad c_1, c_2, c_5$

$\quad \neg x_2 : \quad c_3$

$\quad\quad x_3 : \quad c_4$

$\quad \neg x_3 :$

$\quad\quad x_4 : \quad c_1, c_3$

$\quad \neg x_4 : \quad c_2, c_4$

Assign x_2 at DL1 by c_5

Activities
(increment=2):

$\quad x_1 \quad 1$

$\quad x_2 \quad 1$

$\quad x_3 \quad 0$

$\quad x_4 \quad 1$

Trail:

$\quad$ DL1: $\quad \neg x_1 :$ NULL

$\quad\quad\quad x_2 : c_5$

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4}) \wedge$
$c_5 : (x_1 \vee \underline{x_2})$

Watch lists:

$x_1 : \quad c_5$

$\neg x_1 :$

$x_2 : \quad c_1, c_2, c_5$

$\neg x_2 : \quad c_3$

$x_3 : \quad c_4$

$\neg x_3 :$

$x_4 : \quad c_1, c_3$

$\neg x_4 : \quad c_2, c_4$

Propagate x_2 in

Activities
(increment=2):

$x_1 \quad 1$

$x_2 \quad 1$

$x_3 \quad 0$

$x_4 \quad 1$

Trail:

DL1: $\quad \neg x_1 : \text{NULL}$

$\quad\quad x_2 : c_5$

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4}) \wedge$
$c_5 : (x_1 \vee \underline{x_2})$

Watch lists:

$\quad x_1 : \quad c_5$

$\quad \neg x_1 :$

$\quad x_2 : \quad c_1, c_2, c_5$

$\quad \neg x_2 : \quad c_3$

$\quad x_3 : \quad c_4$

$\quad \neg x_3 :$

$\quad x_4 : \quad c_1, c_3$

$\quad \neg x_4 : \quad c_2, c_4$

Propagate x_2 in $\quad c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4})$

Activities
(increment=2):

$\quad x_1 \quad 1$

$\quad x_2 \quad 1$

$\quad x_3 \quad 0$

$\quad x_4 \quad 1$

Trail:

$\quad$ DL1: $\quad \neg x_1 :$ NULL

$\quad\quad\quad x_2 : c_5$

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \neg x_4) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4}) \wedge$
$c_5 : (x_1 \vee \underline{x_2})$

Watch lists:

$x_1 :$	c_5
$\neg x_1 :$	
$x_2 :$	c_1, c_2, c_5
$\neg x_2 :$	c_3
$x_3 :$	c_4
$\neg x_3 :$	
$x_4 :$	c_1, c_3
$\neg x_4 :$	c_2, c_4

Activities (increment=2):

x_1	1
x_2	1
x_3	0
x_4	1

Trail:

DL1: $\neg x_1 : \text{NULL}$
$x_2 : c_5$
$x_4 : c_3$

Propagate x_2 in $\quad c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \;\rightarrow\;$ Assign x_4

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4}) \wedge$
$c_5 : (x_1 \vee \underline{x_2})$

Watch lists:

$x_1 :$	c_5
$\neg x_1 :$	
$x_2 :$	c_1, c_2, c_5
$\neg x_2 :$	c_3
$x_3 :$	c_4
$\neg x_3 :$	
$x_4 :$	c_1, c_3
$\neg x_4 :$	c_2, c_4

Propagate x_4 in

Activities
(increment=2):

x_1	1
x_2	1
x_3	0
x_4	1

Trail:

DL1: $\neg x_1 :$ NULL
$x_2 : c_5$
$x_4 : c_3$

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4}) \wedge$
$c_5 : (x_1 \vee \underline{x_2})$

Watch lists:

$x_1 :$	c_5
$\neg x_1 :$	
$x_2 :$	c_1, c_2, c_5
$\neg x_2 :$	c_3
$x_3 :$	c_4
$\neg x_3 :$	
$x_4 :$	c_1, c_3
$\neg x_4 :$	c_2, c_4

Propagate x_4 in $\quad c_2 : (\underline{x_2} \vee \underline{\neg x_4})$

Activities
(increment=2):

x_1	1
x_2	1
x_3	0
x_4	1

Trail:

DL1: $\neg x_1 : $ NULL
  $x_2 : c_5$
  $x_4 : c_3$

Example 1

$c_1 : (x_1 \lor \underline{x_2} \lor \underline{x_4}) \land c_2 : (\underline{x_2} \lor \underline{\neg x_4}) \land c_3 : (x_1 \lor \underline{\neg x_2} \lor \underline{x_4}) \land c_4 : (\underline{x_3} \lor \underline{\neg x_4}) \land$
$c_5 : (x_1 \lor \underline{x_2})$

Watch lists:

$x_1 :$	c_5
$\neg x_1 :$	
$x_2 :$	c_1, c_2, c_5
$\neg x_2 :$	c_3
$x_3 :$	c_4
$\neg x_3 :$	
$x_4 :$	c_1, c_3
$\neg x_4 :$	c_2, c_4

Activities (increment=2):

x_1	1
x_2	1
x_3	0
x_4	1

Trail:

DL1: $\neg x_1 :$ NULL
     $x_2 : c_5$
     $x_4 : c_3$

Propagate x_4 in $c_2 : (\underline{x_2} \lor \underline{\neg x_4}) \rightarrow$ O.K.

Example 1

$c_1 : (x_1 \vee \underline{x_2} \vee \underline{x_4}) \wedge c_2 : (\underline{x_2} \vee \underline{\neg x_4}) \wedge c_3 : (x_1 \vee \underline{\neg x_2} \vee \underline{x_4}) \wedge c_4 : (\underline{x_3} \vee \underline{\neg x_4}) \wedge$
$c_5 : (x_1 \vee \underline{x_2})$

Watch lists:

$x_1 :$	c_5
$\neg x_1 :$	
$x_2 :$	c_1, c_2, c_5
$\neg x_2 :$	c_3
$x_3 :$	c_4
$\neg x_3 :$	
$x_4 :$	c_1, c_3
$\neg x_4 :$	c_2, c_4

Propagate x_4 in $c_4 : (\underline{x_3} \vee \underline{\neg x_4})$

Activities (increment=2):

x_1	1
x_2	1
x_3	0
x_4	1

Trail:

DL1: $\neg x_1 :$ NULL
$x_2 : c_5$
$x_4 : c_3$

Example 1

$c_1 : (x_1 \lor \underline{x_2} \lor \underline{x_4}) \land c_2 : (\underline{x_2} \lor \underline{\neg x_4}) \land c_3 : (x_1 \lor \underline{\neg x_2} \lor \underline{x_4}) \land c_4 : (\underline{x_3} \lor \underline{\neg x_4}) \land$
$c_5 : (x_1 \lor \underline{x_2})$

Watch lists:

$x_1 :$	c_5
$\neg x_1 :$	
$x_2 :$	c_1, c_2, c_5
$\neg x_2 :$	c_3
$x_3 :$	c_4
$\neg x_3 :$	
$x_4 :$	c_1, c_3
$\neg x_4 :$	c_2, c_4

Activities
(increment=2):

x_1	1
x_2	1
x_3	0
x_4	1

Trail:

DL1: $\neg x_1 :$ NULL
$x_2 : c_5$
$x_4 : c_3$
$x_3 : c_4$

Propagate x_4 in $\quad c_4 : (\underline{x_3} \lor \underline{\neg x_4}) \rightarrow$ Assign x_3

Example 1

$c_1 : (x_1 \lor \underline{x_2} \lor \underline{x_4}) \land c_2 : (\underline{x_2} \lor \underline{\neg x_4}) \land c_3 : (x_1 \lor \underline{\neg x_2} \lor \underline{x_4}) \land c_4 : (\underline{x_3} \lor \underline{\neg x_4}) \land$
$c_5 : (x_1 \lor x_2)$

Watch lists:

$x_1 :$	c_5
$\neg x_1 :$	
$x_2 :$	c_1, c_2, c_5
$\neg x_2 :$	c_3
$x_3 :$	c_4
$\neg x_3 :$	
$x_4 :$	c_1, c_3
$\neg x_4 :$	$c_2,$

$\rightarrow$ SAT

Activities
(increment=2):

x_1	1
x_2	1
x_3	0
x_4	1

Trail:

DL1: $\neg x_1 :$ NULL
$x_2 : c_5$
$x_4 : c_3$
$x_3 : c_4$

Bonus exercise 9

Assume the following propositional logic formula in CNF:

$$(a \vee b) \wedge (\neg b \vee c \vee d) \wedge (\neg b \vee \neg c) \wedge (c \vee \neg d)$$

Initially, all variables are unassigned. Propagate the first decision $a := 0$ and resolve the resulting conflict. What is the resulting asserting clause (according to the first UIP)? *Note: here, you may identify unit clauses manually, without implementing watched literals.*

- ()
- (a)
- ($\neg a$)
- (b)
- ($\neg b$)
- ($\neg b \vee c$)

Assume the following propositional logic formula in CNF:

$$(a \vee b) \wedge (\neg b \vee c \vee d) \wedge (\neg b \vee \neg c) \wedge (c \vee \neg d)$$

Initially, all variables are unassigned. Propagate the first decision $a := 0$ and resolve the resulting conflict. What is the resulting asserting clause (according to the first UIP)? *Note: here, you may identify unit clauses manually, without implementing watched literals.*

- $()$
- (a)
- $(\neg a)$
- (b)
- $(\neg b)$
- $(\neg b \vee c)$

- We use enumeration and propagation in DPLL-style for the search, and CDCL-style conflict resolution for backtracking.
- We use watched literals (underlined in formulas) to speed up propagation.
- We use VSIDS as variable ordering heuristics and assign the value *false* to decision variables.
- In VSIDS, to order variables with the same activity value, we use the lexicographic order; in our example this will be $a < b < c < d$.

Example

$c_1 : (a \vee b \vee \neg c) \wedge c_2 : (b \vee c) \wedge c_3 : (\neg a \vee b \vee \neg c) \wedge c_4 : (a \vee \neg b \vee c) \wedge$
$c_5 : (a \vee \neg c \vee d) \wedge c_6 : (\neg c \vee \neg d)$

Example – Watchlists

$c_1 : (a \vee b \vee \neg c) \wedge c_2 : (b \vee c) \wedge c_3 : (\neg a \vee b \vee \neg c) \wedge c_4 : (a \vee \neg b \vee c) \wedge$
$c_5 : (a \vee \neg c \vee d) \wedge c_6 : (\neg c \vee \neg d)$

Watch lists:

a :
$\neg a$:
b :
$\neg b$:
c :
$\neg c$:
d :
$\neg d$:

Example – Watchlists

$c_1 : (\underline{a} \vee \underline{b} \vee \neg c) \wedge c_2 : (b \vee c) \wedge c_3 : (\neg a \vee b \vee \neg c) \wedge c_4 : (a \vee \neg b \vee c) \wedge$
$c_5 : (a \vee \neg c \vee d) \wedge c_6 : (\neg c \vee \neg d)$

Watch lists:

$$
\begin{aligned}
a &: \quad c_1 \\
\neg a &: \\
b &: \quad c_1 \\
\neg b &: \\
c &: \\
\neg c &: \\
d &: \\
\neg d &:
\end{aligned}
$$

Example – Watchlists

$c_1 : (\underline{a} \vee \underline{b} \vee \neg c) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee b \vee \neg c) \wedge c_4 : (a \vee \neg b \vee c) \wedge$
$c_5 : (a \vee \neg c \vee d) \wedge c_6 : (\neg c \vee \neg d)$

Watch lists:

$$
\begin{array}{rl}
a: & c_1 \\
\neg a: & \\
b: & c_1, c_2 \\
\neg b: & \\
c: & c_2 \\
\neg c: & \\
d: & \\
\neg d: &
\end{array}
$$

Example – Watchlists

$c_1 : (\underline{a} \vee \underline{b} \vee \neg c) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \neg b \vee c) \wedge$
$c_5 : (a \vee \neg c \vee d) \wedge c_6 : (\neg c \vee \neg d)$

Watch lists:

$$
\begin{array}{rl}
a : & c_1 \\
\neg a : & c_3 \\
b : & c_1, c_2, c_3 \\
\neg b : & \\
c : & c_2 \\
\neg c : & \\
d : & \\
\neg d : &
\end{array}
$$

Example – Watchlists

$c_1 : (\underline{a} \lor \underline{b} \lor \neg c) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\underline{\neg a} \lor \underline{b} \lor \neg c) \land c_4 : (\underline{a} \lor \underline{\neg b} \lor c) \land$
$c_5 : (a \lor \neg c \lor d) \land c_6 : (\neg c \lor \neg d)$

Watch lists:

$$
\begin{array}{rl}
a : & c_1, c_4 \\
\neg a : & c_3 \\
b : & c_1, c_2, c_3 \\
\neg b : & c_4 \\
c : & c_2 \\
\neg c : & \\
d : & \\
\neg d : &
\end{array}
$$

Example – Watchlists

$c_1 : (\underline{a} \lor \underline{b} \lor \neg c) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\underline{\neg a} \lor \underline{b} \lor \neg c) \land c_4 : (\underline{a} \lor \underline{\neg b} \lor c) \land$
$c_5 : (\underline{a} \lor \underline{\neg c} \lor d) \land c_6 : (\neg c \lor \neg d)$

Watch lists:

$$
\begin{array}{rl}
a : & c_1, c_4, c_5 \\
\neg a : & c_3 \\
b : & c_1, c_2, c_3 \\
\neg b : & c_4 \\
c : & c_2 \\
\neg c : & c_5 \\
d : & \\
\neg d : &
\end{array}
$$

Example – Watchlists

$c_1 : (\underline{a} \vee \underline{b} \vee \neg c) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (\underline{a} \vee \underline{\neg b} \vee c) \wedge$
$c_5 : (\underline{a} \vee \underline{\neg c} \vee d) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

$$
\begin{aligned}
a &: \quad c_1, c_4, c_5 \\
\neg a &: \quad c_3 \\
b &: \quad c_1, c_2, c_3 \\
\neg b &: \quad c_4 \\
c &: \quad c_2 \\
\neg c &: \quad c_5, c_6 \\
d &: \quad \\
\neg d &: \quad c_6
\end{aligned}
$$

Example – Activities

$c_1 : (\underline{a} \lor \underline{b} \lor \neg c) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\underline{\neg a} \lor \underline{b} \lor \neg c) \land c_4 : (\underline{a} \lor \underline{\neg b} \lor c) \land$
$c_5 : (\underline{a} \lor \underline{\neg c} \lor d) \land c_6 : (\underline{\neg c} \lor \underline{\neg d})$

Watch lists:

$a :$	c_1, c_4, c_5
$\neg a :$	c_3
$b :$	c_1, c_2, c_3
$\neg b :$	c_4
$c :$	c_2
$\neg c :$	c_5, c_6
$d :$	
$\neg d :$	c_6

Activities
(increment=1):

a	0
b	0
c	0
d	0

$c_1 : (\underline{a} \vee \underline{b} \vee \neg c) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (\underline{a} \vee \underline{\neg b} \vee c) \wedge$
$c_5 : (\underline{a} \vee \underline{\neg c} \vee d) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

$a :$	c_1, c_4, c_5
$\neg a :$	c_3
$b :$	c_1, c_2, c_3
$\neg b :$	c_4
$c :$	c_2
$\neg c :$	c_5, c_6
$d :$	
$\neg d :$	c_6

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

SAT solving: Example 2

$c_1 : (\underline{a} \vee \underline{b} \vee \neg c) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (\underline{a} \vee \underline{\neg b} \vee c) \wedge$
$c_5 : (\underline{a} \vee \underline{\neg c} \vee d) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

$a :$	c_1, c_4, c_5
$\neg a :$	c_3
$b :$	c_1, c_2, c_3
$\neg b :$	c_4
$c :$	c_2
$\neg c :$	c_5, c_6
$d :$	
$\neg d :$	c_6

Decide $\neg a$

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

DL1: $\neg a : $ NULL

SAT solving: Example 2

$c_1 : (\underline{a} \vee \underline{b} \vee \neg c) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (\underline{a} \vee \underline{\neg b} \vee c) \wedge$
$c_5 : (\underline{a} \vee \underline{\neg c} \vee d) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

$a :$	c_1, c_4, c_5
$\neg a :$	c_3
$b :$	c_1, c_2, c_3
$\neg b :$	c_4
$c :$	c_2
$\neg c :$	c_5, c_6
$d :$	
$\neg d :$	c_6

Propagate $\neg a$ in

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

DL1: $\neg a :$ NULL

SAT solving: Example 2

$c_1 : (\underline{a} \vee \underline{b} \vee \neg c) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (\underline{a} \vee \underline{\neg b} \vee c) \wedge$
$c_5 : (\underline{a} \vee \underline{\neg c} \vee d) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

Activities (increment=1):

Trail:

$a : \quad c_1, c_4, c_5$

$\neg a : \quad c_3$

$b : \quad c_1, c_2, c_3$

$\neg b : \quad c_4$

$c : \quad c_2$

$\neg c : \quad c_5, c_6$

$d : $

$\neg d : \quad c_6$

a	0
b	0
c	0
d	0

DL1: $\neg a :$ NULL

Propagate $\neg a$ in $\quad c_1 : (\underline{a} \vee \underline{b} \vee \neg c)$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (\underline{a} \vee \underline{\neg b} \vee c) \wedge$
$c_5 : (\underline{a} \vee \underline{\neg c} \vee d) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

Activities
(increment=1):

Trail:

$a :$ $\cancel{c_1}, c_4, c_5$

$\neg a :$ c_3

$b :$ c_1, c_2, c_3

$\neg b :$ c_4

$c :$ c_2

$\neg c :$ c_5, c_6, c_1

$d :$

$\neg d :$ c_6

a	0
b	0
c	0
d	0

DL1: $\neg a :$ NULL

Propagate $\neg a$ in $\quad c_1 : (\underline{a} \vee \underline{b} \vee \neg c) \;\rightarrow\; (a \vee \underline{b} \vee \underline{\neg c})$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (\underline{a} \vee \underline{\neg b} \vee c) \wedge$
$c_5 : (\underline{a} \vee \underline{\neg c} \vee d) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

a :	$\cancel{c_1}, c_4, c_5$
$\neg a$:	c_3
b :	c_1, c_2, c_3
$\neg b$:	c_4
c :	c_2
$\neg c$:	c_5, c_6, c_1
d :	
$\neg d$:	c_6

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

DL1: $\neg a$: NULL

Propagate $\neg a$ in $\quad c_4 : (\underline{a} \vee \underline{\neg b} \vee c)$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (\underline{a} \vee \underline{\neg c} \vee d) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

a :	$\cancel{c_1}, \cancel{c_4}, c_5$
$\neg a$:	c_3
b :	c_1, c_2, c_3
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1
d :	
$\neg d$:	c_6

Propagate $\neg a$ in $c_4 : (\underline{a} \vee \underline{\neg b} \vee c) \ \rightarrow \ (a \vee \underline{\neg b} \vee \underline{c})$

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

DL1: $\neg a :$ NULL

SAT solving: Example 2

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (\underline{a} \vee \underline{\neg c} \vee d) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

a :	$\cancel{c_1}, \cancel{c_4}, c_5$
$\neg a$:	c_3
b :	c_1, c_2, c_3
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1
d :	
$\neg d$:	c_6

Propagate $\neg a$ in $\quad c_5 : (\underline{a} \vee \underline{\neg c} \vee d)$

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

DL1: $\neg a : $ NULL

SAT solving: Example 2

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

Activities (increment=1):

Trail:

a :	$\cancel{c_1}, \cancel{c_4}, \cancel{c_5}$
$\neg a$:	c_3
b :	c_1, c_2, c_3
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1
d :	c_5
$\neg d$:	c_6

a	0
b	0
c	0
d	0

DL1: $\neg a$: NULL

Propagate $\neg a$ in $\quad c_5 : (\underline{a} \vee \underline{\neg c} \vee d) \ \rightarrow (a \vee \underline{\neg c} \vee \underline{d})$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

$a :$	
$\neg a :$	c_3
$b :$	c_1, c_2, c_3
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Decide $\neg b$

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

DL1: $\neg a :$ NULL
DL2: $\neg b :$ NULL

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

a :	
$\neg a$:	c_3
b :	c_1, c_2, c_3
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1
d :	c_5
$\neg d$:	c_6

Propagate $\neg b$ in

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

DL1: $\neg a$: NULL
DL2: $\neg b$: NULL

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

a :	
$\neg a$:	c_3
b :	c_1, c_2, c_3
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1
d :	c_5
$\neg d$:	c_6

Propagate $\neg b$ in $c_1 : (a \vee \underline{b} \vee \underline{\neg c})$

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

DL1: $\neg a$: NULL
DL2: $\neg b$: NULL

$c_1 : (a \lor \underline{b} \lor \underline{\neg c}) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\underline{\neg a} \lor \underline{b} \lor \neg c) \land c_4 : (a \lor \underline{\neg b} \lor \underline{c}) \land$
$c_5 : (a \lor \underline{\neg c} \lor \underline{d}) \land c_6 : (\underline{\neg c} \lor \underline{\neg d})$

Watch lists:

$a :$

$\neg a : \quad c_3$

$b : \quad c_1, c_2, c_3$

$\neg b : \quad c_4$

$c : \quad c_2, c_4$

$\neg c : \quad c_5, c_6, c_1$

$d : \quad c_5$

$\neg d : \quad c_6$

Propagate $\neg b$ in $\quad c_1 : (a \lor \underline{b} \lor \underline{\neg c}) \rightarrow$ assign $\neg c$

Activities
(increment=1):

$a \quad 0$

$b \quad 0$

$c \quad 0$

$d \quad 0$

Trail:

DL1: $\neg a :$ NULL

DL2: $\neg b :$ NULL

$\neg c : c_1$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

$a :$	
$\neg a :$	c_3
$b :$	c_1, c_2, c_3
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

DL1: $\neg a$: NULL
DL2: $\neg b$: NULL
$\neg c$: c_1

Propagate $\neg b$ in $\quad c_2 : (\underline{b} \vee \underline{c})$

$c_1 : (a \lor \underline{b} \lor \underline{\neg c}) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\underline{\neg a} \lor \underline{b} \lor \neg c) \land c_4 : (a \lor \underline{\neg b} \lor \underline{c}) \land$
$c_5 : (a \lor \underline{\neg c} \lor \underline{d}) \land c_6 : (\underline{\neg c} \lor \underline{\neg d})$

Watch lists:

$a :$	
$\neg a :$	c_3
$b :$	c_1, c_2, c_3
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

DL1: $\neg a$: NULL
DL2: $\neg b$: NULL
$\neg c$: c_1

Propagate $\neg b$ in $\quad c_2 : (\underline{b} \lor \underline{c}) \;\to\; \lightning$ conflict!

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

a :	
$\neg a$:	c_3
b :	c_1, c_2, c_3
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1
d :	c_5
$\neg d$:	c_6

Conflict resolution:

Activities
(increment=1):

a	0
b	0
c	0
d	0

Trail:

DL1: $\neg a$: NULL
DL2: $\neg b$: NULL
       $\neg c$: c_1

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Watch lists:

$a :$

$\neg a : \quad c_3$

$b : \quad c_1, c_2, c_3$

$\neg b : \quad c_4$

$c : \quad c_2, c_4$

$\neg c : \quad c_5, c_6, c_1$

$d : \quad c_5$

$\neg d : \quad c_6$

Conflict resolution: $\dfrac{c_2 : (b \vee c) \quad c_1 : (a \vee b \vee \neg c)}{c_7 : (a \vee b)}$

Activities
(increment=2):

$a \quad \emptyset \; 1$

$b \quad \emptyset \; 1$

$c \quad \emptyset \; 1$

$d \quad 0$

Trail:

DL1: $\neg a$: NULL

DL2: $\neg b$: NULL

$\neg c : c_1$

$c_1 : (a \lor \underline{b} \lor \underline{\neg c}) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\underline{\neg a} \lor \underline{b} \lor \neg c) \land c_4 : (a \lor \underline{\neg b} \lor \underline{c}) \land$
$c_5 : (a \lor \underline{\neg c} \lor \underline{d}) \land c_6 : (\underline{\neg c} \lor \underline{\neg d}) \land c_7 : (\underline{a} \lor \underline{b})$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Add conflict clause

Activities
(increment=2):

a	1
b	1
c	1
d	0

Trail:

DL1: $\neg a :$ NULL
DL2: $\neg b :$ NULL
   $\neg c : c_1$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

a :	c_7
$\neg a$:	c_3
b :	c_1, c_2, c_3, c_7
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1
d :	c_5
$\neg d$:	c_6

Backtrack to DL1

Activities
(increment=2):

a	1
b	1
c	1
d	0

Trail:

DL1: $\neg a$: NULL
~~DL2:~~ ~~$\neg b$: NULL~~
~~$\neg c$: c_1~~

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Assign b at DL1 by c_7

Activities
(increment=2):

a	1
b	1
c	1
d	0

Trail:

DL1: $\neg a :$ NULL
      $b : c_7$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

$a :$ c_7

$\neg a :$ c_3

$b :$ c_1, c_2, c_3, c_7

$\neg b :$ c_4

$c :$ c_2, c_4

$\neg c :$ c_5, c_6, c_1

$d :$ c_5

$\neg d :$ c_6

Propagate b in

Activities
(increment=2):

a 1
b 1
c 1
d 0

Trail:

DL1: $\neg a :$ NULL

     $b : c_7$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=2):

a	1
b	1
c	1
d	0

Trail:

DL1: $\neg a :$ NULL
  $b : c_7$

Propagate b in $c_4 : (a \vee \underline{\neg b} \vee \underline{c})$

SAT solving: Example 2

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Activities (increment=2):

a	1
b	1
c	1
d	0

Trail:

DL1: $\neg a$: NULL
  $b : c_7$
  $c : c_4$

Propagate b in $c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \;\rightarrow$ assign c

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Propagate c in

Activities
(increment=2):

a	1
b	1
c	1
d	0

Trail:

DL1: $\neg a :$ NULL
$b : c_7$
$c : c_4$

SAT solving: Example 2

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Activities (increment=2):

a	1
b	1
c	1
d	0

Trail:

DL1: $\neg a :$ NULL
     $b : c_7$
     $c : c_4$

Propagate c in $c_5 : (a \vee \underline{\neg c} \vee \underline{d})$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

a :	c_7
$\neg a$:	c_3
b :	c_1, c_2, c_3, c_7
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1
d :	c_5
$\neg d$:	c_6

Activities
(increment=2):

a	1
b	1
c	1
d	0

Trail:

DL1: $\neg a$: NULL
b : c_7
c : c_4
d : c_5

Propagate c in $c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \rightarrow$ assign d

SAT solving: Example 2

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Propagate c in $c_6 : (\underline{\neg c} \vee \underline{\neg d})$

Activities
(increment=2):

a	1
b	1
c	1
d	0

Trail:

DL1: $\neg a :$ NULL
   $b : c_7$
   $c : c_4$
   $d : c_5$

SAT solving: Example 2

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=2):

a	1
b	1
c	1
d	0

Trail:

DL1: $\neg a :$ NULL
$\quad b : c_7$
$\quad c : c_4$
$\quad d : c_5$

Propagate c in $\quad c_6 : (\underline{\neg c} \vee \underline{\neg d}) \rightarrow \notni$ conflict!

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

$a :$ c_7

$\neg a :$ c_3

$b :$ c_1, c_2, c_3, c_7

$\neg b :$ c_4

$c :$ c_2, c_4

$\neg c :$ c_5, c_6, c_1

$d :$ c_5

$\neg d :$ c_6

Conflict resolution:

Activities
(increment=2):

a 1

b 1

c 1

d 0

Trail:

DL1: $\neg a :$ NULL

$b : c_7$

$c : c_4$

$d : c_5$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b})$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=3):

a	$\cancel{1}$	3
b	$\cancel{1}$	3
c	$\cancel{1}$	3
d	$\emptyset$	2

Trail:

DL1: $\neg a :$ NULL
  $b : c_7$
  $c : c_4$
  $d : c_5$

Conflict resolution:

$$\frac{\dfrac{\dfrac{c_6 : (\neg c \vee \neg d) \quad c_5 : (a \vee \neg c \vee d)}{(a \vee \neg c) \quad c_4 : (a \vee \neg b \vee c)}}{(a \vee \neg b) \quad c_7 : (a \vee b)}}{c_8 : (a)}$$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Add conflict clause

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

DL1: $\neg a$: NULL
  $b : c_7$
  $c : c_4$
  $d : c_5$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Backtrack to DL0

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

~~DL1:~~ ~~$\neg a$: NULL~~
~~b : c_7~~
~~c : c_4~~
~~d : c_5~~

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

a :	c_7
$\neg a$:	c_3
b :	c_1, c_2, c_3, c_7
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1
d :	c_5
$\neg d$:	c_6

Assign a at DL0 by c_8

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $a : c_8$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Propagate a in

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $a : c_8$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

$a :$	c_7
$\neg a :$	c_3
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $\quad a : c_8$

Propagate a in $\quad c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c)$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

Activities
(increment=3):

Trail:

a :	c_7
$\neg a$:	$\cancel{c_3}$
b :	c_1, c_2, c_3, c_7
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1, c_3
d :	c_5
$\neg d$:	c_6

a	3
b	3
c	3
d	2

DL0: $a : c_8$

Propagate a in $c_3 : (\underline{\neg a} \vee \underline{b} \vee \neg c) \rightarrow (\neg a \vee \underline{b} \vee \underline{\neg c})$

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

$a :$	c_7
$\neg a :$	
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Decide $\neg b$

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $a : c_8$
DL1: $\neg b :$ NULL

$c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

$a :$	c_7
$\neg a :$	
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Propagate $\neg b$ in

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $a : c_8$
DL1: $\neg b : $ NULL

$c_1 : (a \lor \underline{b} \lor \underline{\neg c}) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\neg a \lor \underline{b} \lor \underline{\neg c}) \land c_4 : (a \lor \underline{\neg b} \lor \underline{c}) \land$
$c_5 : (a \lor \underline{\neg c} \lor \underline{d}) \land c_6 : (\underline{\neg c} \lor \underline{\neg d}) \land c_7 : (\underline{a} \lor \underline{b}) \land c_8 : (a)$

Watch lists:

$a :$	c_7
$\neg a :$	
$b :$	c_1, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Activities (increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $a : c_8$
DL1: $\neg b :$ NULL

Propagate $\neg b$ in $c_1 : (a \lor \underline{b} \lor \underline{\neg c})$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

$a :$	c_7, c_1
$\neg a :$	
$b :$	$\cancel{c_1}, c_2, c_3, c_7$
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $a : c_8$
DL1: $\neg b : \text{NULL}$

Propagate $\neg b$ in $c_1 : (a \vee \underline{b} \vee \underline{\neg c}) \rightarrow (\underline{a} \vee b \vee \underline{\neg c})$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

$a :$	c_7, c_1
$\neg a :$	
$b :$	$\cancel{c_1}, c_2, c_3, c_7$
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $a : c_8$
DL1: $\neg b :$ NULL

Propagate $\neg b$ in $c_2 : (\underline{b} \vee \underline{c})$

SAT solving: Example 2

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

$a :$	c_7, c_1
$\neg a :$	
$b :$	~~c_1~~, c_2, c_3, c_7
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Propagate $\neg b$ in $\quad c_2 : (\underline{b} \vee \underline{c}) \rightarrow$ assign c

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $a : c_8$
DL1: $\neg b : $ NULL
      $c : c_2$

$c_1 : (\underline{a} \lor b \lor \underline{\neg c}) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\neg a \lor \underline{b} \lor \underline{\neg c}) \land c_4 : (a \lor \underline{\neg b} \lor \underline{c}) \land$
$c_5 : (a \lor \underline{\neg c} \lor \underline{d}) \land c_6 : (\underline{\neg c} \lor \underline{\neg d}) \land c_7 : (\underline{a} \lor \underline{b}) \land c_8 : (a)$

Watch lists:

$a :$	c_7, c_1
$\neg a :$	
$b :$	$~~c_1~~, c_2, c_3, c_7$
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Activities (increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $a : c_8$
DL1: $\neg b : \text{NULL}$
         $c : c_2$

Propagate $\neg b$ in $c_3 : (\neg a \lor \underline{b} \lor \underline{\neg c})$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

a :	c_7, c_1
$\neg a$:	
b :	$\cancel{c_1}, c_2, c_3, c_7$
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1, c_3
d :	c_5
$\neg d$:	c_6

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $a : c_8$
DL1: $\neg b : $ NULL
     $c : c_2$

Propagate $\neg b$ in $c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \rightarrow \lightning$ conflict!

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a)$

Watch lists:

$a :$	c_7, c_1
$\neg a :$	
$b :$	$\cancel{c_1}, c_2, c_3, c_7$
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Conflict resolution:

Activities
(increment=3):

a	3
b	3
c	3
d	2

Trail:

DL0: $a : c_8$
DL1: $\neg b : \text{NULL}$
          $c : c_2$

$c_1 : (\underline{a} \lor b \lor \underline{\neg c}) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\neg a \lor \underline{b} \lor \underline{\neg c}) \land c_4 : (a \lor \underline{\neg b} \lor \underline{c}) \land$
$c_5 : (a \lor \underline{\neg c} \lor \underline{d}) \land c_6 : (\underline{\neg c} \lor \underline{\neg d}) \land c_7 : (\underline{a} \lor \underline{b}) \land c_8 : (a)$

Watch lists: Activities   Trail:

                                (increment=4):

a :	c_7, c_1	
$\neg a$:		
b :	$\cancel{c_1}, c_2, c_3, c_7$	
$\neg b$:	c_4	
c :	c_2, c_4	
$\neg c$:	c_5, c_6, c_1, c_3	
d :	c_5	
$\neg d$:	c_6	

Activities:

a $\cancel{3}$ 6
b $\cancel{3}$ 6
c $\cancel{3}$ 6
d 2

Trail:

DL0: $a : c_8$
DL1: $\neg b :$ NULL
         $c : c_2$

Conflict resolution: $\dfrac{c_3 : (\neg a \lor b \lor \neg c) \quad c_2 : (b \lor c)}{c_9 : (\neg a \lor b)}$

$c_1 : (\underline{a} \lor b \lor \underline{\neg c}) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\neg a \lor \underline{b} \lor \underline{\neg c}) \land c_4 : (a \lor \underline{\neg b} \lor \underline{c}) \land$
$c_5 : (a \lor \underline{\neg c} \lor \underline{d}) \land c_6 : (\underline{\neg c} \lor \underline{\neg d}) \land c_7 : (\underline{a} \lor \underline{b}) \land c_8 : (a) \land c_9 : (\underline{\neg a} \lor \underline{b})$

Watch lists:

$a :$	c_7, c_1
$\neg a :$	c_9
$b :$	$\cancel{c_1}, c_2, c_3, c_7, c_9$
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Add conflict clause

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
DL1: $\neg b :$ NULL
       $c : c_2$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$

$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a) \wedge c_9 : (\underline{\neg a} \vee \underline{b})$

Watch lists:

$a :$	c_7, c_1
$\neg a :$	c_9
$b :$	$\cancel{c_1}, c_2, c_3, c_7, c_9$
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Backtrack to DL0

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$

~~DL1:~~   ~~$\neg b$: NULL~~

         ~~$c : c_2$~~

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a) \wedge c_9 : (\underline{\neg a} \vee \underline{b})$

Watch lists:

$a :$	c_7, c_1
$\neg a :$	c_9
$b :$	$\cancel{c_1}, c_2, c_3, c_7, c_9$
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Assign b by c_9

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
          $b : c_9$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a) \wedge c_9 : (\underline{\neg a} \vee \underline{b})$

Watch lists:

a :	c_7, c_1
$\neg a$:	c_9
b :	c_2, c_3, c_7, c_9
$\neg b$:	c_4
c :	c_2, c_4
$\neg c$:	c_5, c_6, c_1, c_3
d :	c_5
$\neg d$:	c_6

Propagate b in

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
      $b : c_9$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a) \wedge c_9 : (\underline{\neg a} \vee \underline{b})$

Watch lists:

$a :$	c_7, c_1
$\neg a :$	c_9
$b :$	c_2, c_3, c_7, c_9
$\neg b :$	c_4
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Propagate b in $c_4 : (a \vee \underline{\neg b} \vee \underline{c})$

Activities (increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
$b : c_9$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (\underline{a} \vee \neg b \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a) \wedge c_9 : (\underline{\neg a} \vee \underline{b})$

Watch lists:

$a :$	$c_7, c_1, {\color{green}c_4}$
$\neg a :$	c_9
$b :$	c_2, c_3, c_7, c_9
${\color{green}\neg b} :$	$\cancel{c_4}$
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
           ${\color{green}b : c_9}$

{\color{green}Propagate b in} $c_4 : (a \vee \underline{\neg b} \vee \underline{c}) \rightarrow (\underline{a} \vee \neg b \vee \underline{c})$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (\underline{a} \vee \neg b \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a) \wedge c_9 : (\underline{\neg a} \vee \underline{b})$

Watch lists:

$a :$	c_7, c_1, c_4
$\neg a :$	c_9
$b :$	c_2, c_3, c_7, c_9
$\neg b :$	
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Decide $\neg c$

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
      $b : c_9$
DL1: $\neg c : NULL$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (\underline{a} \vee \neg b \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a) \wedge c_9 : (\underline{\neg a} \vee \underline{b})$

Watch lists:

$a :$	c_7, c_1, c_4
$\neg a :$	c_9
$b :$	c_2, c_3, c_7, c_9
$\neg b :$	
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Propagate $\neg c$ in

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
         $b : c_9$
DL1: $\neg c : NULL$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (\underline{a} \vee \neg b \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a) \wedge c_9 : (\underline{\neg a} \vee \underline{b})$

Watch lists:

$a :$	c_7, c_1, c_4
$\neg a :$	c_9
$b :$	c_2, c_3, c_7, c_9
$\neg b :$	
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
      $b : c_9$
DL1: $\neg c : NULL$

Propagate $\neg c$ in $c_2 : (\underline{b} \vee \underline{c})$

$c_1 : (\underline{a} \lor b \lor \underline{\neg c}) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\neg a \lor \underline{b} \lor \underline{\neg c}) \land c_4 : (\underline{a} \lor \neg b \lor \underline{c}) \land$
$c_5 : (a \lor \underline{\neg c} \lor \underline{d}) \land c_6 : (\underline{\neg c} \lor \underline{\neg d}) \land c_7 : (\underline{a} \lor \underline{b}) \land c_8 : (a) \land c_9 : (\underline{\neg a} \lor \underline{b})$

Watch lists:

$a :$	c_7, c_1, c_4
$\neg a :$	c_9
$b :$	c_2, c_3, c_7, c_9
$\neg b :$	
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
    $b : c_9$
DL1: $\neg c : NULL$

Propagate $\neg c$ in $c_4 : (\underline{a} \lor \neg b \lor \underline{c})$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (\underline{a} \vee \neg b \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a) \wedge c_9 : (\underline{\neg a} \vee \underline{b})$

Watch lists:

$a :$	c_7, c_1, c_4
$\neg a :$	c_9
$b :$	c_2, c_3, c_7, c_9
$\neg b :$	
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Decide $\neg d$

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
         $b : c_9$
DL1: $\neg c : NULL$
DL2: $\neg d : NULL$

$c_1 : (\underline{a} \lor b \lor \underline{\neg c}) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\neg a \lor \underline{b} \lor \underline{\neg c}) \land c_4 : (\underline{a} \lor \neg b \lor \underline{c}) \land$
$c_5 : (a \lor \underline{\neg c} \lor \underline{d}) \land c_6 : (\underline{\neg c} \lor \underline{\neg d}) \land c_7 : (\underline{a} \lor \underline{b}) \land c_8 : (a) \land c_9 : (\underline{\neg a} \lor \underline{b})$

Watch lists:

$a :$	c_7, c_1, c_4
$\neg a :$	c_9
$b :$	c_2, c_3, c_7, c_9
$\neg b :$	
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Propagate $\neg d$ in

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
         $b : c_9$
DL1: $\neg c : NULL$
DL2: $\neg d : NULL$

$c_1 : (\underline{a} \vee b \vee \underline{\neg c}) \wedge c_2 : (\underline{b} \vee \underline{c}) \wedge c_3 : (\neg a \vee \underline{b} \vee \underline{\neg c}) \wedge c_4 : (\underline{a} \vee \neg b \vee \underline{c}) \wedge$
$c_5 : (a \vee \underline{\neg c} \vee \underline{d}) \wedge c_6 : (\underline{\neg c} \vee \underline{\neg d}) \wedge c_7 : (\underline{a} \vee \underline{b}) \wedge c_8 : (a) \wedge c_9 : (\underline{\neg a} \vee \underline{b})$

Watch lists:

$a :$	c_7, c_1, c_4
$\neg a :$	c_9
$b :$	c_2, c_3, c_7, c_9
$\neg b :$	
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $a : c_8$
         $b : c_9$
DL1: $\neg c : NULL$
DL2: $\neg d : NULL$

Propagate $\neg d$ in $c_5 : (a \vee \underline{\neg c} \vee \underline{d})$

$c_1 : (\underline{a} \lor b \lor \underline{\neg c}) \land c_2 : (\underline{b} \lor \underline{c}) \land c_3 : (\neg a \lor \underline{b} \lor \underline{\neg c}) \land c_4 : (\underline{a} \lor \neg b \lor \underline{c}) \land$
$c_5 : (a \lor \underline{\neg c} \lor \underline{d}) \land c_6 : (\underline{\neg c} \lor \underline{\neg d}) \land c_7 : (\underline{a} \lor \underline{b}) \land c_8 : (a) \land c_9 : (\underline{\neg a} \lor \underline{b})$

Watch lists:

$a :$	c_7, c_1, c_4
$\neg a :$	c_9
$b :$	c_2, c_3, c_7, c_9
$\neg b :$	
$c :$	c_2, c_4
$\neg c :$	c_5, c_6, c_1, c_3
$d :$	c_5
$\neg d :$	c_6

$\Rightarrow$ SAT $\quad a \quad b \quad \neg c \quad \neg d$

Activities
(increment=4):

a	6
b	6
c	6
d	2

Trail:

DL0: $\quad a : c_8$
$\qquad\quad b : c_9$
DL1: $\neg c : NULL$
DL2: $\neg d : NULL$

- How to compute with the DPLL+CDCL-based SAT solving algorithm?