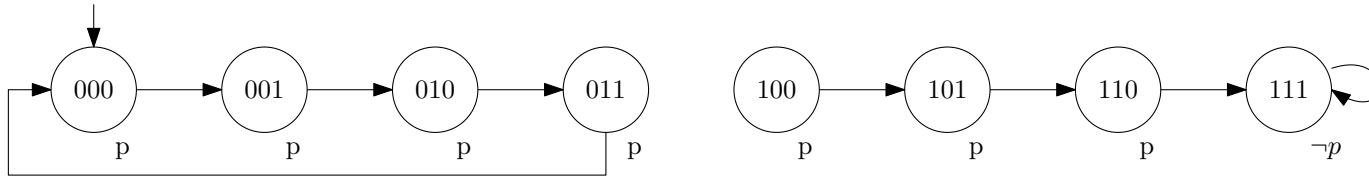


Model checking HW4 - Solution and common mistakes

Task 4b.



Initialize $F_0 = S_0$ and $F_1 = p$.

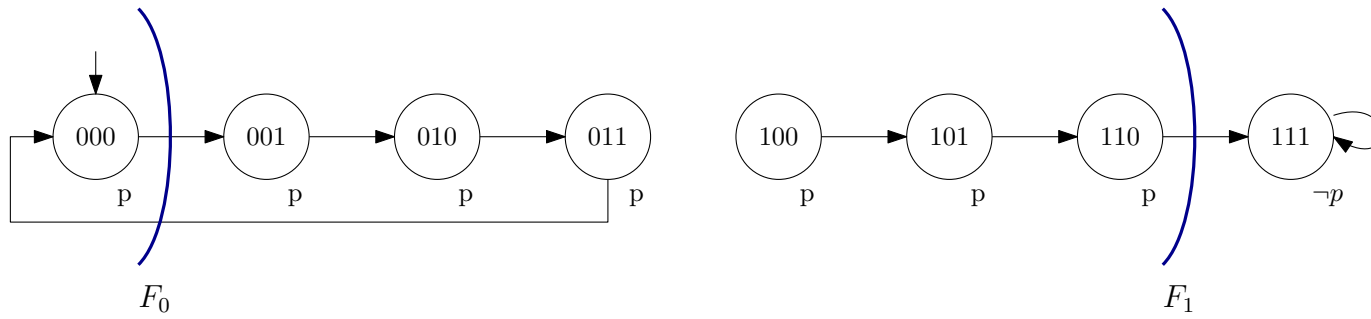
Model checking HW4 - Solution and common mistakes

Task 4b.

$$k = 1$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = p$$



Initialize $F_0 = S_0$ and $F_1 = p$.

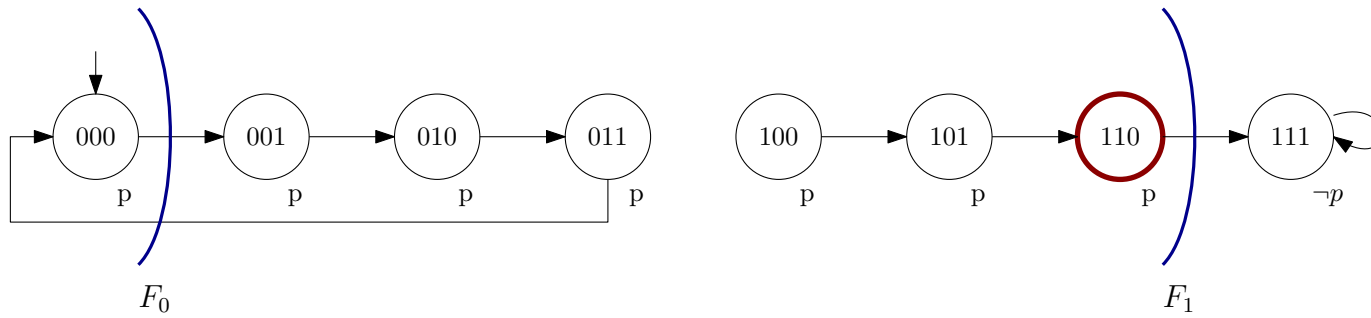
Model checking HW4 - Solution and common mistakes

Task 4b.

$$k = 1$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = p$$



$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3 \longrightarrow \text{removeBad}(k, s)$$

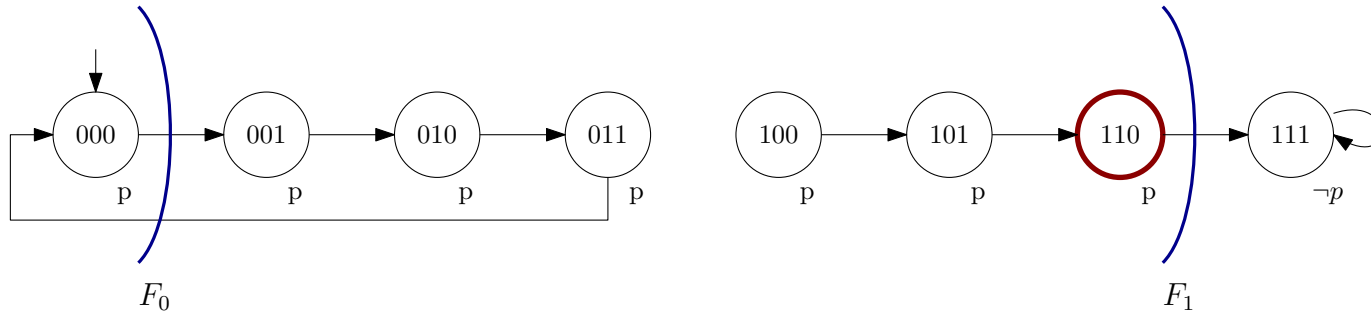
Model checking HW4 - Solution and common mistakes

Task 4b.

$$k = 1$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = p$$



$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

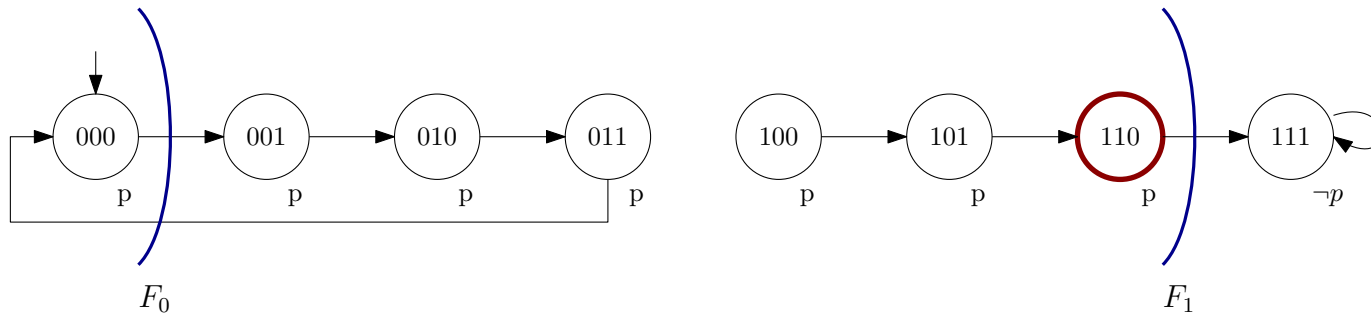
Model checking HW4 - Solution and common mistakes

Task 4b.

$$k = 1$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = p$$



$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

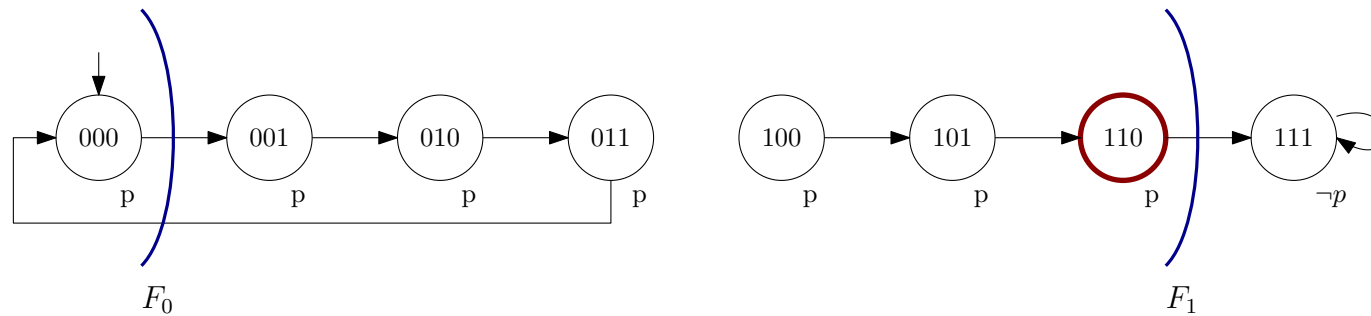
Model checking HW4 - Solution and common mistakes

Task 4b.

$$k = 1$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = p$$



$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

generalize($i = 1, s = \{110\}$)

$$c = [\top, l_1, l_2, l_1 \wedge l_2, l_3, l_1 \wedge l_3, l_2 \wedge l_3, l_1 \wedge l_2 \wedge l_3]$$

$$c \leftarrow s \quad ?$$

$$\text{UNSAT}(\neg c \wedge F_0 \wedge R \wedge c') \quad ?$$

$$\text{UNSAT}(S_0 \wedge c) \quad ?$$

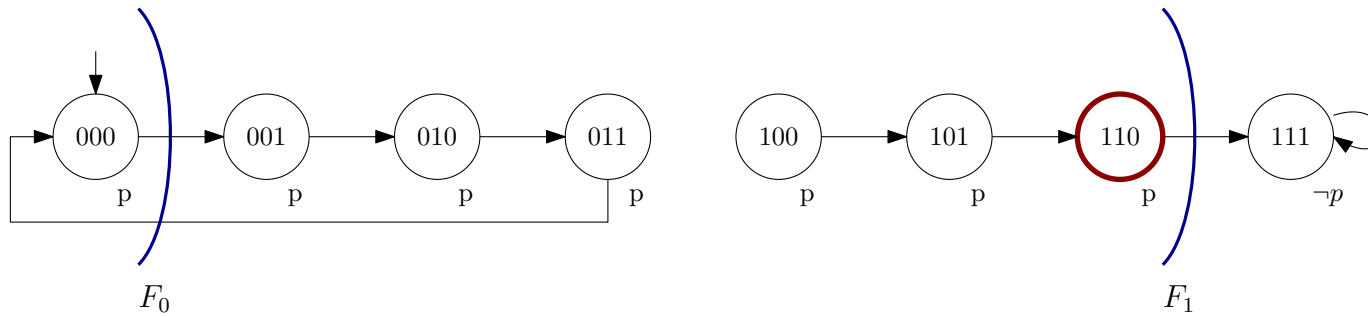
Model checking HW4 - Solution and common mistakes

Task 4b.

$$k = 1$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = p$$



$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

generalize($i = 1, s = \{110\}$)

$$c = \top \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3]$$

$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_0 \wedge R \wedge c') \quad ? \quad \checkmark$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \times$$

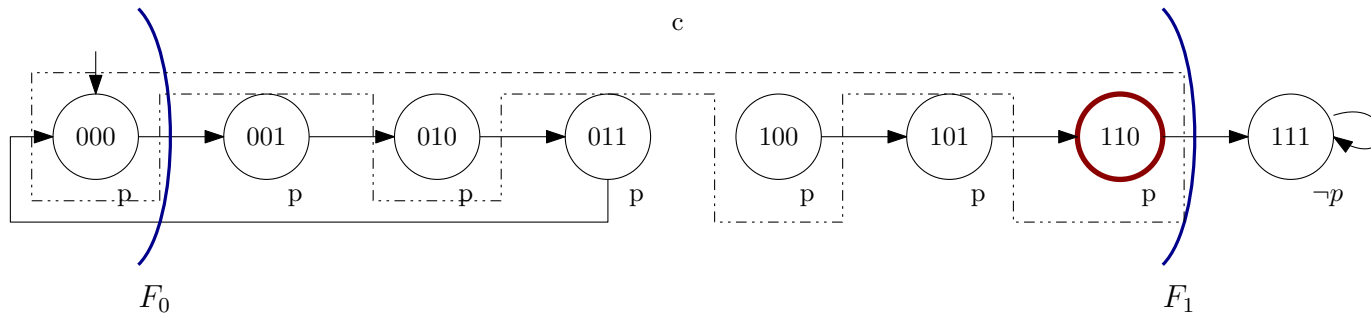
Model checking HW4 - Solution and common mistakes

Task 4b.

$$k = 1$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = p$$



$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

generalize($i = 1, s = \{110\}$)

$$c = \neg x_3 \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3]$$

$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_0 \wedge R \wedge c') \quad ? \quad \checkmark$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \times$$

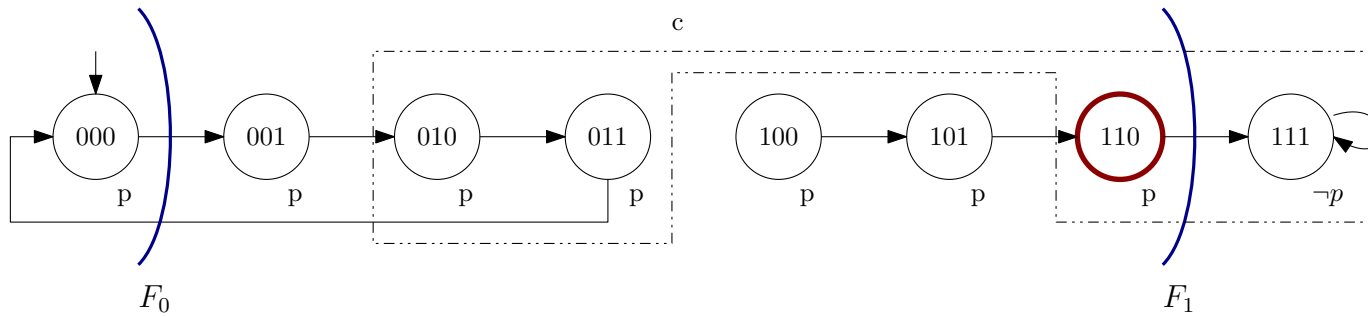
Model checking HW4 - Solution and common mistakes

Task 4b.

$$k = 1$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = p$$



$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

generalize($i = 1, s = \{110\}$)

$$c = x_2 \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3]$$

$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_0 \wedge R \wedge c') \quad ? \quad \checkmark$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \checkmark$$

Note: A common mistake was to consider that x_2 was not a right cube to generalize. The next one that works is x_1 . In this case, the solution ends up being the same as in task 4a.

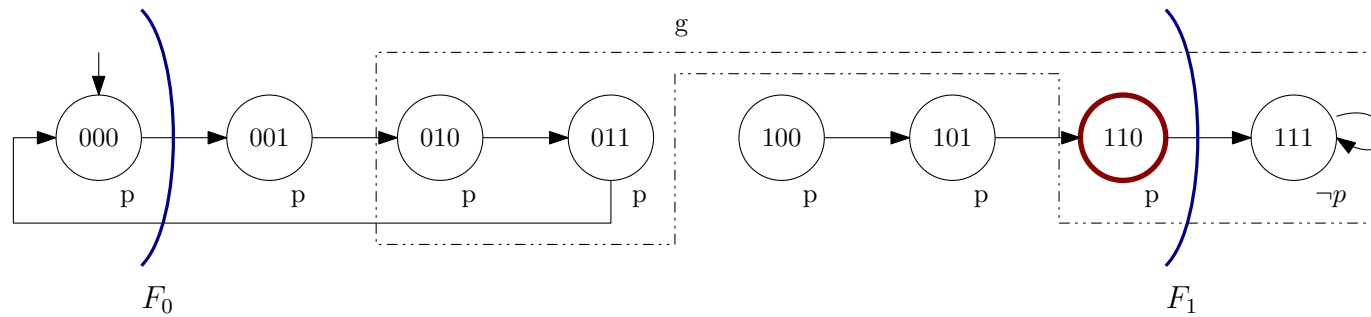
Model checking HW4 - Solution and common mistakes

Task 4b.

$$k = 1$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = p$$



$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

generalize($i = 1, s = \{110\}$)

$$g = x_2 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

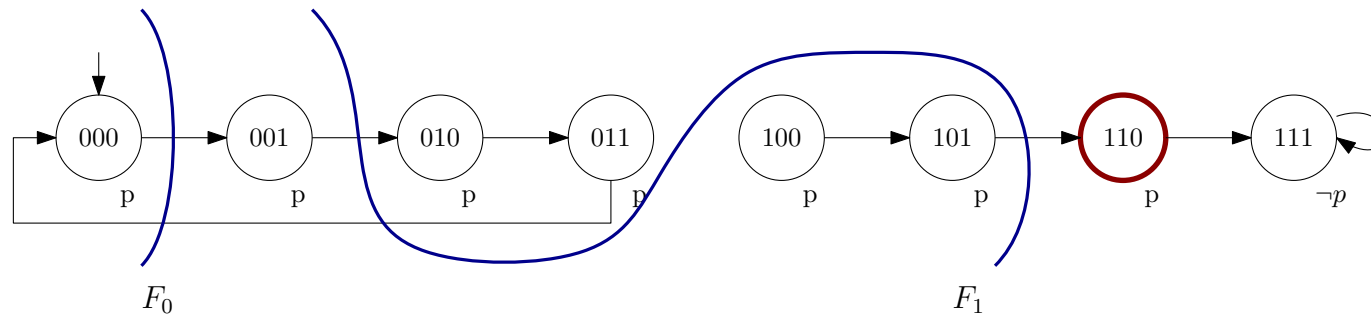
Model checking HW4 - Solution and common mistakes

Task 4b.

$$k = 1$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = p \wedge \neg x_2 = \neg x_2$$



$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

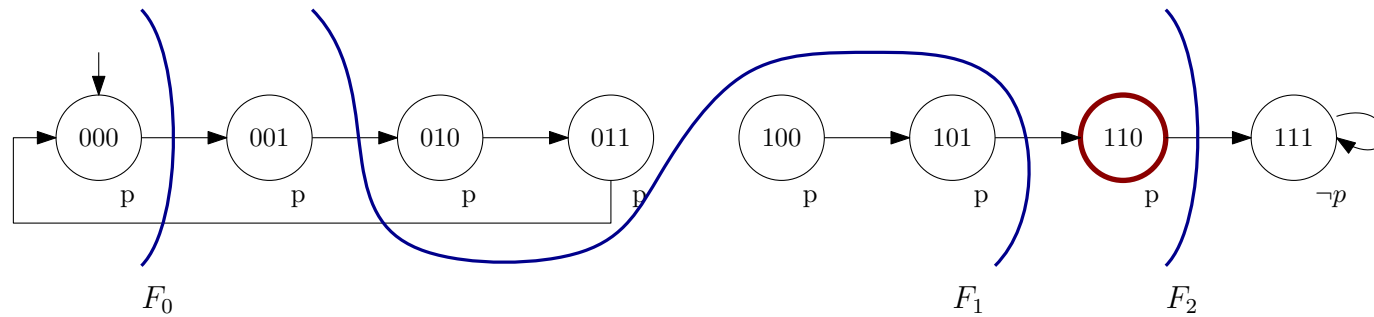
$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

generalize($i = 1, s = \{110\}$)

$$g = x_2 \quad \longrightarrow \quad \text{Update } F_1 := F_1 \wedge \neg g$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

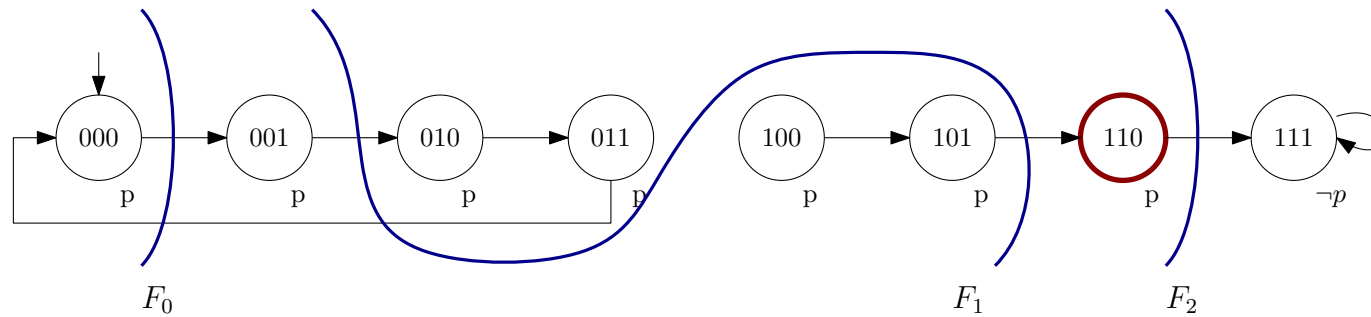
generalize($i = 1, s = \{110\}$)

$$g = x_2 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

$k++$ and $F_2 = p$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

generalize($i = 1, s = \{110\}$)

$$g = x_2 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

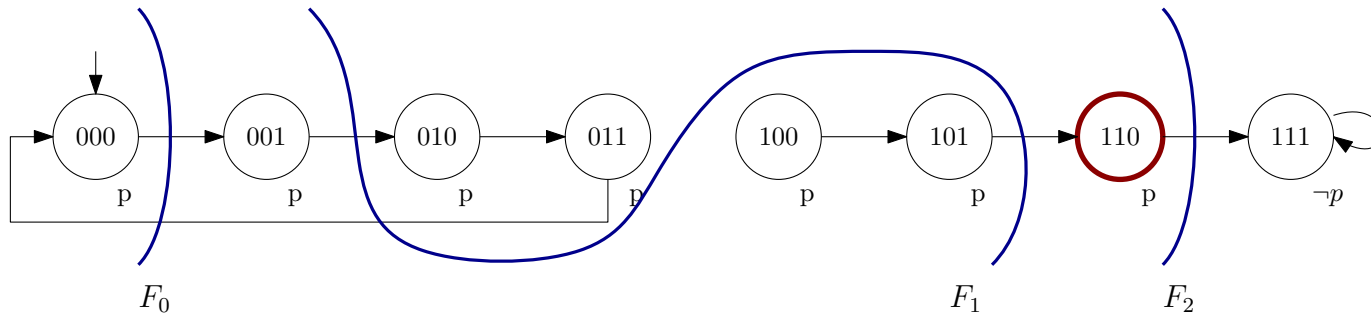
$k++$ and $F_2 = p$

propagateClauses($k = 2$)

$$i = 0, \quad F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

generalize($i = 1, s = \{110\}$)

$$g = x_2 \quad \longrightarrow \quad \text{Update } F_1 := F_1 \wedge \neg g$$

$k++$ and $F_2 = p$

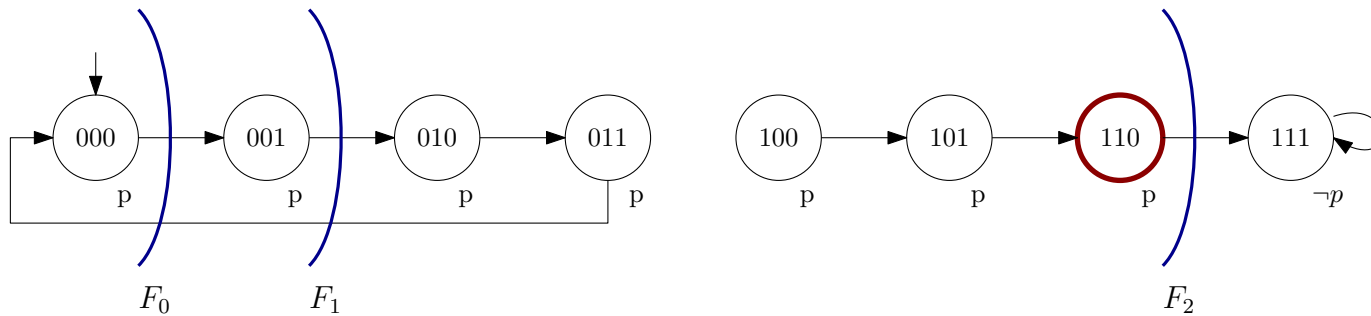
propagateClauses($k = 2$)

$$i = 0, \quad F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$\text{UNSAT}(F_0 \wedge R \wedge \neg(\neg x_1')) \quad ? \quad \checkmark \quad \rightarrow F_1 := F_1 \wedge \neg x_1$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

generalize($i = 1, s = \{110\}$)

$$g = x_2 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

$k++$ and $F_2 = p$

propagateClauses($k = 2$)

$$i = 0, \quad F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$\text{UNSAT}(F_0 \wedge R \wedge \neg(\neg x_1')) \quad ? \quad \checkmark \quad \rightarrow F_1 := F_1 \wedge \neg x_1$$

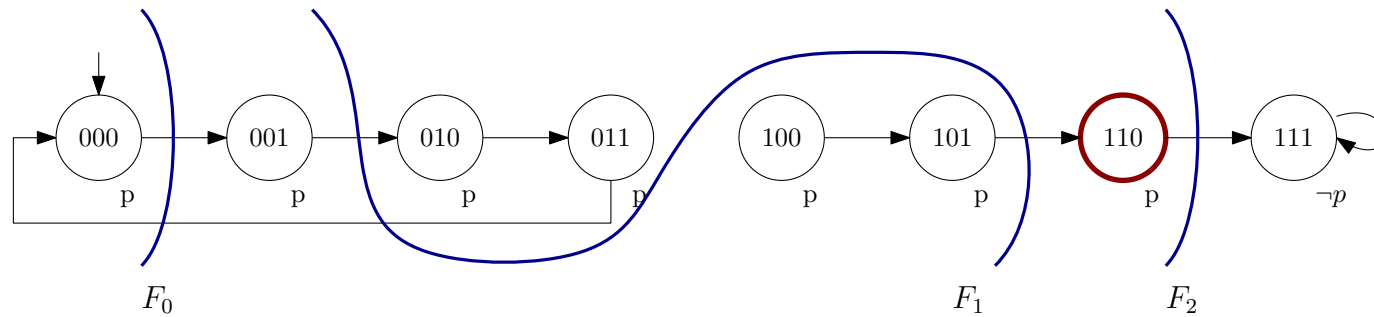
Note: This state of the algorithm is the same as in page 15 of the task 4a. Since from that step task 4a does not use the function **generalize** the continuation is the same.

However, the original intention of the algorithm was to use **propagateClauses** for all frames **except** F_0 , so from now we will follow task 4b with this alternative version of **propagateClauses**.

As for grading, we have considered both options (propagating F_0 or not) equally valid.

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

generalize($i = 1, s = \{110\}$)

$$g = x_2 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

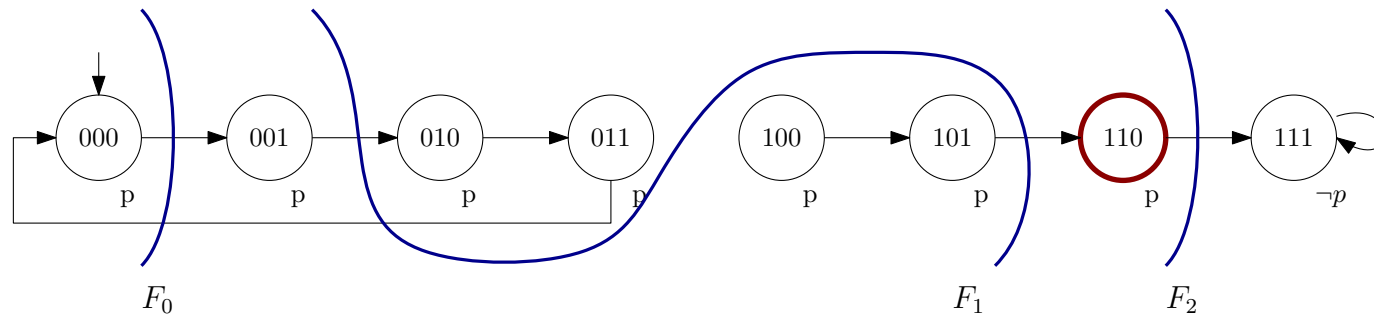
$k++$ and $F_2 = p$

propagateClauses($k = 2$)

$$i = 1, \quad F_1 = \neg x_2$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_1 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 1, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge \neg s' \text{ UNSAT}$$

generalize($i = 1, s = \{110\}$)

$$g = x_2 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

$k++$ and $F_2 = p$

propagateClauses($k = 2$)

$$i = 1, \quad F_1 = \neg x_2$$

$$\text{UNSAT}(F_1 \wedge R \wedge \neg(\neg x_2')) \quad ? \quad \times$$

Model checking HW4 - Solution and common mistakes

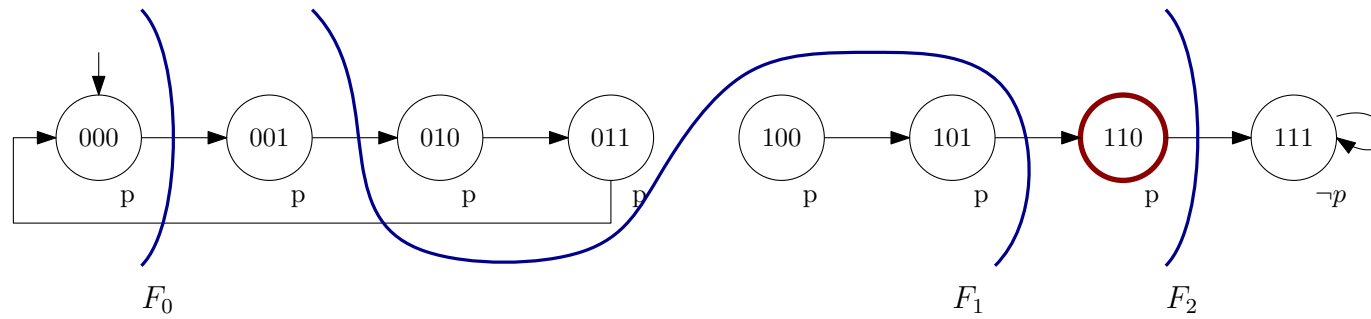
Task 4b.

$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

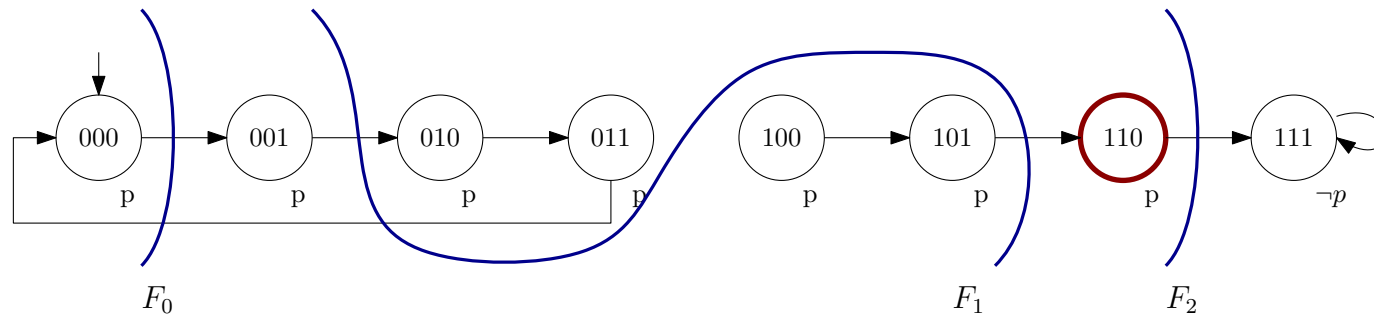
$$F_2 = p$$



$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3 \longrightarrow \text{removeBad}(k, s)$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

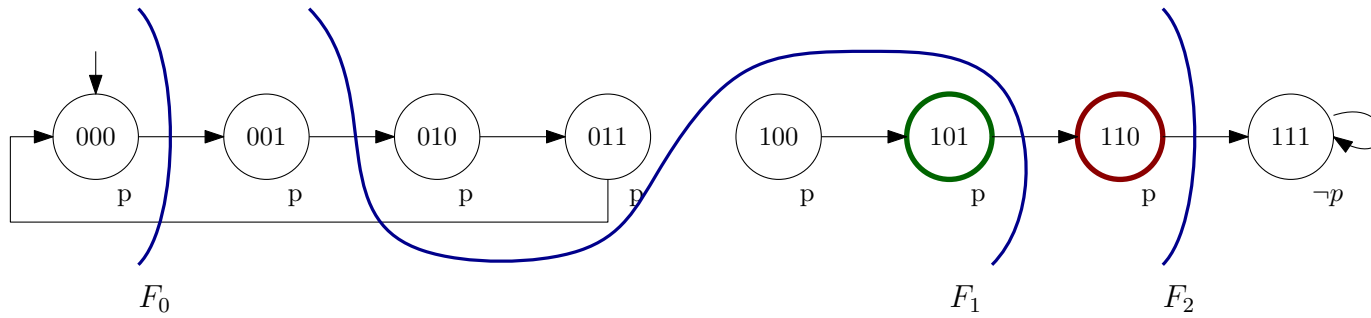
$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

`removeBad(k = 2, s = {110})`

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

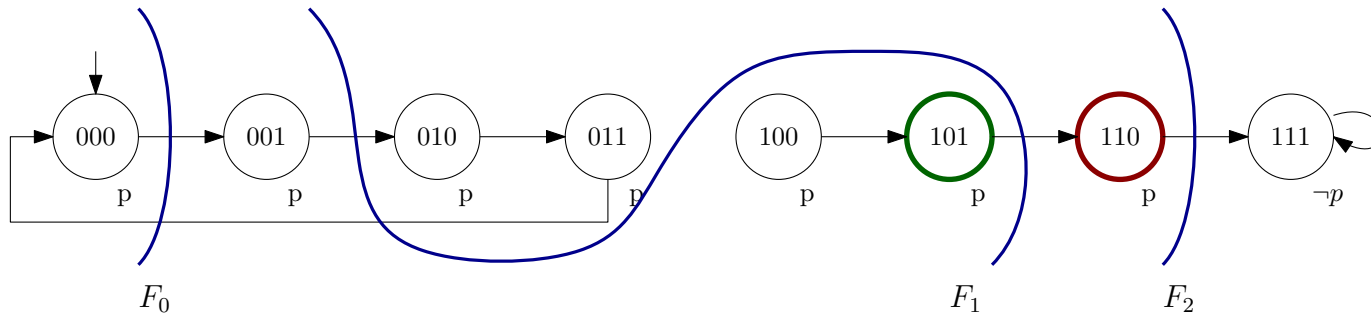
$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

`removeBad(i = 1, t = {101})`

Note: A common mistake was to remove and generalize first state s . In that case, the second `removeBad()` call is unnecessary, because state 101 is removed by `generalize()`.

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$c = [\top, l_1, l_2, l_1 \wedge l_2, l_3, l_1 \wedge l_3, l_2 \wedge l_3, l_1 \wedge l_2 \wedge l_3]$$

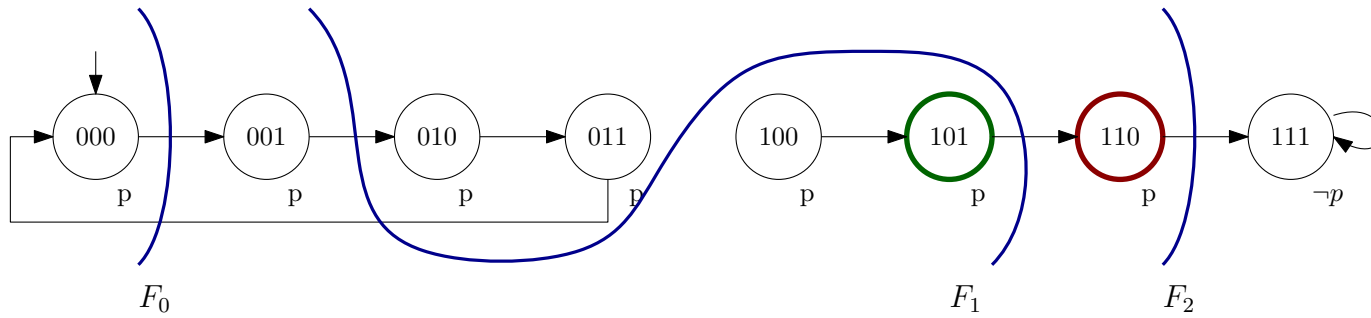
$$c \leftarrow t \quad ?$$

$$\text{UNSAT}(\neg c \wedge F_0 \wedge R \wedge c') \quad ?$$

$$\text{UNSAT}(S_0 \wedge c) \quad ?$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$c = \top \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3]$$

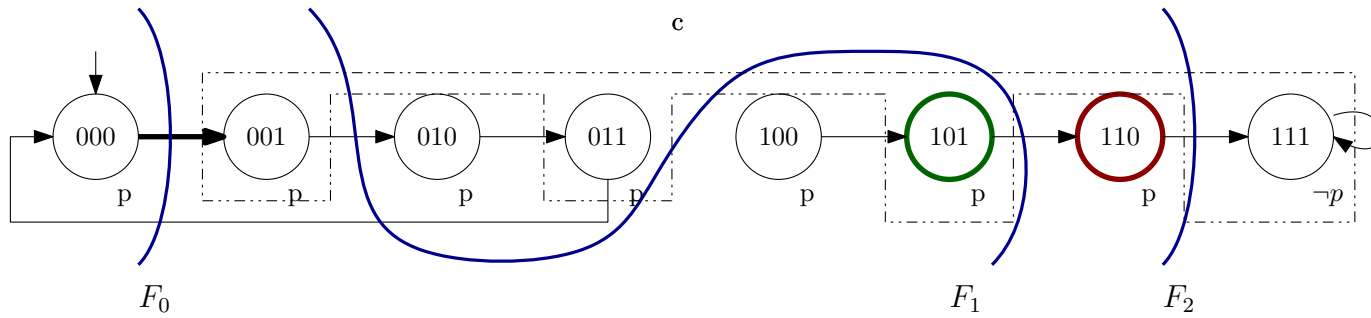
$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_0 \wedge R \wedge c') \quad ? \quad \checkmark$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \times$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$c = x_3 \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3]$$

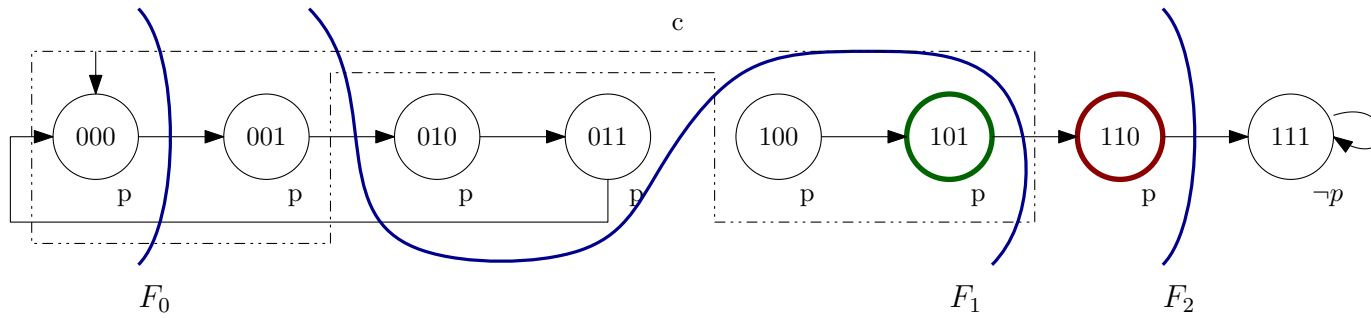
$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_0 \wedge R \wedge c') \quad ? \quad \times$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \checkmark$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$c = \neg x_2 \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3]$$

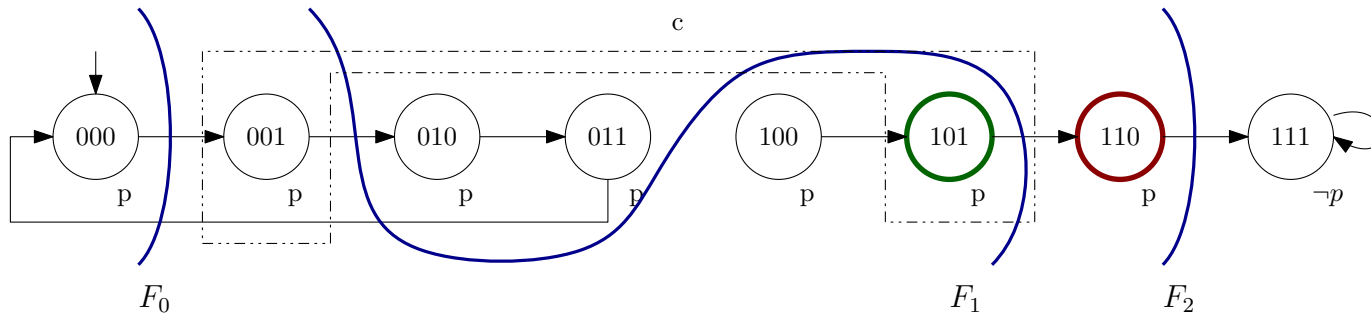
$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_0 \wedge R \wedge c') \quad ? \quad \checkmark$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \times$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$c = \neg x_2 \wedge x_3 \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3]$$

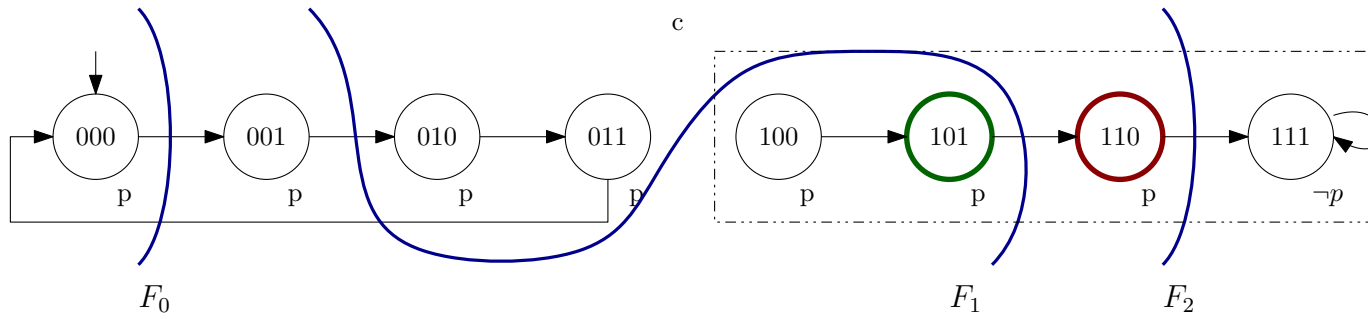
$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_0 \wedge R \wedge c') \quad ? \quad \times$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \checkmark$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$c = x_1 \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3]$$

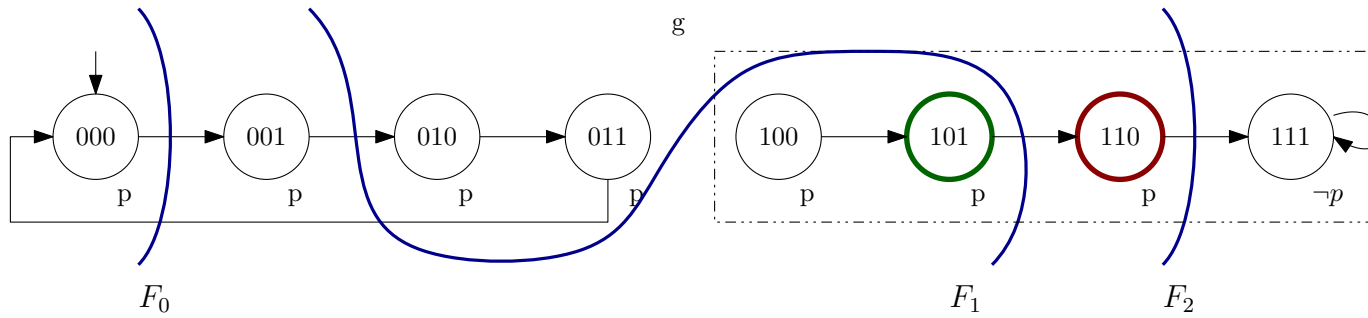
$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_0 \wedge R \wedge c') \quad ? \quad \checkmark$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \checkmark$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

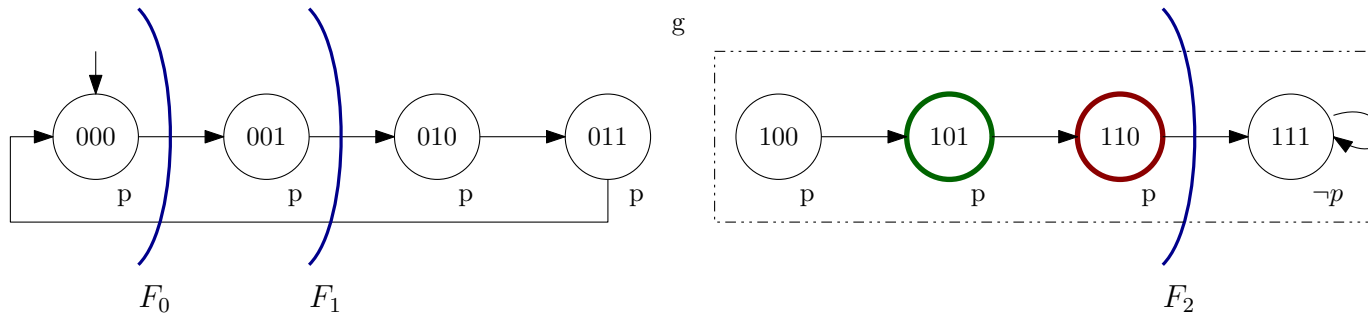
$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$g = x_1 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

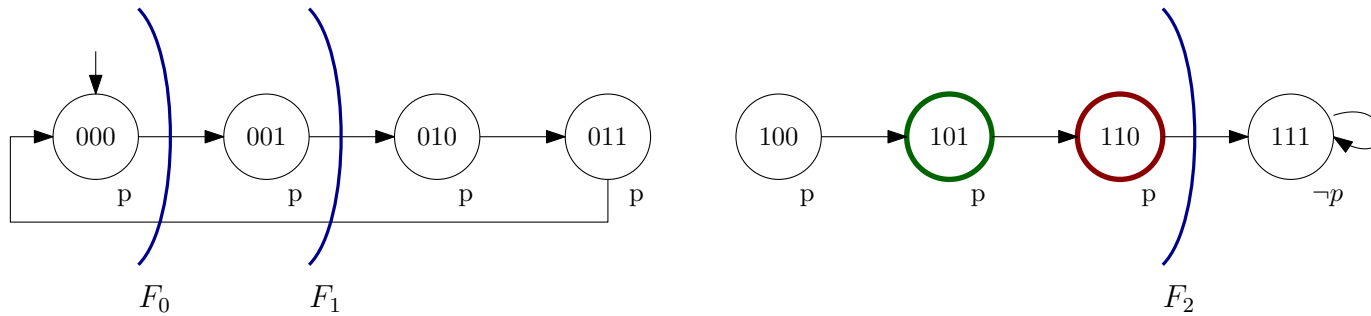
$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$g = x_1 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$c = [\top, l_1, l_2, l_1 \wedge l_2, l_3, l_1 \wedge l_3, l_2 \wedge l_3, l_1 \wedge l_2 \wedge l_3] \quad g = x_1 \quad \longrightarrow \quad \text{Update } F_1 := F_1 \wedge \neg g$$

$$c \leftarrow t \quad ?$$

$$\text{UNSAT}(\neg c \wedge F_1 \wedge R \wedge c') \quad ?$$

$$\text{UNSAT}(S_0 \wedge c) \quad ?$$

removeBad($i = 1, t = \{101\}$)

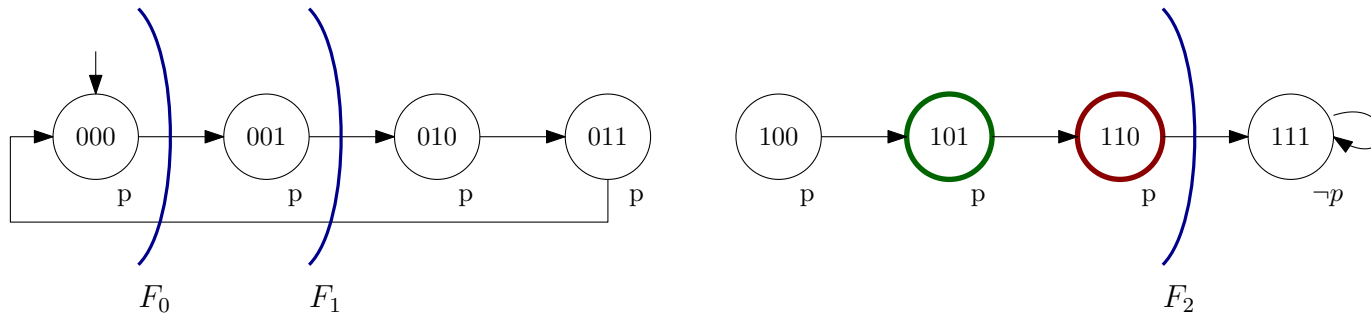
$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \quad \text{UNSAT}$$

generalize($i = 1, t = \{101\}$)

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$c = \top \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3] \quad g = x_1 \quad \longrightarrow \quad \text{Update } F_1 := F_1 \wedge \neg g$$

$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_1 \wedge R \wedge c') \quad ? \quad \checkmark$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \times$$

removeBad($i = 1, t = \{101\}$)

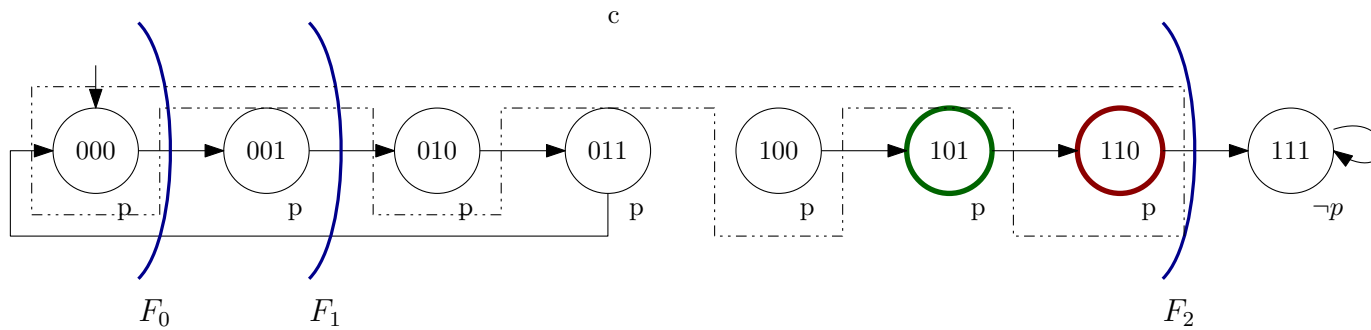
$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \quad \text{UNSAT}$$

generalize($i = 1, t = \{101\}$)

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$c = \neg x_3 \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3] \quad g = x_1 \quad \longrightarrow \quad \text{Update } F_1 := F_1 \wedge \neg g$$

$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_1 \wedge R \wedge c') \quad ? \quad \times$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \times$$

removeBad($i = 1, t = \{101\}$)

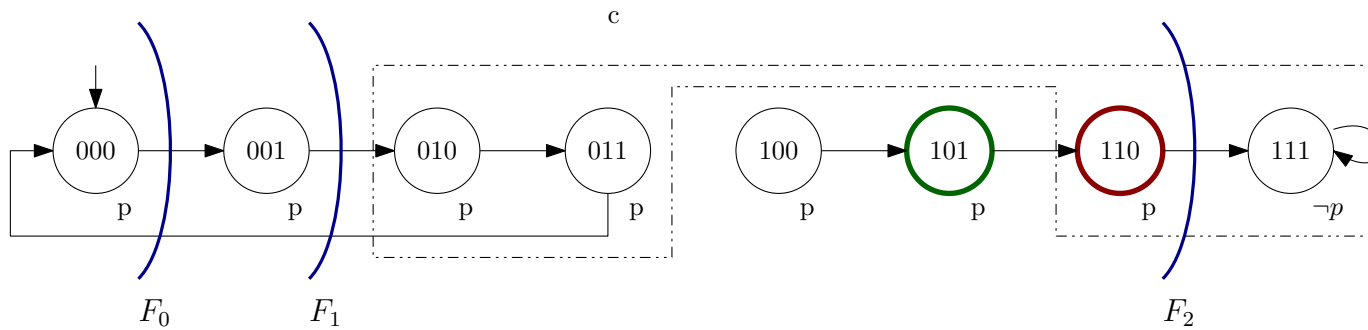
$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \quad \text{UNSAT}$$

generalize($i = 1, t = \{101\}$)

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$c = x_2 \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3] \quad g = x_1 \quad \longrightarrow \quad \text{Update } F_1 := F_1 \wedge \neg g$$

$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_1 \wedge R \wedge c') \quad ? \quad \times$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \checkmark$$

removeBad($i = 1, t = \{101\}$)

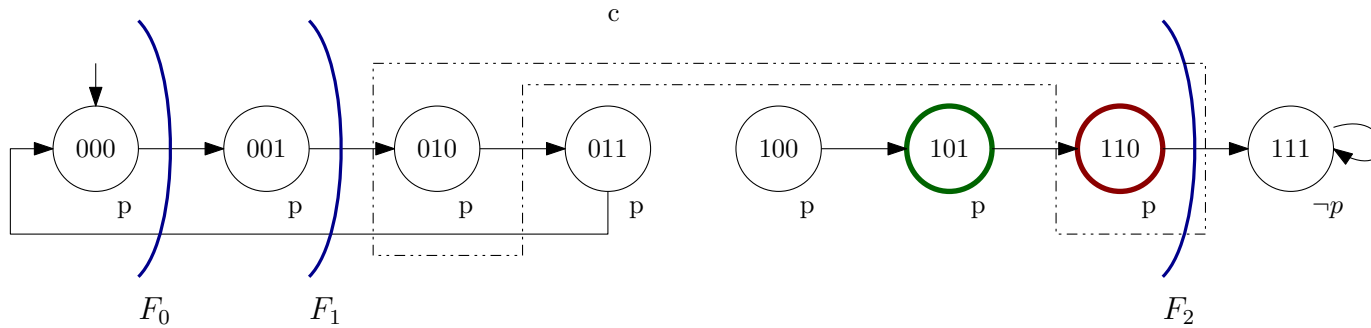
$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \quad \text{UNSAT}$$

generalize($i = 1, t = \{101\}$)

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$c = x_2 \wedge \neg x_3$$

$$[\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge g_3] x_1$$



Update $F_1 := F_1 \wedge \neg g$

$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_1 \wedge R \wedge c') \quad ? \quad \times$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \checkmark$$

removeBad($i = 1, t = \{101\}$)

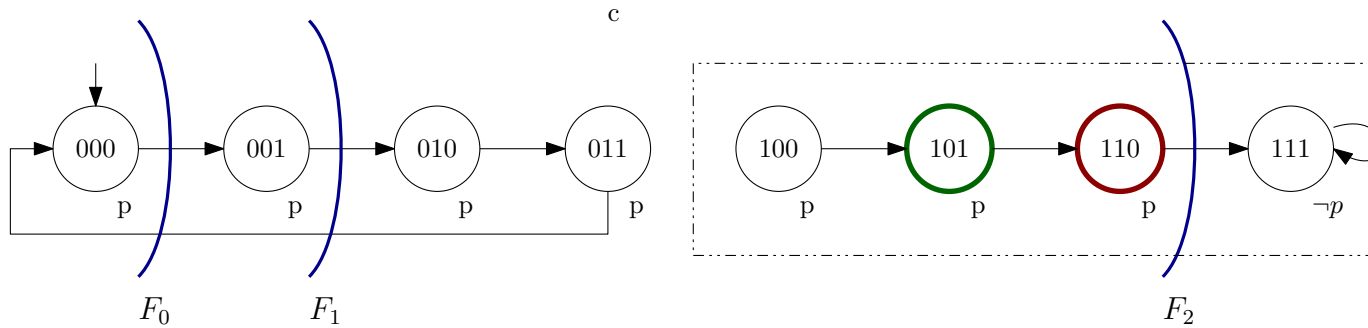
$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$c = x_1 \quad [\top, l_3, l_2, l_3 \wedge l_2, l_1, l_3 \wedge l_1, l_2 \wedge l_1, l_1 \wedge l_2 \wedge l_3] \quad g = x_1 \quad \longrightarrow \quad \text{Update } F_1 := F_1 \wedge \neg g$$

$$c \leftarrow s \quad ? \quad \checkmark$$

$$\text{UNSAT}(\neg c \wedge F_1 \wedge R \wedge c') \quad ? \quad \checkmark$$

$$\text{UNSAT}(S_0 \wedge c) \quad ? \quad \checkmark$$

removeBad($i = 1, t = \{101\}$)

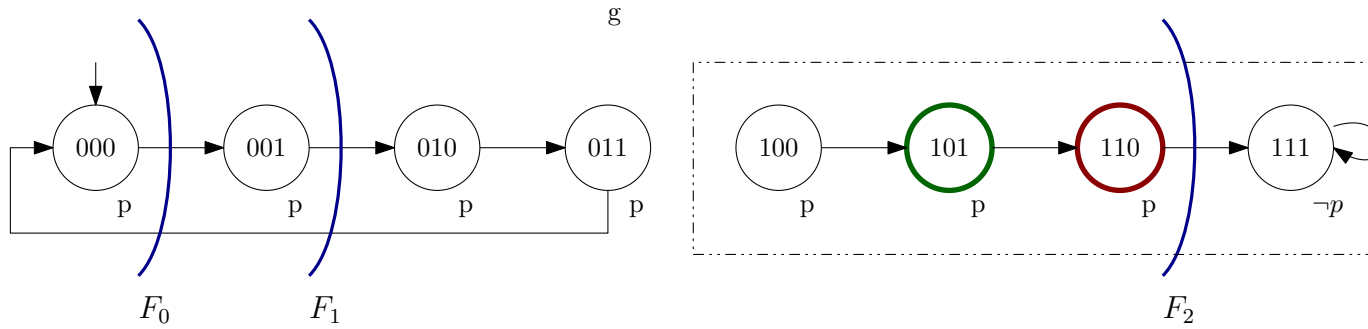
$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \quad \text{UNSAT}$$

generalize($i = 1, t = \{101\}$)

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$g = x_1 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g \text{ (nothing to do)}$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

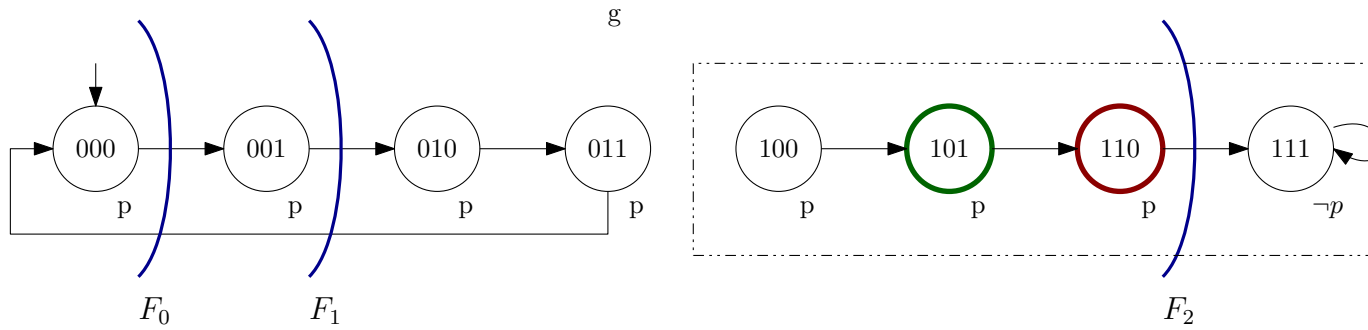
$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$g = x_1 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 2$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$g = x_1 \longrightarrow \text{Update } F_2 := F_2 \wedge \neg g$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

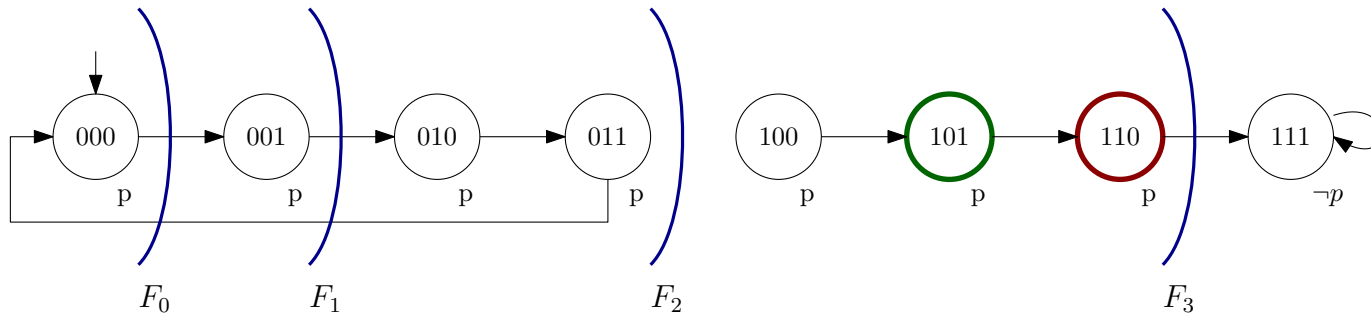
$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$g = x_1 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 3$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = \neg x_1$$

$$F_3 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$g = x_1 \longrightarrow \text{Update } F_2 := F_2 \wedge \neg g$$

$k++$ and $F_3 = p$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

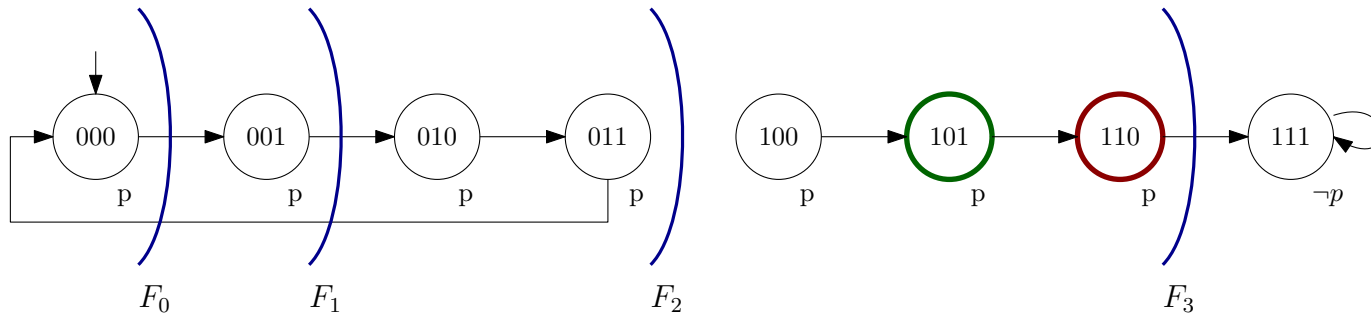
$$F_0 \wedge R \wedge t' \text{ UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$g = x_1 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 3$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = \neg x_1$$

$$F_3 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$g = x_1 \longrightarrow \text{Update } F_2 := F_2 \wedge \neg g$$

$k++$ and $F_3 = p$

propagateClauses($k = 3$)

$$i = 1, \quad F_1 = \neg x_1 \wedge \neg x_2$$

$$\text{UNSAT}(F_1 \wedge R \wedge \neg(\neg x'_1)) \quad ? \quad \checkmark \rightarrow F_2 := F_2 \wedge \neg x_1 \text{ (doesn't change anything)}$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

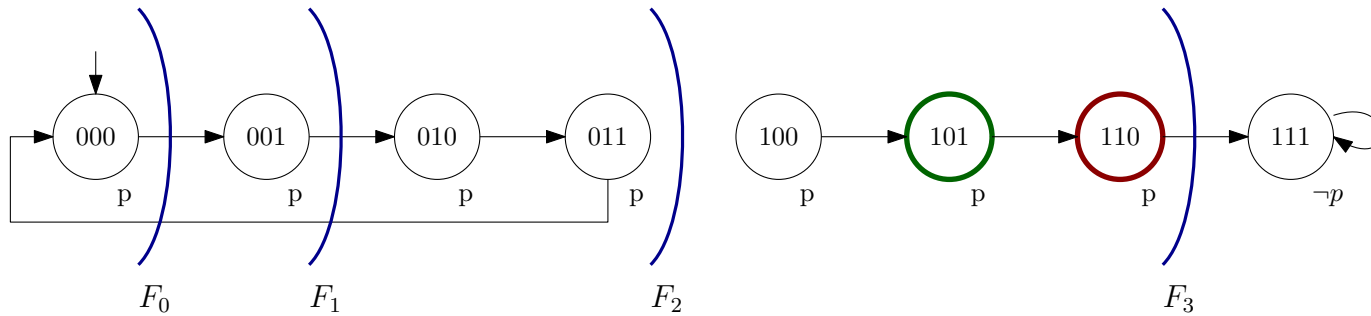
$$F_0 \wedge R \wedge t' \quad \text{UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$g = x_1 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 3$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = \neg x_1$$

$$F_3 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$g = x_1 \longrightarrow \text{Update } F_2 := F_2 \wedge \neg g$$

$k++$ and $F_3 = p$

propagateClauses($k = 3$)

$$i = 1, \quad F_1 = \neg x_1 \wedge \neg x_2$$

$$\text{UNSAT}(F_1 \wedge R \wedge \neg(\neg x_2')) \quad ? \quad \times$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

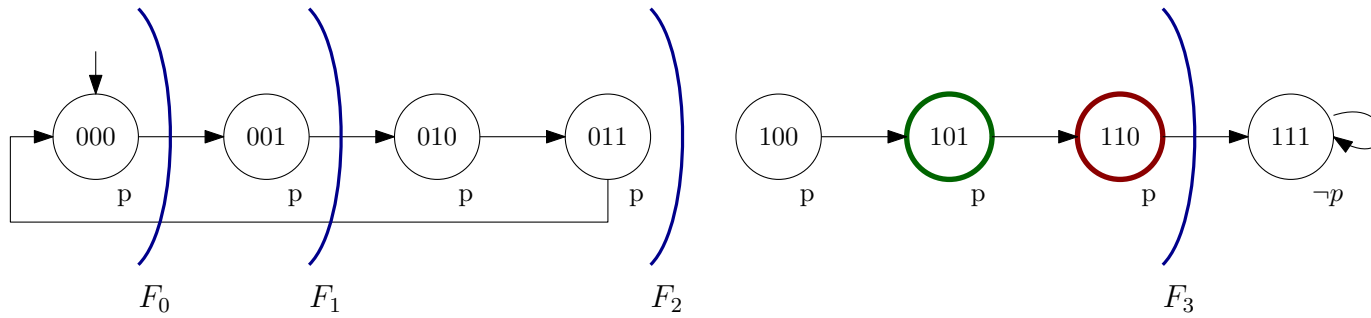
$$F_0 \wedge R \wedge t' \quad \text{UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$g = x_1 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 3$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = \neg x_1$$

$$F_3 = p$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$g = x_1 \longrightarrow \text{Update } F_2 := F_2 \wedge \neg g$$

$k++$ and $F_3 = p$

propagateClauses($k = 3$)

$$i = 2, \quad F_2 = \neg x_1$$

$$\text{UNSAT}(F_2 \wedge R \wedge \neg(\neg x_1')) \quad ? \quad \checkmark \quad \rightarrow F_3 := F_3 \wedge \neg x_1$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

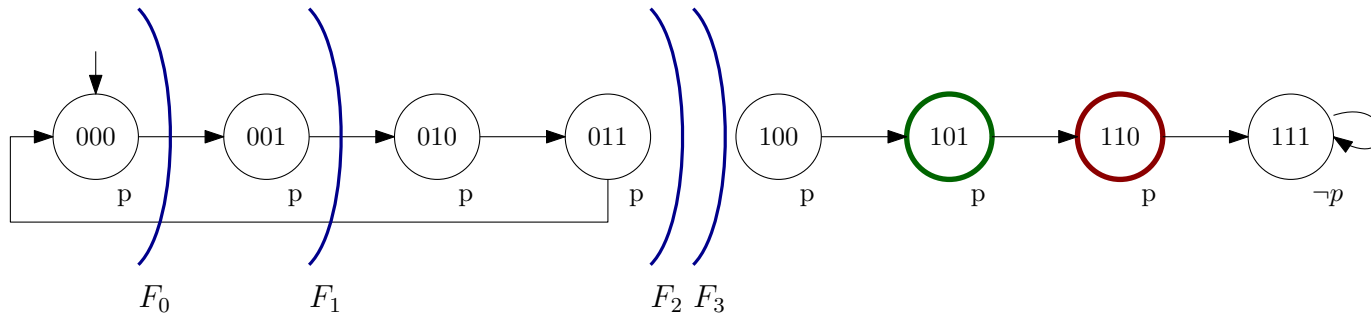
$$F_0 \wedge R \wedge t' \quad \text{UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$g = x_1 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

Model checking HW4 - Solution and common mistakes

Task 4b.



$$k = 3$$

$$F_0 = \neg x_1 \wedge \neg x_2 \wedge \neg x_3$$

$$F_1 = \neg x_1 \wedge \neg x_2$$

$$F_2 = \neg x_1$$

$$F_3 = \neg x_1$$

$$s := \text{SAT}(F_2 \wedge R \wedge \neg p') = x_1 \wedge x_2 \wedge \neg x_3$$

removeBad($k = 2, s = \{110\}$)

$$S_0 \wedge s \text{ UNSAT} \rightarrow \checkmark$$

$$t := \text{SAT}(F_1 \wedge R \wedge s') = x_1 \wedge x_2 \wedge \neg x_3$$

generalize($i = 2, s = \{110\}$)

$$g = x_1 \longrightarrow \text{Update } F_2 := F_2 \wedge \neg g$$

$k++$ and $F_3 = p$

propagateClauses($k = 3$)

$$i = 2, \quad F_2 = \neg x_1$$

$$\text{UNSAT}(F_2 \wedge R \wedge \neg(\neg x_1')) \quad ? \quad \checkmark \rightarrow F_3 := F_3 \wedge \neg x_1$$

removeBad($i = 1, t = \{101\}$)

$$S_0 \wedge t \text{ UNSAT} \rightarrow \checkmark$$

$$F_0 \wedge R \wedge t' \quad \text{UNSAT}$$

generalize($i = 1, t = \{101\}$)

$$g = x_1 \longrightarrow \text{Update } F_1 := F_1 \wedge \neg g$$

$$F_2 = F_3 \longrightarrow \checkmark$$

return $M \models AG p$