**Kurze korrekte Schreibweisen:**

**Es geht nicht um die Richtigkeit der Bilder, sondern nur um die Schreibweise!!!**

## CDCL:

| Level | Variable | Belegung | Grund |
|---|---|---|---|
| 1 | $x$ | 0 | Decision |
| 2 | $y$ | 0 | Decision |
| | $z$ | 0 | $\{x, y, \neg z\}$ |
| | $w$ | 1 | $\{x, y, z, w\}$ |
| | $t$ | 0 | $\{x, z, \neg t\}$ |
| 3 | $u$ | 0 | Decision |
| | $v$ | 1 | $\{t, u, v\}$ |
| | $p$ | 0 | $\{u, \neg v, \neg p\}$ |
| | $p$ | 1 | $\{p, z, \neg v\}$ Konfliktklausel |

## Branch & Bound:

Schritte:
Initiales $UB = 4$.

$\varphi_w = \{\{x,y\},\{\neg x,\neg z\},\{\neg y,\neg z\},\{z\},\{x\}\}$
$LB = 0$

$\varphi_{wx} = \{\{\neg z\},\{\neg y,\neg z\},\{z\}\}$
$LB = 0$

$\varphi_{wxy} = \{\{\neg z\},\{\neg z\},\{z\}\}$
$LB = 0$

$\varphi_{wxyz} = \{\{\},\{\}\}$
$LB = 2$
$UB = min(4,2) = 2$

$\varphi_{wxy\bar{z}} = \{\{\}\}$
$LB = 1$
$UB = min(2,1) = 1$

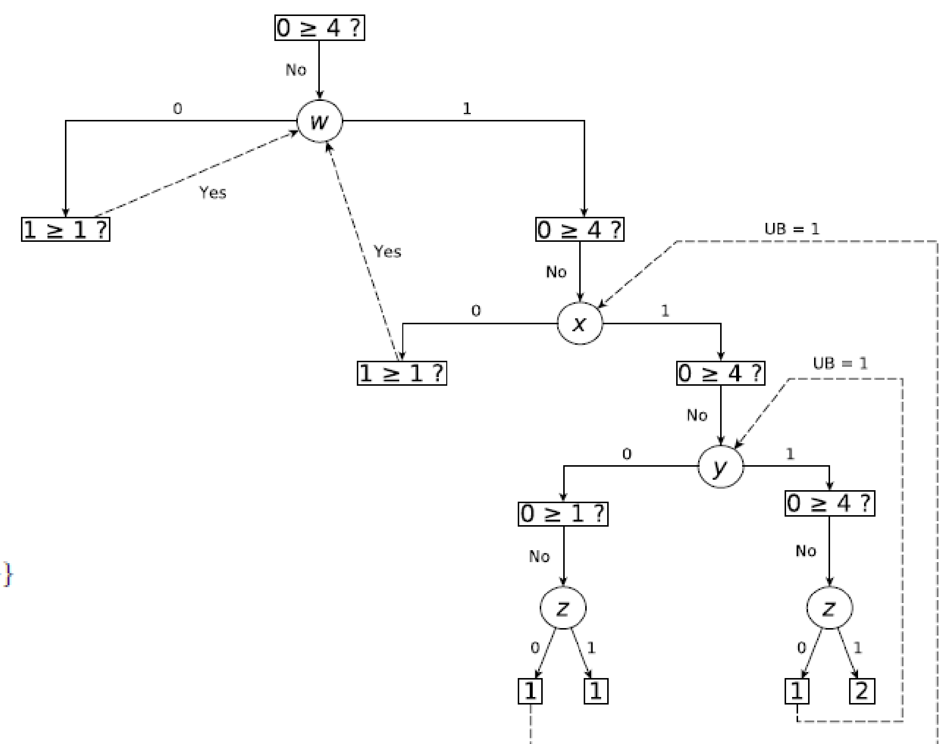
$\varphi_{wx\bar{y}} = \{\{\neg z\},\{z\}\}$
$LB = 0$

$\varphi_{wx\bar{y}z} = \{\{\}\}$
$LB = 1$
$UB = min(1,1) = 1$

$\varphi_{wx\bar{y}\bar{z}} = \{\{\}\}$
$LB = 1$
$UB = min(1,1) = 1$

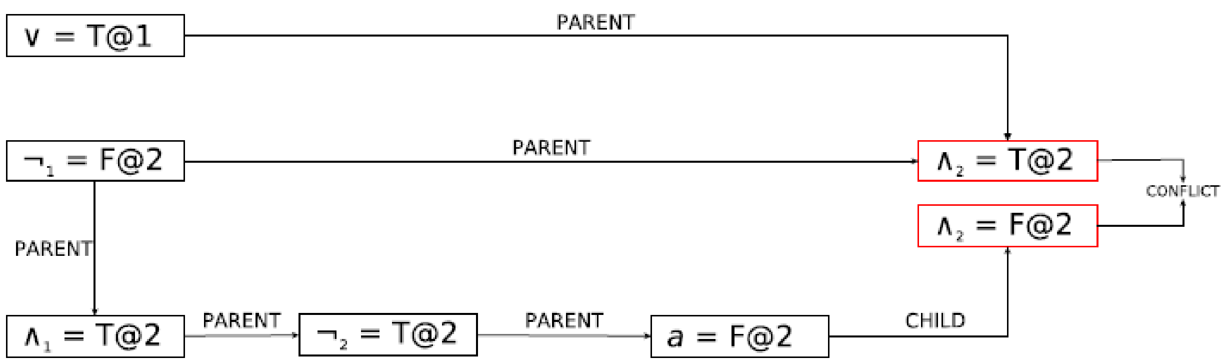
$\varphi_{w\bar{x}} = \{\{y\},\{\neg y,\neg z\},\{\neg y,\neg z\},\{z\},\{\}\}$
$LB = 1$ und $LB \geq UB \Rightarrow$ return 1

$\varphi_{\bar{w}} = \{\{x,y\},\{\neg x,\neg z\},\{\},\{z\},\{x\}\}$
$LB = 1$ und $LB \geq UB \Rightarrow$ return 1



## NonCNF:

| Lv | Var | Val | Grund | Ursache | Stack |
|---|---|---|---|---|---|
| 1 | $\vee$ | T | Decision | | $\vee = \mathsf{T}@1$ |
| 2 | $\neg_1$ | F | Decision | | $\neg_1 = \mathsf{F}@2$ |
| | $\wedge_2$ | T | Parent | $\{\vee = \mathsf{T}, \neg_1 = \mathsf{F}\}$ | $\wedge_2 = \mathsf{T}@2$ |
| | $\wedge_1$ | T | Parent | $\{\neg_1 = \mathsf{F}\}$ | $\wedge_1 = \mathsf{T}@2$ |
| | $b$ | T | Parent | $\{\wedge_1 = \mathsf{T}\}$ | $b = \mathsf{T}@2$ |
| | $\neg_2$ | T | Parent | $\{\wedge_1 = \mathsf{T}\}$ | $\neg_2 = \mathsf{T}@2$ |
| | $a$ | F | Parent | $\{\neg_2 = \mathsf{T}\}$ | $a = \mathsf{F}@2$ |
| | $\wedge_2$ | F | Child | $\{a = \mathsf{F}\}$ | |




Bestimmen der NoGood-Menge:

$$\begin{aligned}&(\{\vee = \mathsf{T}@1, \neg_1 = \mathsf{F}@2, a = \mathsf{F}@2\} \setminus \{a = \mathsf{F}@2\}) \cup \{\neg_2 = \mathsf{T}@2\}\\ =\ &\{\vee = \mathsf{T}@1, \neg_1 = \mathsf{F}@2, \neg_2 = \mathsf{T}@2\}\end{aligned}$$

$$\begin{aligned}&(\{\vee = \mathsf{T}@1, \neg_1 = \mathsf{F}@2, \neg_2 = \mathsf{T}@2\} \setminus \{\neg_2 = \mathsf{T}@2\}) \cup \{\wedge_1 = \mathsf{T}@2\}\\ =\ &\{\vee = \mathsf{T}@1, \neg_1 = \mathsf{F}@2, \wedge_1 = \mathsf{T}@2\}\end{aligned}$$

$$\begin{aligned}&(\{\vee = \mathsf{T}@1, \neg_1 = \mathsf{F}@2, \wedge_1 = \mathsf{T}@2\} \setminus \{\wedge_1 = \mathsf{T}@2\}) \cup \{\neg_1 = \mathsf{F}@2\}\\ =\ &\{\vee = \mathsf{T}@1, \neg_1 = \mathsf{F}@2\}\end{aligned}$$

# Backbone:

Backbone KaiserKüchlin

$\varphi = \{\{x,y\},\{u,z\},\{\neg w,z\},\{\neg x,z\},\{u,\neg w\},\{x,\neg y\}\}$

$SAT(\varphi \cup u) = \{x,z\}$
$SAT(\varphi \cup \neg u) = \{\neg w,x,z\}$

$SAT(\varphi \cup w) = \{u,x,z\}$
$SAT(\varphi \cup \neg w) = \{x,z\}$

$SAT(\varphi \cup x) = \{u,x,z\}$
$SAT(\varphi \cup \neg x) = \emptyset$
$P_\varphi = \{x\}$

$SAT(\varphi \cup y) = \{u,x,z\}$
$SAT(\varphi \cup \neg y) = \{u,x,z\}$

$SAT(\varphi \cup z) = \{u,x\}$
$SAT(\varphi \cup \neg z) = \emptyset$
$P_\varphi = \{x,z\}$

return $P_\varphi = \{x,z\}, N_\varphi = \emptyset$
$B_\varphi = \{x,z\}$

Backbone mit Flips

$\beta^* = \nu = \{u,w,x,y,z\}$

1.1 $\nu = \{\neg u,\neg w,x,y,z\}$
1.3 $\beta^* = \{x,y,z\}$

2.1 $\nu = \{\neg u,\neg w,x,\neg y,z\}$
2.3 $\beta^* = \{x,z\}$

3.1 $\nu = \emptyset$
3.2 return $\beta = \{x,z\}$

## LeBerre:

$\varphi = \{\{x\}, \{\neg y\}, \{y, b_1\}, \{x, y, b_2\}, \{\neg x, b_3\}, \{\neg x, y, b_4\}, \{z, b_5\}, \{\neg x, \neg z, b_6\}, \{y, z, b_7\}, \{y, \neg z, b_8\}\}$
ub $\leftarrow$ 8
1. Iteration
Sat$(\varphi \cup \mathrm{CNF}(\sum_{i=1}^{8} < ub(=8) = true$
$(z.B.x = 1, y = 0, b_1 = 1, b_3 = 1, b_4 = 1, z = 1, b_6 = 1, b_8 = 1, b_2 = 0, b_5 = 0, b_7 = 0)$
#satisfiedBlockingVariables $= 5 > 0$
$\Rightarrow$ ub $\leftarrow$ 5
2. Iteration
Sat$(\varphi \cup \mathrm{CNF}(\sum_{i=1}^{8} < ub(=5)) = false$
$\Rightarrow$ return ub(=5)

## Binäre Suche:

$\varphi = \{\{x\}, \{\neg y\}, \{y, b_1\}, \{x, y, b_2\}, \{\neg x, b_3\}, \{\neg x, y, b_4\}, \{z, b_5\}, \{\neg x, \neg z, b_6\}, \{y, z, b_7\}, \{y, \neg z, b_8\}\}$
lb=0
ub=8
mid=4
1. Iteration
Sat$(\varphi \cup \mathrm{CNF}(\sum_{i=1}^{8} \leq mid) = false$
lb=5
mid =6
2. Iteration
Sat$(\varphi \cup \mathrm{CNF}(\sum_{i=1}^{8} \leq mid) = true$
(z.B.$x = 1.y = 0, z = 1, b_1 = 1, b_2 = 0, b_3 = 1, b_4 = 1, b_5 = 0, b_6 = 1, b_7 = 0, b_8 = 1$)
ub=6
mid=5
2. Iteration
Sat$(\varphi \cup \mathrm{CNF}(\sum_{i=1}^{8} \leq mid)$=true
(z.B.$x = 1.y = 0, z = 1, b_1 = 1, b_2 = 0, b_3 = 1, b_4 = 1, b_5 = 0, b_6 = 1, b_7 = 0, b_8 = 1$)
ub=5
Eine erfüllende Belegung:
$x = 1.y = 0, z = 1, b_1 = 1, b_2 = 0, b_3 = 1, b_4 = 1, b_5 = 0, b_6 = 1, b_7 = 0, b_8 = 1$
Kosten: 5

## FuMalik:

1. Iteration $\mathrm{SAT}(\varphi) = \mathsf{false}$

   $\varphi_c \leftarrow \{\{\neg x\}, \{\neg z\}, \{x, z\}\}$

$$
\begin{aligned}
\varphi \leftarrow \{ & \{\neg x\}, \{\neg z\}, \{z, \neg w\}, && \text{Hard} \\
& \{w\}, \{\neg y\}, \{x, y\}, && \text{Soft} \\
& \left\{x, z, b_1^1\right\}\} && \text{Blockklausel} \\
& \cup \operatorname{CNF}\left(\sum_{i=1}^{1} b_i^1 = 1\right)
\end{aligned}
$$

   $\mathsf{cost} \leftarrow 1$

2. Iteration $\mathrm{SAT}(\varphi) = \mathsf{false}$

   $\varphi_c = \{\{\neg z\}, \{z, \neg w\}, \{w\}\}$

$$
\begin{aligned}
\varphi \leftarrow \{ & \{\neg x\}, \{\neg z\}, \{z, \neg w\}, && \text{Hard} \\
& \{\neg y\}, \{x, y\}, && \text{Soft} \\
& \left\{x, z, b_1^1\right\}, \left\{w, b_1^2\right\}\} && \text{Blockklausel} \\
& \cup \operatorname{CNF}\left(\sum_{i=1}^{1} b_i^1 = 1\right) \cup \operatorname{CNF}\left(\sum_{i=1}^{1} b_i^2 = 1\right)
\end{aligned}
$$

   $\mathsf{cost} \leftarrow 2$

3. $\mathrm{SAT}(\varphi) = \mathsf{false}$

   $\varphi_c = \{\{\neg x\}, \{\neg y\}, \{x, y\}\}$

$$
\begin{aligned}
\varphi \leftarrow \{ & \{\neg x\}, \{\neg z\}, \{z, \neg w\}, && \text{Hard} \\
& \left\{x, z, b_1^1\right\}, \left\{w, b_1^2\right\}, \left\{\neg y, b_1^3\right\}, \left\{x, y, b_2^3\right\}\} && \text{Blockklausel} \\
& \cup \operatorname{CNF}\left(\sum_{i=1}^{1} b_i^1 = 1\right) \cup \operatorname{CNF}\left(\sum_{i=1}^{1} b_i^2 = 1\right) \cup \operatorname{CNF}\left(\sum_{i=1}^{2} b_i^3 = 1\right)
\end{aligned}
$$

   $\mathsf{cost} \leftarrow 3$

4. Iteration $\mathrm{SAT}(\varphi) = \mathsf{true}$. Die Kosten betragen 3 und eine passende Belegung ist:

$$\{x \mapsto 0, z \mapsto 0, w \mapsto 0, y \mapsto 0\}$$

   . Unerfüllt bleiben die Klauseln: $\{x, y\}, \{w\}, \{x, z\}$.