

CS514 A7 Solution Sketch



$$1. P = (a \vee c) \wedge (b \vee d)$$

(a) Clauses are a , b , c , and d .

$$(b) P_a = P_{a=\text{true}} \oplus P_{a=\text{false}}$$

$$\begin{aligned} &= ((\text{true} \vee c) \wedge (b \vee d)) \oplus (\text{false} \vee c) \wedge (b \vee d) \\ &= (\text{true} \wedge (b \vee d)) \oplus (c \wedge (b \vee d)) \\ &= (b \vee d) \oplus (c \wedge (b \vee d)) \\ &= (b \vee d) \wedge \neg c \end{aligned}$$

In a similar manner, you can show

$$P_b = (a \vee c) \wedge \neg d$$

$$P_c = (b \vee d) \wedge \neg a$$

$$P_d = (a \vee c) \wedge \neg b$$

You need to show your work.

(c)

	a	b	c	d	P	P_a	P_b	P_c	P_d	Alt
1	T	T	T	T	T	F	F	F	F	None
2	T	T	T	F	T	F	T	F	F	b
3	T	T	F	T	T	T	F	F	F	a
4	T	T	F	F	T	T	F	F	F	a, b
5	T	F	T	T	T	F	F	F	T	d
6	T	F	F	T	F	F	T	F	T	b, d
7	T	F	F	T	T	F	T	F	T	a, d
8	T	F	F	F	F	F	T	F	T	b, d
9	F	T	T	T	T	F	F	T	F	c
10	F	T	T	F	T	F	T	F	T	b, c
11	F	T	F	T	F	T	F	T	F	a, c
12	F	T	F	F	F	T	F	T	F	a, c
13	F	F	T	T	T	F	F	T	T	c, d
14	F	F	T	F	F	F	T	F	T	b, d
15	F	F	F	T	F	T	F	T	F	a, c
16	F	F	F	F	F	F	F	F	F	None

For reference

$$P = (a \vee c) \wedge (b \vee d)$$

$$P_a = (b \vee d) \wedge \neg c$$

$$P_b = (a \vee c) \wedge \neg d$$

$$P_c = (b \vee d) \wedge \neg a$$

$$P_d = (a \vee c) \wedge \neg b$$

The alt column is obtained by listing claim x if $P_x = T$

(d) GACC pairs

Clause a.

- Inspect rows where $P_a = T$ or Alt column contains a.
 - Choose rows where $a = T \{3, 4, 7\}$
 - Choose rows where $a = F \{11, 12, 15\}$.
- Pairs are $\{(3, 11), (3, 12), (3, 15)\}$
 $\{(4, 11), (4, 12), (4, 15)\}$
 $\{(7, 11), (7, 12), (7, 15)\}$
or $\{3, 4, 7\} \times \{11, 12, 15\}$ Cartesian Product

Clause b. shown using green highlight
 $\{2, 4, 10\} \times \{6, 8, 14\}$

Clause C. shown using cyan highlight
 $\{9, 10, 13\} \times \{11, 12, 15\}$

Clause d. shown using magenta highlight.
 $\{5, 7, 13\} \times \{6, 8, 14\}$

(e) For this predicate, it so happens that when a clause determines the predicate, the predicate changes when the clause changes. So we can use the same pairs.

(f) RACC coverage.

Clause a:

(3, 11), (4, 12), (7, 15)

Clause b:

(2, 6), (4, 8), (10, 14)

Clause c:

(9, 11), (10, 12), (13, 15)

Clause d:

(5, 6), (7, 8), (13, 14)

(g) GICC coverage.

Clause a. Consider rows where $P_a = F$.

Predicate P is T

$a \text{ is } T \rightarrow \{1, 2, 5\} - A$

$a \text{ is } F \rightarrow \{9, 10, 13\} - B$

Predicate P is F

$a \text{ is } T \rightarrow \{6, 8\} - C$

$a \text{ is } F \rightarrow \{14, 16\} - D$

$A \times B \times C \times D$ gives all the tuples.

Clause b

$P_b = F, P = T, b = T$	$\{1, 3, 9\}$
$b = F$	$\times \{5, 7, 13\}$
$P_b = F, b = T$	$\times \{11, 12\}$
$b = F$	$\times \{15, 16\}$

Clause c

$P_c = F, P = T, c = T$	$\{1, 2, 5\}$
$c = F$	$\times \{3, 4, 7\}$
$P_c = F, c = T$	$\times \{6, 14\}$
$c = F$	$\times \{8, 16\}$

Clause d

$P_d = F, P = T, d = T$	$\{1, 3, 9\}$
$d = F$	$\times \{2, 4, 10\}$
$P_d = F, d = T$	$\times \{11, 15\}$
$d = F$	$\times \{12, 16\}$

(h) RICC tuples

Clause a. $P_a = F$

$P = T$ minor clauses must be the same but a changes in each pair. $\{(1, 9), (2, 10), (5, 13)\}$

$P = F$ $\{(6, 14), (8, 16)\}$

Tuples are given by $\{(1, 9), (2, 10), (5, 13)\}$

$\times \{(6, 14), (8, 16)\}$

Clause b $P_b = F$

$p=T$ b changes but other clauses remain the same. $\{(1, 5), (3, 7), (9, 13)\}$

$p=F$ b changes but other clauses remain the same $\{(11, 15), (12, 16)\}$

Tuples = $\{(1, 5), (3, 7), (9, 13)\} \times \{(11, 15), (12, 16)\}$

Clause c $P_c = F$

$p=T$ c changes $\{(1, 3), (2, 4), (6, 7)\}$

$p=F$ c changes $\times \{(6, 8), (14, 16)\}$

Clause d $P_d = F$

$p=T$ d changes $\{(1, 2), (3, 4), (9, 10)\}$

$p=F$ d changes $\times \{(11, 12), (15, 16)\}$

2. There are 3 predicates in the program

Predicate 1: $(y \% 4 == 0)$

Predicate 2: $(\text{isDivisibleBy4} \And (y \% 100 != 0))$

which is the same as

$(y \% 4 == 0) \And (y \% 100 != 0)$

Predicate 3:

$((\underbrace{(y \% 4 == 0)}_a) \And (\underbrace{(y \% 100 != 0)}_b)) \quad \text{||} \quad (\underbrace{(y \% 400 == 0)}_c)$

Predicate is $(a \And b) \Or c$

You can also formulate it so that $y \% 100 == 0$ is a clause. Then it would be $(a \And \neg b) \Or c$.

$$\begin{aligned} P_a &= ((\text{true} \And b) \Or c) \oplus ((\text{false} \And b) \Or c) \\ &= (b \Or c) \oplus (\text{false} \Or c) \\ &= (b \Or c) \oplus c \\ &= \neg c \And b \end{aligned}$$

$$\begin{aligned}
 P_b &= ((a \wedge \text{true}) \vee c) \oplus ((a \wedge \text{false}) \vee c) \\
 &= (a \vee c) \oplus (\text{false} \vee c) \\
 &= (a \vee c) \oplus c \\
 &= \neg c \wedge a
 \end{aligned}$$

$$\begin{aligned}
 P_c &= ((a \wedge b) \vee \text{true}) \oplus ((a \wedge b) \vee \text{false}) \\
 &= \text{true} \oplus (a \wedge b) \\
 &= \neg(a \wedge b) \\
 &= \neg a \vee \neg b
 \end{aligned}$$

Truth table $(a \wedge b) \vee c$

	a	b	c	P	P_a	P_b	P_c	Alt
1	T	T	T	T	F	T	F	None
2	T	T	F	F	T	F	F	a, b
3	T	F	T	T	F	F	T	c
4	T	F	F	F	F	T	T	b, c
5	F	T	T	T	F	F	T	c
6	F	T	F	F	T	F	T	a, c
7	F	F	T	T	F	F	T	c
8	F	F	F	F	F	F	T	c

(a) RACC tuples

Clause a: Rows (2, 6)

Clause b: Rows (2, 4)

Clause c: Rows (3, 4), (5, 6), (7, 8)
(any of these pairs)

Row 2: divisible by 4,
not divisible by 100,
not divisible by 400 } 2004

Row 6: not divisible by 4
not divisible by 100
not divisible by 400 } 2005

Row 4: divisible by 4
divisible by 100
not divisible by 400 } 1900

Row 3: divisible by 4
divisible by 100
divisible by 400 } 2000

(b)	Make a inactive	$P_a = F$
	$p=T$	$a=T$ in rows 1, 3 $a=F$ in rows 5, 7
	$p=F$	$a=T$ in rows 4 $a=F$ in rows 8
		$\frac{(1, 5) \text{ or } (3, 7)}{(4, 8)}$

Make	b inactive	$P_b = F$
$p=T$	$b=T$ in rows 1, 5 $b=F$ in rows 3, 7	$\frac{(1, 3) \text{ or } (5, 7)}{(6, 8)}$
$p=F$	$b=T$ in rows 6 $b=F$ in rows 8	

Make	c inactive	$P_c = F$	} can't satisfy
$p=T$	$c=T$ in rows 1 $c=F$ in rows 2		
$p=F$	$c=T$ in rows N/A $c=F$ in rows		

From the above we must select rows $(4, 6, 8)$ and either $(1, 3, 5)$ or $(1, 5, 7)$ or $(1, 3, 7)$ or $(3, 5, 7)$

Rows 3, 4, 6 were done on page 9.

Row 8: not divisible by 4 but divisible by 100. Infeasible.

Row 1: divisible by 4
not divisible by 100
divisible by 400.
Infeasible.

Row 5: not divisible by 4
not divisible by 100
divisible by 400

Infeasible

Row 7 not divisible by 4
divisible by 100

Infeasible.