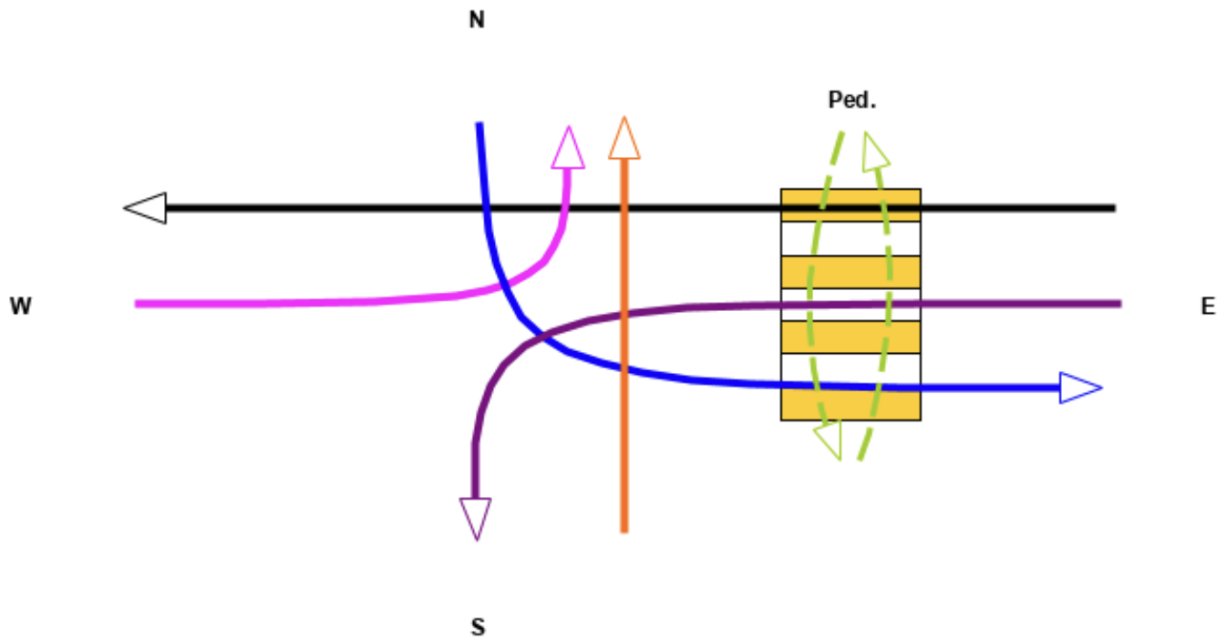


Traffic Light Generator

By Oleg Sidorenkov

More stuff, including code and trail logs can be found in my [repo](#)!

Option №7



Introduction

In this report we will take a look at a simulation of traffic lights working and will verify it

In order to do so, we will need to prove the following features:

- Safety: lights for conflicting paths must not be green simultaneously
- Liveness: if the light is queued to be green, it will become one eventually
- Fairness: no traffic light is green eternally

Architecture

Generator

```
proctype TrafficGenerator(){
  do
    :: SN_light ! 1
    :: WN_light ! 1
    :: EW_light ! 1
    :: ES_light ! 1
    :: NE_light ! 1
    :: P_light ! 1
```

```

    od
}

```

Sends a signal from cars and pedestrians in traffic to sensor

Parallel processes

```

init {
    /* 1: SN conflicts: EW(3), ES(4), NE(5) */
    run TrafficLight(1, 2, 3, 4, 5, 0, 0, SN_light);

    /* 2: WN conflicts: EW(3), NE(5) */
    run TrafficLight(2, 3, 3, 5, 0, 0, 0, WN_light);

    /* 3: EW conflicts: SN(1), WN(2), NE(5), P(6) */
    run TrafficLight(3, 4, 1, 2, 5, 6, 0, EW_light);

    /* 4: ES conflicts: P(6), SN(1), NE(5) */
    run TrafficLight(4, 5, 6, 1, 5, 0, 0, ES_light);

    /* 5: NE conflicts: EW(3), WN(2), ES(4), SN(1), P(6) */
    run TrafficLight(5, 6, 3, 2, 4, 1, 6, NE_light);

    /* 6: P conflicts: EW(3), ES(4), NE(5) */
    run TrafficLight(6, 1, 3, 4, 5, 0, 0, P_light);

    run TrafficGenerator();
}

```

Apart from generator, processes imitating each traffic light, are started

EventLoop

Each process waits for global pointer to point to it

Global pointer is a simple round-robins alogrithm: 1, 2, 3, 4, 5, 6, 1, 2, 3, 4, 5, 6, etc...

When traffic light is active, it checks if there is any traffic, and if there is, it sets a flag that it needs green

The loop also includes somehting like a race with priority for the mutex

Process with most priority gains green

Results

Safety

```

ltl s1 { [] !(statuses[0] && (statuses[2] || statuses[3] || statuses[4]))
}

```

```

ltl s2 { [] !(statuses[1] && (statuses[2] || statuses[4])) }
ltl s3 { [] !(statuses[2] && (statuses[0] || statuses[1] || statuses[4] ||
statuses[5])) }
ltl s4 { [] !(statuses[3] && (statuses[5] || statuses[0] || statuses[4]))
}
ltl s5 { [] !(statuses[4] && (statuses[2] || statuses[1] || statuses[3] ||
statuses[0] || statuses[5])) }
ltl s6 { [] !(statuses[5] && (statuses[2] || statuses[3] || statuses[4]))
}

```

Statuses store the status of the traffic light

Statements check that intersecting roads statuses don't both have green lights

```

> ltl system.pml s1 s2 s3 s4 s5 s6
Processing file system.pml

> Running LTL s1
> LTL s1 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL s2
> LTL s2 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL s3
> LTL s3 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL s4
> LTL s4 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL s5
> LTL s5 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL s6
> LTL s6 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0s

```

Failed to find a counter example (that 2 intersecting paths have green in the same time)

```

pan: ltl formula s1
Depth= 381587 States= 1e+06 Transitions= 5.16e+06 Memory= 418.613 t=
2.39 R= 4e+05
Depth= 381587 States= 2e+06 Transitions= 1.1e+07 Memory= 655.625 t=
4.84 R= 4e+05
Depth= 381587 States= 3e+06 Transitions= 1.65e+07 Memory= 892.636 t=

```

```

7.46 R= 4e+05
Depth= 381587 States= 4e+06 Transitions= 2.2e+07 Memory= 1129.648 t=
10.1 R= 4e+05

```

```

(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction

```

Full statespace search for:

```

never claim          + (s1)
assertion violations + (if within scope of claim)
acceptance cycles    + (fairness disabled)
invalid end states   - (disabled by never claim)

```

```

State-vector 268 byte, depth reached 381587, errors: 0
4254858 states, stored
19216161 states, matched
23471019 transitions (= stored+matched)
0 atomic steps
hash conflicts: 2082649 (resolved)

```

Stats on memory usage (in Megabytes):

```

1201.094 equivalent memory usage for states (stored*(State-vector +
overhead))
1010.961 actual memory usage for states (compression: 84.17%)
state-vector as stored = 221 byte + 28 byte overhead
128.000 memory used for hash table (-w24)
53.406 memory used for DFS stack (-m1000000)
2.270 memory lost to fragmentation
1190.097 total actual memory usage

```

unreached in proctype TrafficLight

```

system.pml:52, state 14, "statuses[(curr-1)] = 1"
system.pml:53, state 15, "queue[(curr-1)] = 0"
system.pml:54, state 16, "currentTurn = next"
system.pml:59, state 21, "firstthirdValue = 0"
system.pml:63, state 27, "secondValue = 0"
system.pml:104, state 77, "-end-"
(6 of 77 states)

```

unreached in proctype TrafficGenerator

```

system.pml:115, state 10, "-end-"
(1 of 10 states)

```

unreached in init

```

(0 of 8 states)

```

unreached in claim s1

```

_spin_nvr.tmp:8, state 10, "-end-"
(1 of 10 states)

```

pan: elapsed time 10.7 seconds

pan: rate 396169.27 states/second

```

ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && ((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||

```

```

(ltl s4: [] (! ((status[3]) && (((status[5]) || (status[0])) ||
(status[4]))))
ltl s5: [] (! ((status[4]) && (((status[2]) || (status[1])) ||
(status[3])) || (status[0])) || (status[5]))))
ltl s6: [] (! ((status[5]) && (((status[2]) || (status[3])) ||
(status[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (status[0])))) || (<>
(status[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (status[1])))) || (<>
(status[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (status[2])))) || (<>
(status[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (status[3])))) || (<>
(status[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (status[4])))) || (<>
(status[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (status[5])))) || (<>
(status[5])))
ltl f1: [] (<> (! (status[0])))
ltl f2: [] (<> (! (status[1])))
ltl f3: [] (<> (! (status[2])))
ltl f4: [] (<> (! (status[3])))
ltl f5: [] (<> (! (status[4])))
ltl f6: [] (<> (! (status[5])))

```

the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4, l3, l2, l1, s6, s5, s4, s3, s2, s1

only one claim is used in a verification run

choose which one with ./pan -a -N name (defaults to -N s1)

or use e.g.: spin -search -ltl s1 system.pml

pan: ltl formula s2

Depth=	381587	States=	1e+06	Transitions=	5.16e+06	Memory=	418.613	t=	
2.46	R=	4e+05							
Depth=	381587	States=	2e+06	Transitions=	1.1e+07	Memory=	655.625	t=	
5.5	R=	4e+05							
Depth=	381587	States=	3e+06	Transitions=	1.65e+07	Memory=	892.636	t=	
8.1	R=	4e+05							
Depth=	381587	States=	4e+06	Transitions=	2.2e+07	Memory=	1129.648	t=	
11.1	R=	4e+05							

(Spin Version 6.5.0 -- 1 July 2019)

+ Partial Order Reduction

Full statespace search for:

```

never claim          + (s2)
assertion violations  + (if within scope of claim)
acceptance cycles    + (fairness disabled)
invalid end states   - (disabled by never claim)

```

State-vector 268 byte, depth reached 381587, errors: 0

```

4254858 states, stored
19216161 states, matched
23471019 transitions (= stored+matched)
    0 atomic steps
hash conflicts: 2087126 (resolved)

```

Stats on memory usage (in Megabytes):

```

1201.094   equivalent memory usage for states (stored*(State-vector +
overhead))
1010.961   actual memory usage for states (compression: 84.17%)
            state-vector as stored = 221 byte + 28 byte overhead
128.000    memory used for hash table (-w24)
53.406     memory used for DFS stack (-m1000000)
2.270      memory lost to fragmentation
1190.097   total actual memory usage

```

unreached in proctype TrafficLight

```

system.pml:52, state 14, "statuses[(curr-1)] = 1"
system.pml:53, state 15, "queue[(curr-1)] = 0"
system.pml:54, state 16, "currentTurn = next"
system.pml:59, state 21, "firstthirdValue = 0"
system.pml:63, state 27, "secondValue = 0"
system.pml:104, state 77, "-end-"
(6 of 77 states)

```

unreached in proctype TrafficGenerator

```

system.pml:115, state 10, "-end-"
(1 of 10 states)

```

unreached in init

```

(0 of 8 states)

```

unreached in claim s2

```

_spin_nvr.tmp:17, state 10, "-end-"
(1 of 10 states)

```

pan: elapsed time 11.8 seconds

pan: rate 362115.57 states/second

```

ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && (((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<>
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<>
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<>
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<>

```

```
(statuses[3]))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<>
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<>
(statuses[5])))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))
the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
l3, l2, l1, s6, s5, s4, s3, s2, s1
only one claim is used in a verification run
choose which one with ./pan -a -N name (defaults to -N s1)
or use e.g.: spin -search -ltl s1 system.pml
```

```
pan: ltl formula s3
Depth= 381587 States= 1e+06 Transitions= 5.16e+06 Memory= 418.613 t=
2.45 R= 4e+05
Depth= 381587 States= 2e+06 Transitions= 1.1e+07 Memory= 655.625 t=
5.29 R= 4e+05
Depth= 381587 States= 3e+06 Transitions= 1.65e+07 Memory= 892.636 t=
8.54 R= 4e+05
Depth= 381587 States= 4e+06 Transitions= 2.2e+07 Memory= 1129.648 t=
11.7 R= 3e+05
```

(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction

Full statespace search for:

```
never claim          + (s3)
assertion violations  + (if within scope of claim)
acceptance cycles    + (fairness disabled)
invalid end states   - (disabled by never claim)
```

State-vector 268 byte, depth reached 381587, errors: 0

4254858 states, stored

19216161 states, matched

23471019 transitions (= stored+matched)

0 atomic steps

hash conflicts: 2090846 (resolved)

Stats on memory usage (in Megabytes):

1201.094 equivalent memory usage for states (stored*(State-vector + overhead))

1010.961 actual memory usage for states (compression: 84.17%)
state-vector as stored = 221 byte + 28 byte overhead

128.000 memory used for hash table (-w24)

53.406 memory used for DFS stack (-m1000000)

2.270 memory lost to fragmentation

1190.097 total actual memory usage

unreached in proctype TrafficLight

```
system.pml:52, state 14, "statuses[(curr-1)] = 1"
system.pml:53, state 15, "queue[(curr-1)] = 0"
system.pml:54, state 16, "currentTurn = next"
system.pml:59, state 21, "firstthirdValue = 0"
system.pml:63, state 27, "secondValue = 0"
system.pml:104, state 77, "-end-"
(6 of 77 states)
```

unreached in proctype TrafficGenerator

```
system.pml:115, state 10, "-end-"
(1 of 10 states)
```

unreached in init

```
(0 of 8 states)
```

unreached in claim s3

```
_spin_nvr.tmp:26, state 10, "-end-"
(1 of 10 states)
```

pan: elapsed time 12.6 seconds

pan: rate 337419.35 states/second

```
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && (((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && ((((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<>
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<>
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<>
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<>
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<>
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<>
(statuses[5])))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))
```

the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4, l3, l2, l1, s6, s5, s4, s3, s2, s1

only one claim is used in a verification run


```
choose which one with ./pan -a -N name (defaults to -N s1)
or use e.g.: spin -search -ltl s1 system.pml
```

```
pan: ltl formula s4
Depth= 381587 States= 1e+06 Transitions= 5.16e+06 Memory= 418.613 t=
2.68 R= 4e+05
Depth= 381587 States= 2e+06 Transitions= 1.1e+07 Memory= 655.625 t=
5.37 R= 4e+05
Depth= 381587 States= 3e+06 Transitions= 1.65e+07 Memory= 892.636 t=
7.97 R= 4e+05
Depth= 381587 States= 4e+06 Transitions= 2.2e+07 Memory= 1129.648 t=
10.7 R= 4e+05
```

```
(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction
```

Full statespace search for:

```
never claim          + (s4)
assertion violations  + (if within scope of claim)
acceptance cycles    + (fairness disabled)
invalid end states   - (disabled by never claim)
```

State-vector 268 byte, depth reached 381587, errors: 0

```
4254858 states, stored
19216161 states, matched
23471019 transitions (= stored+matched)
0 atomic steps
```

hash conflicts: 2085266 (resolved)

Stats on memory usage (in Megabytes):

```
1201.094 equivalent memory usage for states (stored*(State-vector +
overhead))
1010.961 actual memory usage for states (compression: 84.17%)
state-vector as stored = 221 byte + 28 byte overhead
128.000 memory used for hash table (-w24)
53.406 memory used for DFS stack (-m1000000)
2.270 memory lost to fragmentation
1190.097 total actual memory usage
```

unreached in proctype TrafficLight

```
system.pml:52, state 14, "statuses[(curr-1)] = 1"
system.pml:53, state 15, "queue[(curr-1)] = 0"
system.pml:54, state 16, "currentTurn = next"
system.pml:59, state 21, "firstthirdValue = 0"
system.pml:63, state 27, "secondValue = 0"
system.pml:104, state 77, "-end-"
(6 of 77 states)
```

unreached in proctype TrafficGenerator

```
system.pml:115, state 10, "-end-"
(1 of 10 states)
```

```

unreached in init
  (0 of 8 states)
unreached in claim s4
  _spin_nvr.tmp:35, state 10, "--end--"
  (1 of 10 states)

pan: elapsed time 11.5 seconds
pan: rate 370955.36 states/second
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && ((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<>
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<>
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<>
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<>
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<>
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<>
(statuses[5])))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml

```

```

pan: ltl formula s5
Depth= 381587 States= 1e+06 Transitions= 5.16e+06 Memory= 418.613 t=
2.73 R= 4e+05
Depth= 381587 States= 2e+06 Transitions= 1.1e+07 Memory= 655.625 t=
5.72 R= 3e+05
Depth= 381587 States= 3e+06 Transitions= 1.65e+07 Memory= 892.636 t=
8.4 R= 4e+05
Depth= 381587 States= 4e+06 Transitions= 2.2e+07 Memory= 1129.648 t=

```

11.3 R= 4e+05

(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction

Full statespace search for:

never claim + (s5)
assertion violations + (if within scope of claim)
acceptance cycles + (fairness disabled)
invalid end states - (disabled by never claim)

State-vector 268 byte, depth reached 381587, errors: 0

4254858 states, stored

19216161 states, matched

23471019 transitions (= stored+matched)

0 atomic steps

hash conflicts: 2085264 (resolved)

Stats on memory usage (in Megabytes):

1201.094 equivalent memory usage for states (stored*(State-vector + overhead))

1010.961 actual memory usage for states (compression: 84.17%)
state-vector as stored = 221 byte + 28 byte overhead

128.000 memory used for hash table (-w24)

53.406 memory used for DFS stack (-m1000000)

2.270 memory lost to fragmentation

1190.097 total actual memory usage

unreached in proctype TrafficLight

system.pml:52, state 14, "statuses[(curr-1)] = 1"

system.pml:53, state 15, "queue[(curr-1)] = 0"

system.pml:54, state 16, "currentTurn = next"

system.pml:59, state 21, "firstthirdValue = 0"

system.pml:63, state 27, "secondValue = 0"

system.pml:104, state 77, "-end-"

(6 of 77 states)

unreached in proctype TrafficGenerator

system.pml:115, state 10, "-end-"

(1 of 10 states)

unreached in init

(0 of 8 states)

unreached in claim s5

_spin_nvr.tmp:44, state 10, "-end-"

(1 of 10 states)

pan: elapsed time 12.1 seconds

pan: rate 351641.16 states/second

```
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
```

```
ltl s2: [] (! ((statuses[1]) && ((statuses[2]) || (statuses[4]))))
```

```
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
```

```
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
```

```

(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<>
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<>
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<>
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<>
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<>
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<>
(statuses[5])))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml

```

```

pan: ltl formula s6
Depth= 381587 States= 1e+06 Transitions= 5.16e+06 Memory= 418.613 t=
2.56 R= 4e+05
Depth= 381587 States= 2e+06 Transitions= 1.1e+07 Memory= 655.625 t=
5.28 R= 4e+05
Depth= 381587 States= 3e+06 Transitions= 1.65e+07 Memory= 892.636 t=
7.72 R= 4e+05
Depth= 381587 States= 4e+06 Transitions= 2.2e+07 Memory= 1129.648 t=
10.2 R= 4e+05

```

(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction

Full statespace search for:

```

  never claim          + (s6)
  assertion violations  + (if within scope of claim)
  acceptance cycles    + (fairness disabled)
  invalid end states   - (disabled by never claim)

```

State-vector 268 byte, depth reached 381587, errors: 0
4254858 states, stored
19216161 states, matched

```

23471019 transitions (= stored+matched)
      0 atomic steps
hash conflicts: 2083746 (resolved)

Stats on memory usage (in Megabytes):
1201.094   equivalent memory usage for states (stored*(State-vector +
overhead))
1010.961   actual memory usage for states (compression: 84.17%)
            state-vector as stored = 221 byte + 28 byte overhead
128.000    memory used for hash table (-w24)
53.406     memory used for DFS stack (-m1000000)
2.270      memory lost to fragmentation
1190.097   total actual memory usage

```

```

unreached in proctype TrafficLight
  system.pml:52, state 14, "statuses[(curr-1)] = 1"
  system.pml:53, state 15, "queue[(curr-1)] = 0"
  system.pml:54, state 16, "currentTurn = next"
  system.pml:59, state 21, "firstthirdValue = 0"
  system.pml:63, state 27, "secondValue = 0"
  system.pml:104, state 77, "-end-"
(6 of 77 states)

```

```

unreached in proctype TrafficGenerator
  system.pml:115, state 10, "-end-"
(1 of 10 states)

```

```

unreached in init
(0 of 8 states)

```

```

unreached in claim s6
  _spin_nvr.tmp:53, state 10, "-end-"
(1 of 10 states)

```

```

pan: elapsed time 11 seconds
pan: rate 385403.8 states/second
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && ((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<>
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<>
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<>
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<>
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<>

```

```
(statuses[4]))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<>
(statuses[5])))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml
```

Liveness

```
ltl l1 { [] ((queue[0]==1 && !statuses[0]) -> <> statuses[0]) }
ltl l2 { [] ((queue[1]==1 && !statuses[1]) -> <> statuses[1]) }
ltl l3 { [] ((queue[2]==1 && !statuses[2]) -> <> statuses[2]) }
ltl l4 { [] ((queue[3]==1 && !statuses[3]) -> <> statuses[3]) }
ltl l5 { [] ((queue[4]==1 && !statuses[4]) -> <> statuses[4]) }
ltl l6 { [] ((queue[5]==1 && !statuses[5]) -> <> statuses[5]) }
```

Queue stores lights that will eventually be applied

Therefore, we check that any traffic light that has already competed for

```
> ltl system.pml l1 l2 l3 l4 l5 l6
Processing file system.pml

> Running LTL l1
> LTL l1 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL l2
> LTL l2 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL l3
> LTL l3 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL l4
> LTL l4 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL l5
> LTL l5 is correct: failed to find a counter example; state-vector bytes:
```

268, depth: 3448, errors: 0

> Running LTL l6

> LTL l6 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

Failed to find a counter example (queued traffic light that never has been applied)

pan: ltl formula l1

Depth=	1798	States=	1e+06	Transitions=	5.97e+06	Memory=	300.156	t=
2.33	R=	4e+05						
Depth=	1798	States=	2e+06	Transitions=	1.2e+07	Memory=	418.613	t=
4.66	R=	4e+05						
Depth=	4846	States=	3e+06	Transitions=	1.79e+07	Memory=	537.363	t=
6.86	R=	4e+05						
Depth=	4846	States=	4e+06	Transitions=	2.4e+07	Memory=	655.820	t=
9.11	R=	4e+05						
Depth=	6730	States=	5e+06	Transitions=	2.99e+07	Memory=	774.472	t=
11.4	R=	4e+05						
Depth=	6730	States=	6e+06	Transitions=	3.6e+07	Memory=	893.027	t=
13.8	R=	4e+05						
Depth=	227169	States=	7e+06	Transitions=	4.2e+07	Memory=	1030.820	t=
16.4	R=	4e+05						
Depth=	381587	States=	8e+06	Transitions=	5.28e+07	Memory=	1264.316	t=
21.5	R=	4e+05						
Depth=	381587	States=	9e+06	Transitions=	6.29e+07	Memory=	1501.425	t=
26.3	R=	3e+05						
Depth=	381587	States=	1e+07	Transitions=	7.18e+07	Memory=	1716.660	t=
30.6	R=	3e+05						
Depth=	381587	States=	1.1e+07	Transitions=	8.15e+07	Memory=	1948.203	t=
35.3	R=	3e+05						

(Spin Version 6.5.0 -- 1 July 2019)

+ Partial Order Reduction

Full statespace search for:

never claim + (l1)
 assertion violations + (if within scope of claim)
 acceptance cycles + (fairness disabled)
 invalid end states - (disabled by never claim)

State-vector 268 byte, depth reached 381587, errors: 0

7804166 states, stored (1.13535e+07 visited)

74150875 states, matched

85504349 transitions (= visited+matched)

0 atomic steps

hash conflicts: 11878770 (resolved)

Stats on memory usage (in Megabytes):

2203.019 equivalent memory usage for states (stored*(State-vector + overhead))

1854.110 actual memory usage for states (compression: 84.16%)

```

state-vector as stored = 221 byte + 28 byte overhead
128.000 memory used for hash table (-w24)
53.406 memory used for DFS stack (-m1000000)
4.110 memory lost to fragmentation
2031.406 total actual memory usage

```

unreached in proctype TrafficLight

```

system.pml:52, state 14, "statuses[(curr-1)] = 1"
system.pml:53, state 15, "queue[(curr-1)] = 0"
system.pml:54, state 16, "currentTurn = next"
system.pml:59, state 21, "firstthirdValue = 0"
system.pml:63, state 27, "secondValue = 0"
system.pml:104, state 77, "-end-"
(6 of 77 states)

```

unreached in proctype TrafficGenerator

```

system.pml:115, state 10, "-end-"
(1 of 10 states)

```

unreached in init

```

(0 of 8 states)

```

unreached in claim l1

```

_spin_nvr.tmp:64, state 13, "-end-"
(1 of 13 states)

```

pan: elapsed time 37.4 seconds

pan: rate 303812.52 states/second

```

ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && (((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<
(statuses[5])))
ltl f1: [] (< (! (statuses[0])))
ltl f2: [] (< (! (statuses[1])))
ltl f3: [] (< (! (statuses[2])))
ltl f4: [] (< (! (statuses[3])))
ltl f5: [] (< (! (statuses[4])))

```



```

ltl f6: [] (<> (! (statuses[5])))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
  l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml

```

```

pan: ltl formula l2
Depth=   1850 States=   1e+06 Transitions= 5.93e+06 Memory=   300.156 t=
2.37 R=   4e+05
Depth=   1850 States=   2e+06 Transitions= 1.2e+07 Memory=   418.613 t=
4.8 R=   4e+05
Depth=   4286 States=   3e+06 Transitions= 1.79e+07 Memory=   537.363 t=
7.21 R=   4e+05
Depth=   4286 States=   4e+06 Transitions= 2.4e+07 Memory=   655.820 t=
9.56 R=   4e+05
Depth=   6170 States=   5e+06 Transitions= 2.98e+07 Memory=   774.472 t=
12 R=   4e+05
Depth=   6170 States=   6e+06 Transitions= 3.59e+07 Memory=   892.929 t=
14.6 R=   4e+05
Depth=  287869 States=   7e+06 Transitions= 4.2e+07 Memory=  1038.340 t=
17.3 R=   4e+05
Depth=  381587 States=   8e+06 Transitions= 5.2e+07 Memory=  1268.320 t=
22.4 R=   4e+05
Depth=  381587 States=   9e+06 Transitions= 6.09e+07 Memory=  1485.996 t=
26.5 R=   3e+05
Depth=  381587 States=  1e+07 Transitions= 7.16e+07 Memory=  1715.781 t=
31.8 R=   3e+05
Depth=  381587 States=  1.1e+07 Transitions= 8.13e+07 Memory=  1947.812 t=
36.6 R=   3e+05

```

(Spin Version 6.5.0 -- 1 July 2019)
 + Partial Order Reduction

Full statespace search for:

- never claim + (l2)
- assertion violations + (if within scope of claim)
- acceptance cycles + (fairness disabled)
- invalid end states - (disabled by never claim)

State-vector 268 byte, depth reached 381587, errors: 0
 7806790 states, stored (1.13587e+07 visited)
 74017142 states, matched
 85375864 transitions (= visited+matched)
 0 atomic steps
 hash conflicts: 11608526 (resolved)

Stats on memory usage (in Megabytes):
 2203.760 equivalent memory usage for states (stored*(State-vector +
 overhead))
 1854.697 actual memory usage for states (compression: 84.16%)

```

state-vector as stored = 221 byte + 28 byte overhead
128.000 memory used for hash table (-w24)
53.406 memory used for DFS stack (-m1000000)
4.112 memory lost to fragmentation
2031.992 total actual memory usage

```

unreached in proctype TrafficLight

```

system.pml:52, state 14, "statuses[(curr-1)] = 1"
system.pml:53, state 15, "queue[(curr-1)] = 0"
system.pml:54, state 16, "currentTurn = next"
system.pml:59, state 21, "firstthirdValue = 0"
system.pml:63, state 27, "secondValue = 0"
system.pml:104, state 77, "-end-"
(6 of 77 states)

```

unreached in proctype TrafficGenerator

```

system.pml:115, state 10, "-end-"
(1 of 10 states)

```

unreached in init

```

(0 of 8 states)

```

unreached in claim l2

```

_spin_nvr.tmp:75, state 13, "-end-"
(1 of 13 states)

```

pan: elapsed time 38.7 seconds

pan: rate 293658.79 states/second

```

ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && (((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<
(statuses[5])))
ltl f1: [] (< (! (statuses[0])))
ltl f2: [] (< (! (statuses[1])))
ltl f3: [] (< (! (statuses[2])))
ltl f4: [] (< (! (statuses[3])))
ltl f5: [] (< (! (statuses[4])))

```

```

ltl f6: [] (<> (! (statuses[5])))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
  l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml

```

```

pan: ltl formula l3
Depth=    984 States=    1e+06 Transitions= 6.03e+06 Memory=    300.058 t=
2.44 R=    4e+05
Depth=   3358 States=    2e+06 Transitions= 1.2e+07 Memory=    418.808 t=
4.78 R=    4e+05
Depth=   5242 States=    3e+06 Transitions= 1.8e+07 Memory=    537.363 t=
7.01 R=    4e+05
Depth=   5242 States=    4e+06 Transitions= 2.4e+07 Memory=    655.820 t=
9.57 R=    4e+05
Depth=   6897 States=    5e+06 Transitions= 3e+07 Memory=    774.472 t=
12.1 R=    4e+05
Depth=  24581 States=    6e+06 Transitions= 3.6e+07 Memory=    894.199 t=
14.6 R=    4e+05
Depth= 381587 States=    7e+06 Transitions= 4.56e+07 Memory=   1114.804 t=
19.7 R=    4e+05
Depth= 381587 States=    8e+06 Transitions= 5.6e+07 Memory=   1346.250 t=
24.7 R=    3e+05
Depth= 381587 States=    9e+06 Transitions= 6.45e+07 Memory=   1550.254 t=
29.1 R=    3e+05
Depth= 381587 States=   1e+07 Transitions= 7.37e+07 Memory=   1765.488 t=
33.5 R=    3e+05

```

(Spin Version 6.5.0 -- 1 July 2019)
 + Partial Order Reduction

Full statespace search for:
 never claim + (l3)
 assertion violations + (if within scope of claim)
 acceptance cycles + (fairness disabled)
 invalid end states - (disabled by never claim)

State-vector 268 byte, depth reached 381587, errors: 0
 7620293 states, stored (1.09857e+07 visited)
 71448780 states, matched
 82434508 transitions (= visited+matched)
 0 atomic steps
 hash conflicts: 11366917 (resolved)

Stats on memory usage (in Megabytes):
 2151.114 equivalent memory usage for states (stored*(State-vector +
 overhead))
 1810.362 actual memory usage for states (compression: 84.16%)
 state-vector as stored = 221 byte + 28 byte overhead
 128.000 memory used for hash table (-w24)

```

53.406   memory used for DFS stack (-m1000000)
4.015    memory lost to fragmentation
1987.754 total actual memory usage

```

unreached in proctype TrafficLight

```

system.pml:52, state 14, "statuses[(curr-1)] = 1"
system.pml:53, state 15, "queue[(curr-1)] = 0"
system.pml:54, state 16, "currentTurn = next"
system.pml:59, state 21, "firstthirdValue = 0"
system.pml:63, state 27, "secondValue = 0"
system.pml:104, state 77, "-end-"
(6 of 77 states)

```

unreached in proctype TrafficGenerator

```

system.pml:115, state 10, "-end-"
(1 of 10 states)

```

unreached in init

```

(0 of 8 states)

```

unreached in claim l3

```

_spin_nvr.tmp:86, state 13, "-end-"
(1 of 13 states)

```

pan: elapsed time 38.9 seconds

pan: rate 282700.15 states/second

```

ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && ((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1) && (! (statuses[0])))) || (<>
(statuses[0]))))
ltl l2: [] ((! (((queue[1]==1) && (! (statuses[1])))) || (<>
(statuses[1]))))
ltl l3: [] ((! (((queue[2]==1) && (! (statuses[2])))) || (<>
(statuses[2]))))
ltl l4: [] ((! (((queue[3]==1) && (! (statuses[3])))) || (<>
(statuses[3]))))
ltl l5: [] ((! (((queue[4]==1) && (! (statuses[4])))) || (<>
(statuses[4]))))
ltl l6: [] ((! (((queue[5]==1) && (! (statuses[5])))) || (<>
(statuses[5]))))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))

```

the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,

```

l3, l2, l1, s6, s5, s4, s3, s2, s1
only one claim is used in a verification run
choose which one with ./pan -a -N name (defaults to -N s1)
or use e.g.: spin -search -ltl s1 system.pml

```

```

pan: ltl formula l4
Depth=    1036 States=    1e+06 Transitions= 5.98e+06 Memory=    300.058 t=
2.5 R=    4e+05
Depth=    4398 States=    2e+06 Transitions= 1.19e+07 Memory=    418.808 t=
4.74 R=    4e+05
Depth=    4398 States=    3e+06 Transitions= 1.79e+07 Memory=    537.265 t=
7.06 R=    4e+05
Depth=    6282 States=    4e+06 Transitions= 2.39e+07 Memory=    656.015 t=
9.24 R=    4e+05
Depth=    6282 States=    5e+06 Transitions= 2.98e+07 Memory=    774.472 t=
11.5 R=    4e+05
Depth=   38827 States=    6e+06 Transitions= 3.58e+07 Memory=    895.175 t=
13.8 R=    4e+05
Depth=  381587 States=    7e+06 Transitions= 4.45e+07 Memory=   1121.054 t=
18.1 R=    4e+05
Depth=  381587 States=    8e+06 Transitions= 5.36e+07 Memory=   1337.851 t=
22.5 R=    4e+05
Depth=  381587 States=    9e+06 Transitions= 6.45e+07 Memory=   1570.761 t=
28.1 R=    3e+05
Depth=  381587 States=   1e+07 Transitions= 7.28e+07 Memory=   1775.156 t=
32.1 R=    3e+05

```

```

(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction

```

```

Full statespace search for:
  never claim          + (l4)
  assertion violations  + (if within scope of claim)
  acceptance cycles    + (fairness disabled)
  invalid end states   - (disabled by never claim)

```

```

State-vector 268 byte, depth reached 381587, errors: 0
  7542277 states, stored (1.08297e+07 visited)
  69714179 states, matched
  80543875 transitions (= visited+matched)
    0 atomic steps
hash conflicts: 10599814 (resolved)

```

```

Stats on memory usage (in Megabytes):
  2129.091  equivalent memory usage for states (stored*(State-vector +
overhead))
  1791.865  actual memory usage for states (compression: 84.16%)
             state-vector as stored = 221 byte + 28 byte overhead
  128.000   memory used for hash table (-w24)
   53.406   memory used for DFS stack (-m1000000)
    3.974   memory lost to fragmentation

```

1969.297 total actual memory usage

unreached in proctype TrafficLight

```
system.pml:52, state 14, "statuses[(curr-1)] = 1"
system.pml:53, state 15, "queue[(curr-1)] = 0"
system.pml:54, state 16, "currentTurn = next"
system.pml:59, state 21, "firstthirdValue = 0"
system.pml:63, state 27, "secondValue = 0"
system.pml:104, state 77, "-end-"
(6 of 77 states)
```

unreached in proctype TrafficGenerator

```
system.pml:115, state 10, "-end-"
(1 of 10 states)
```

unreached in init

```
(0 of 8 states)
```

unreached in claim l4

```
_spin_nvr.tmp:97, state 13, "-end-"
(1 of 13 states)
```

pan: elapsed time 36.2 seconds

pan: rate 298915.15 states/second

```
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && (((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && ((((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<>
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<>
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<>
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<>
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<>
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<>
(statuses[5])))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))
```

the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4, l3, l2, l1, s6, s5, s4, s3, s2, s1

only one claim is used in a verification run

choose which one with `./pan -a -N name` (defaults to `-N s1`)
 or use e.g.: `spin -search -ltl s1 system.pml`

```
pan: ltl formula l5
Depth=   2536 States=   1e+06 Transitions= 6.01e+06 Memory=   300.254 t=
2.49 R=   4e+05
Depth=   3792 States=   2e+06 Transitions= 1.19e+07 Memory=   418.808 t=
5.03 R=   4e+05
Depth=   5676 States=   3e+06 Transitions= 1.79e+07 Memory=   537.363 t=
7.52 R=   4e+05
Depth=   6897 States=   4e+06 Transitions= 2.4e+07 Memory=   656.015 t=
10 R=   4e+05
Depth=  148433 States=   5e+06 Transitions= 2.99e+07 Memory=   785.605 t=
12.6 R=   4e+05
Depth=  381587 States=   6e+06 Transitions= 3.89e+07 Memory=  1006.211 t=
17 R=   4e+05
Depth=  381587 States=   7e+06 Transitions= 4.94e+07 Memory=  1220.859 t=
22.1 R=   3e+05
Depth=  381587 States=   8e+06 Transitions= 5.8e+07 Memory=  1432.382 t=
26.3 R=   3e+05
Depth=  381587 States=   9e+06 Transitions= 6.63e+07 Memory=  1628.574 t=
30.9 R=   3e+05
Depth=  381587 States=  1e+07 Transitions= 7.46e+07 Memory=  1830.918 t=
35 R=   3e+05
```

(Spin Version 6.5.0 -- 1 July 2019)
 + Partial Order Reduction

Full statespace search for:

```
never claim          + (l5)
assertion violations  + (if within scope of claim)
acceptance cycles    + (fairness disabled)
invalid end states   - (disabled by never claim)
```

State-vector 268 byte, depth reached 381587, errors: 0

7317636 states, stored (1.03804e+07 visited)

66620535 states, matched

77000949 transitions (= visited+matched)

0 atomic steps

hash conflicts: 10543668 (resolved)

Stats on memory usage (in Megabytes):

2065.678 equivalent memory usage for states (stored*(State-vector + overhead))

1738.526 actual memory usage for states (compression: 84.16%)
 state-vector as stored = 221 byte + 28 byte overhead

128.000 memory used for hash table (-w24)

53.406 memory used for DFS stack (-m1000000)

3.858 memory lost to fragmentation

1916.074 total actual memory usage

```

unreached in proctype TrafficLight
  system.pml:52, state 14, "statuses[(curr-1)] = 1"
  system.pml:53, state 15, "queue[(curr-1)] = 0"
  system.pml:54, state 16, "currentTurn = next"
  system.pml:59, state 21, "firstthirdValue = 0"
  system.pml:63, state 27, "secondValue = 0"
  system.pml:104, state 77, "-end-"
  (6 of 77 states)
unreached in proctype TrafficGenerator
  system.pml:115, state 10, "-end-"
  (1 of 10 states)
unreached in init
  (0 of 8 states)
unreached in claim l5
  _spin_nvr.tmp:108, state 13, "-end-"
  (1 of 13 states)

pan: elapsed time 36.2 seconds
pan: rate 286356.25 states/second
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && (((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<
(statuses[0]))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<
(statuses[1]))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<
(statuses[2]))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<
(statuses[3]))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<
(statuses[4]))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<
(statuses[5]))
ltl f1: [] (< (! (statuses[0]))
ltl f2: [] (< (! (statuses[1]))
ltl f3: [] (< (! (statuses[2]))
ltl f4: [] (< (! (statuses[3]))
ltl f5: [] (< (! (statuses[4]))
ltl f6: [] (< (! (statuses[5]))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml

```



```

pan: ltl formula l6
Depth=    1746 States=    1e+06 Transitions= 5.99e+06 Memory=    300.156 t=
2.55 R=    4e+05
Depth=    1746 States=    2e+06 Transitions= 1.21e+07 Memory=    418.613 t=
5.31 R=    4e+05
Depth=    4794 States=    3e+06 Transitions= 1.8e+07 Memory=    537.363 t=
7.94 R=    4e+05
Depth=    4794 States=    4e+06 Transitions= 2.41e+07 Memory=    655.820 t=
10.7 R=    4e+05
Depth=    6678 States=    5e+06 Transitions= 3e+07 Memory=    774.472 t=
13.2 R=    4e+05
Depth=    6678 States=    6e+06 Transitions= 3.61e+07 Memory=    893.027 t=
15.8 R=    4e+05
Depth=   333555 States=    7e+06 Transitions= 4.23e+07 Memory=   1044.590 t=
18.6 R=    4e+05
Depth=   381587 States=    8e+06 Transitions= 5.31e+07 Memory=   1279.160 t=
24.4 R=    3e+05
Depth=   381587 States=    9e+06 Transitions= 6.36e+07 Memory=   1516.172 t=
30.2 R=    3e+05
Depth=   381587 States=   1e+07 Transitions= 7.2e+07 Memory=   1728.769 t=
34.8 R=    3e+05
Depth=   381587 States=   1.1e+07 Transitions= 8.24e+07 Memory=   1965.781 t=
40.9 R=    3e+05

```

(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction

Full statespace search for:

```

never claim          + (l6)
assertion violations + (if within scope of claim)
acceptance cycles    + (fairness disabled)
invalid end states   - (disabled by never claim)

```

State-vector 268 byte, depth reached 381587, errors: 0

7767494 states, stored (1.12801e+07 visited)

73792309 states, matched

85072439 transitions (= visited+matched)

0 atomic steps

hash conflicts: 11840377 (resolved)

Stats on memory usage (in Megabytes):

2192.667 equivalent memory usage for states (stored*(State-vector + overhead))

1845.400 actual memory usage for states (compression: 84.16%)

state-vector as stored = 221 byte + 28 byte overhead

128.000 memory used for hash table (-w24)

53.406 memory used for DFS stack (-m1000000)

4.091 memory lost to fragmentation

2022.715 total actual memory usage

```

unreached in proctype TrafficLight
  system.pml:52, state 14, "statuses[(curr-1)] = 1"
  system.pml:53, state 15, "queue[(curr-1)] = 0"
  system.pml:54, state 16, "currentTurn = next"
  system.pml:59, state 21, "firstthirdValue = 0"
  system.pml:63, state 27, "secondValue = 0"
  system.pml:104, state 77, "-end-"
  (6 of 77 states)
unreached in proctype TrafficGenerator
  system.pml:115, state 10, "-end-"
  (1 of 10 states)
unreached in init
  (0 of 8 states)
unreached in claim l6
  _spin_nvr.tmp:119, state 13, "-end-"
  (1 of 13 states)

pan: elapsed time 42.2 seconds
pan: rate 267491.82 states/second
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && (((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<
(statuses[5])))
ltl f1: [] (< (! (statuses[0])))
ltl f2: [] (< (! (statuses[1])))
ltl f3: [] (< (! (statuses[2])))
ltl f4: [] (< (! (statuses[3])))
ltl f5: [] (< (! (statuses[4])))
ltl f6: [] (< (! (statuses[5])))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml

```

Fairness

```
ltl f1 { [] <> !statuses[0] }
ltl f2 { [] <> !statuses[1] }
ltl f3 { [] <> !statuses[2] }
ltl f4 { [] <> !statuses[3] }
ltl f5 { [] <> !statuses[4] }
ltl f6 { [] <> !statuses[5] }
```

Checks that every light will eventually become red

```
> ltl system.pml f1 f2 f3 f4 f5 f6
Processing file system.pml

> Running LTL f1
> LTL f1 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL f2
> LTL f2 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL f3
> LTL f3 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL f4
> LTL f4 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL f5
> LTL f5 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0

> Running LTL f6
> LTL f6 is correct: failed to find a counter example; state-vector bytes:
268, depth: 3448, errors: 0
```

Failed to find a counter example (some light will be green forever, therefore, blocking routes)

```
pan: ltl formula f1
Depth= 381587 States= 1e+06 Transitions= 5.43e+06 Memory= 369.394 t=
2.42 R= 4e+05
Depth= 381587 States= 2e+06 Transitions= 1.29e+07 Memory= 574.179 t=
5.95 R= 3e+05
Depth= 381587 States= 3e+06 Transitions= 1.88e+07 Memory= 801.230 t=
8.85 R= 3e+05
```

```

Depth= 381587 States=      4e+06 Transitions= 2.56e+07 Memory=   998.593 t=
11.7 R=   3e+05
Depth= 381587 States=      5e+06 Transitions= 3.23e+07 Memory=  1198.105 t=
14.9 R=   3e+05

```

```

(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction

```

```

Full statespace search for:
  never claim          + (f1)
  assertion violations  + (if within scope of claim)
  acceptance cycles    + (fairness disabled)
  invalid end states   - (disabled by never claim)

```

```

State-vector 268 byte, depth reached 381587, errors: 0
  4966214 states, stored (5.67757e+06 visited)
  30423918 states, matched
  36101488 transitions (= visited+matched)
    0 atomic steps
hash conflicts:   3072286 (resolved)

```

```

Stats on memory usage (in Megabytes):
  1401.901   equivalent memory usage for states (stored*(State-vector +
overhead))
  1179.885   actual memory usage for states (compression: 84.16%)
              state-vector as stored = 221 byte + 28 byte overhead
  128.000    memory used for hash table (-w24)
   53.406    memory used for DFS stack (-m1000000)
    2.639    memory lost to fragmentation
  1358.652   total actual memory usage

```

```

unreached in proctype TrafficLight
  system.pml:52, state 14, "statuses[(curr-1)] = 1"
  system.pml:53, state 15, "queue[(curr-1)] = 0"
  system.pml:54, state 16, "currentTurn = next"
  system.pml:59, state 21, "firstthirdValue = 0"
  system.pml:63, state 27, "secondValue = 0"
  system.pml:104, state 77, "-end-"
  (6 of 77 states)
unreached in proctype TrafficGenerator
  system.pml:115, state 10, "-end-"
  (1 of 10 states)
unreached in init
  (0 of 8 states)
unreached in claim f1
  _spin_nvr.tmp:130, state 13, "-end-"
  (1 of 13 states)

```

```

pan: elapsed time 16.6 seconds
pan: rate 340995.2 states/second
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && ((statuses[2]) || (statuses[4]))))

```

```

ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1) && (! (statuses[0])))) || (<>
(statuses[0]))))
ltl l2: [] ((! (((queue[1]==1) && (! (statuses[1])))) || (<>
(statuses[1]))))
ltl l3: [] ((! (((queue[2]==1) && (! (statuses[2])))) || (<>
(statuses[2]))))
ltl l4: [] ((! (((queue[3]==1) && (! (statuses[3])))) || (<>
(statuses[3]))))
ltl l5: [] ((! (((queue[4]==1) && (! (statuses[4])))) || (<>
(statuses[4]))))
ltl l6: [] ((! (((queue[5]==1) && (! (statuses[5])))) || (<>
(statuses[5]))))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))

```

the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4, l3, l2, l1, s6, s5, s4, s3, s2, s1
only one claim is used in a verification run
choose which one with ./pan -a -N name (defaults to -N s1)
or use e.g.: spin -search -ltl s1 system.pml

```

pan: ltl formula f2
Depth= 374005 States= 1e+06 Transitions= 5.39e+06 Memory= 340.488 t=
2.32 R= 4e+05
Depth= 381587 States= 2e+06 Transitions= 1.29e+07 Memory= 570.664 t=
6.15 R= 3e+05
Depth= 381587 States= 3e+06 Transitions= 2.03e+07 Memory= 759.433 t=
9.84 R= 3e+05
Depth= 381587 States= 4e+06 Transitions= 2.58e+07 Memory= 996.543 t=
12.9 R= 3e+05
Depth= 381587 States= 5e+06 Transitions= 3.24e+07 Memory= 1198.496 t=
16.2 R= 3e+05

```

(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction

Full statespace search for:

```

never claim          + (f2)
assertion violations + (if within scope of claim)
acceptance cycles    + (fairness disabled)

```

invalid end states - (disabled by never claim)

State-vector 268 byte, depth reached 381587, errors: 0
 4964551 states, stored (5.67424e+06 visited)
 30548930 states, matched
 36223174 transitions (= visited+matched)
 0 atomic steps
 hash conflicts: 3302413 (resolved)

Stats on memory usage (in Megabytes):

1401.431 equivalent memory usage for states (stored*(State-vector + overhead))
 1179.493 actual memory usage for states (compression: 84.16%)
 state-vector as stored = 221 byte + 28 byte overhead
 128.000 memory used for hash table (-w24)
 53.406 memory used for DFS stack (-m1000000)
 2.638 memory lost to fragmentation
 1358.261 total actual memory usage

unreached in proctype TrafficLight

system.pml:52, state 14, "statuses[(curr-1)] = 1"
 system.pml:53, state 15, "queue[(curr-1)] = 0"
 system.pml:54, state 16, "currentTurn = next"
 system.pml:59, state 21, "firstthirdValue = 0"
 system.pml:63, state 27, "secondValue = 0"
 system.pml:104, state 77, "-end-"
 (6 of 77 states)

unreached in proctype TrafficGenerator

system.pml:115, state 10, "-end-"
 (1 of 10 states)

unreached in init

(0 of 8 states)

unreached in claim f2

_spin_nvr.tmp:141, state 13, "-end-"
 (1 of 13 states)

pan: elapsed time 18.2 seconds

pan: rate 312114.63 states/second

```
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && ((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<>
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<>
(statuses[1])))
```

```

ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<>
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<>
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<>
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<>
(statuses[5])))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml

```

```

pan: ltl formula f3
Depth= 242477 States= 1e+06 Transitions= 5.34e+06 Memory= 321.445 t=
2.13 R= 5e+05
Depth= 381587 States= 2e+06 Transitions= 1.22e+07 Memory= 554.843 t=
5.51 R= 4e+05
Depth= 381587 States= 3e+06 Transitions= 1.81e+07 Memory= 791.855 t=
9.14 R= 3e+05
Depth= 381587 States= 4e+06 Transitions= 2.5e+07 Memory= 993.515 t=
12.6 R= 3e+05
Depth= 381587 States= 5e+06 Transitions= 3.2e+07 Memory= 1194.199 t=
15.9 R= 3e+05
Depth= 381587 States= 6e+06 Transitions= 3.89e+07 Memory= 1390.781 t=
18.8 R= 3e+05

```

(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction

Full statespace search for:

```

never claim          + (f3)
assertion violations  + (if within scope of claim)
acceptance cycles    + (fairness disabled)
invalid end states   - (disabled by never claim)

```

```

State-vector 268 byte, depth reached 381587, errors: 0
5153286 states, stored (6.05171e+06 visited)
33105956 states, matched
39157670 transitions (= visited+matched)
0 atomic steps
hash conflicts: 4105195 (resolved)

```

Stats on memory usage (in Megabytes):

```

1454.709    equivalent memory usage for states (stored*(State-vector +
overhead))
1224.318    actual memory usage for states (compression: 84.16%)
            state-vector as stored = 221 byte + 28 byte overhead
128.000     memory used for hash table (-w24)
53.406      memory used for DFS stack (-m1000000)
2.736       memory lost to fragmentation
1402.988    total actual memory usage

```

unreached in proctype TrafficLight

```

system.pml:52, state 14, "statuses[(curr-1)] = 1"
system.pml:53, state 15, "queue[(curr-1)] = 0"
system.pml:54, state 16, "currentTurn = next"
system.pml:59, state 21, "firstthirdValue = 0"
system.pml:63, state 27, "secondValue = 0"
system.pml:104, state 77, "-end-"
(6 of 77 states)

```

unreached in proctype TrafficGenerator

```

system.pml:115, state 10, "-end-"
(1 of 10 states)

```

unreached in init

```

(0 of 8 states)

```

unreached in claim f3

```

_spin_nvr.tmp:152, state 13, "-end-"
(1 of 13 states)

```

pan: elapsed time 18.9 seconds

pan: rate 319520.27 states/second

```

ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && ((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<>
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<>
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<>
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<>
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<>
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<>
(statuses[5])))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))

```



```

ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml

```

```

pan: ltl formula f4
Depth= 381587 States=      1e+06 Transitions= 5.55e+06 Memory=   346.543 t=
2.64 R=    4e+05
Depth= 381587 States=      2e+06 Transitions= 1.27e+07 Memory=   563.730 t=
6.22 R=    3e+05
Depth= 381587 States=      3e+06 Transitions= 2.02e+07 Memory=   748.984 t=
10.1 R=    3e+05
Depth= 381587 States=      4e+06 Transitions= 2.57e+07 Memory=   986.093 t=
13.1 R=    3e+05
Depth= 381587 States=      5e+06 Transitions= 3.26e+07 Memory=  1185.410 t=
16.4 R=    3e+05
Depth= 381587 States=      6e+06 Transitions= 3.99e+07 Memory=  1373.105 t=
19.8 R=    3e+05

```

(Spin Version 6.5.0 -- 1 July 2019)
 + Partial Order Reduction

Full statespace search for:

```

  never claim          + (f4)
  assertion violations  + (if within scope of claim)
  acceptance  cycles   + (fairness disabled)
  invalid end states   - (disabled by never claim)

```

State-vector 268 byte, depth reached 381587, errors: 0

5227654 states, stored (6.20045e+06 visited)

34841041 states, matched

41041491 transitions (= visited+matched)

0 atomic steps

hash conflicts: 4326582 (resolved)

Stats on memory usage (in Megabytes):

1475.702 equivalent memory usage for states (stored*(State-vector + overhead))

1242.032 actual memory usage for states (compression: 84.17%)
 state-vector as stored = 221 byte + 28 byte overhead

128.000 memory used for hash table (-w24)

53.406 memory used for DFS stack (-m1000000)

2.774 memory lost to fragmentation

1420.664 total actual memory usage

```

unreached in proctype TrafficLight
  system.pml:52, state 14, "statuses[(curr-1)] = 1"
  system.pml:53, state 15, "queue[(curr-1)] = 0"
  system.pml:54, state 16, "currentTurn = next"
  system.pml:59, state 21, "firstthirdValue = 0"
  system.pml:63, state 27, "secondValue = 0"
  system.pml:104, state 77, "-end-"
  (6 of 77 states)
unreached in proctype TrafficGenerator
  system.pml:115, state 10, "-end-"
  (1 of 10 states)
unreached in init
  (0 of 8 states)
unreached in claim f4
  _spin_nvr.tmp:163, state 13, "-end-"
  (1 of 13 states)

pan: elapsed time 20.4 seconds
pan: rate 303794.71 states/second
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && (((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<>
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<>
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<>
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<>
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<>
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<>
(statuses[5])))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml

```

```

pan: ltl formula f5
Depth= 151613 States= 1e+06 Transitions= 5.41e+06 Memory= 311.777 t=
2.31 R= 4e+05
Depth= 381587 States= 2e+06 Transitions= 1.23e+07 Memory= 531.601 t=
5.65 R= 4e+05
Depth= 381587 States= 3e+06 Transitions= 1.86e+07 Memory= 759.433 t=
8.97 R= 3e+05
Depth= 381587 States= 4e+06 Transitions= 2.54e+07 Memory= 962.168 t=
12 R= 3e+05
Depth= 381587 States= 5e+06 Transitions= 3.23e+07 Memory= 1162.265 t=
15 R= 3e+05
Depth= 381587 States= 6e+06 Transitions= 3.93e+07 Memory= 1365.293 t=
18.2 R= 3e+05

```

(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction

Full statespace search for:

```

never claim          + (f5)
assertion violations + (if within scope of claim)
acceptance cycles    + (fairness disabled)
invalid end states   - (disabled by never claim)

```

State-vector 268 byte, depth reached 381587, errors: 0

5458629 states, stored (6.6624e+06 visited)

37915145 states, matched

44577545 transitions (= visited+matched)

0 atomic steps

hash conflicts: 5361079 (resolved)

Stats on memory usage (in Megabytes):

1540.903 equivalent memory usage for states (stored*(State-vector + overhead))

1296.937 actual memory usage for states (compression: 84.17%)
state-vector as stored = 221 byte + 28 byte overhead

128.000 memory used for hash table (-w24)

53.406 memory used for DFS stack (-m1000000)

2.894 memory lost to fragmentation

1475.449 total actual memory usage

unreached in proctype TrafficLight

system.pml:52, state 14, "statuses[(curr-1)] = 1"

system.pml:53, state 15, "queue[(curr-1)] = 0"

system.pml:54, state 16, "currentTurn = next"

system.pml:59, state 21, "firstthirdValue = 0"

system.pml:63, state 27, "secondValue = 0"

system.pml:104, state 77, "-end-"

(6 of 77 states)

unreached in proctype TrafficGenerator

system.pml:115, state 10, "-end-"

(1 of 10 states)

```

unreached in init
  (0 of 8 states)
unreached in claim f5
  _spin_nvr.tmp:174, state 13, "--end--"
  (1 of 13 states)

pan: elapsed time 20.4 seconds
pan: rate 325949.12 states/second
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && ((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<>
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<>
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<>
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<>
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<>
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<>
(statuses[5])))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml

```

```

pan: ltl formula f6
Depth= 345523 States= 1e+06 Transitions= 5.37e+06 Memory= 335.507 t=
2.4 R= 4e+05
Depth= 381587 States= 2e+06 Transitions= 1.26e+07 Memory= 568.125 t=
6.37 R= 3e+05
Depth= 381587 States= 3e+06 Transitions= 1.88e+07 Memory= 783.359 t=
9.34 R= 3e+05
Depth= 381587 States= 4e+06 Transitions= 2.56e+07 Memory= 985.410 t=

```

```
12.5 R= 3e+05
Depth= 381587 States= 5e+06 Transitions= 3.23e+07 Memory= 1189.316 t=
15.8 R= 3e+05
```

```
(Spin Version 6.5.0 -- 1 July 2019)
+ Partial Order Reduction
```

Full statespace search for:

```
never claim          + (f6)
assertion violations  + (if within scope of claim)
acceptance cycles    + (fairness disabled)
invalid end states   - (disabled by never claim)
```

```
State-vector 268 byte, depth reached 381587, errors: 0
 5003078 states, stored (5.7513e+06 visited)
30748014 states, matched
36499312 transitions (= visited+matched)
    0 atomic steps
hash conflicts: 3315419 (resolved)
```

Stats on memory usage (in Megabytes):

```
1412.307 equivalent memory usage for states (stored*(State-vector +
overhead))
1188.693 actual memory usage for states (compression: 84.17%)
          state-vector as stored = 221 byte + 28 byte overhead
128.000 memory used for hash table (-w24)
 53.406 memory used for DFS stack (-m1000000)
  2.658 memory lost to fragmentation
1367.441 total actual memory usage
```

unreached in proctype TrafficLight

```
system.pml:52, state 14, "statuses[(curr-1)] = 1"
system.pml:53, state 15, "queue[(curr-1)] = 0"
system.pml:54, state 16, "currentTurn = next"
system.pml:59, state 21, "firstthirdValue = 0"
system.pml:63, state 27, "secondValue = 0"
system.pml:104, state 77, "-end-"
(6 of 77 states)
```

unreached in proctype TrafficGenerator

```
system.pml:115, state 10, "-end-"
(1 of 10 states)
```

unreached in init

```
(0 of 8 states)
```

unreached in claim f6

```
_spin_nvr.tmp:185, state 13, "-end-"
(1 of 13 states)
```

pan: elapsed time 18.2 seconds

pan: rate 316353.03 states/second

```
ltl s1: [] (! ((statuses[0]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl s2: [] (! ((statuses[1]) && ((statuses[2]) || (statuses[4]))))
ltl s3: [] (! ((statuses[2]) && (((statuses[0]) || (statuses[1])) ||
```

```

(statuses[4])) || (statuses[5]))))
ltl s4: [] (! ((statuses[3]) && (((statuses[5]) || (statuses[0])) ||
(statuses[4]))))
ltl s5: [] (! ((statuses[4]) && (((((statuses[2]) || (statuses[1])) ||
(statuses[3])) || (statuses[0])) || (statuses[5]))))
ltl s6: [] (! ((statuses[5]) && (((statuses[2]) || (statuses[3])) ||
(statuses[4]))))
ltl l1: [] ((! (((queue[0]==1)) && (! (statuses[0])))) || (<>
(statuses[0])))
ltl l2: [] ((! (((queue[1]==1)) && (! (statuses[1])))) || (<>
(statuses[1])))
ltl l3: [] ((! (((queue[2]==1)) && (! (statuses[2])))) || (<>
(statuses[2])))
ltl l4: [] ((! (((queue[3]==1)) && (! (statuses[3])))) || (<>
(statuses[3])))
ltl l5: [] ((! (((queue[4]==1)) && (! (statuses[4])))) || (<>
(statuses[4])))
ltl l6: [] ((! (((queue[5]==1)) && (! (statuses[5])))) || (<>
(statuses[5])))
ltl f1: [] (<> (! (statuses[0])))
ltl f2: [] (<> (! (statuses[1])))
ltl f3: [] (<> (! (statuses[2])))
ltl f4: [] (<> (! (statuses[3])))
ltl f5: [] (<> (! (statuses[4])))
ltl f6: [] (<> (! (statuses[5])))
  the model contains 18 never claims: f6, f5, f4, f3, f2, f1, l6, l5, l4,
l3, l2, l1, s6, s5, s4, s3, s2, s1
  only one claim is used in a verification run
  choose which one with ./pan -a -N name (defaults to -N s1)
  or use e.g.: spin -search -ltl s1 system.pml

```

Conclusion

Successfully proved that the system works perfectly: vehicles and pedestrians will never crash and eventually will proceed to their destination without any traffic light eternally being green.