ICTEAM seminar

Formal Verification of Railway Interlocking

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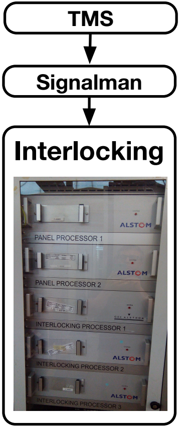
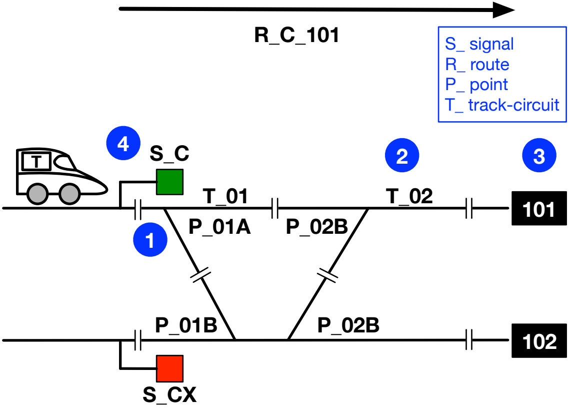
20 November 2017

Elements of railway signaling (e.g., signals, points, LX, . . .)

Interlocking context





S_ signal
R_ route
P_ point
T_ track-circuit

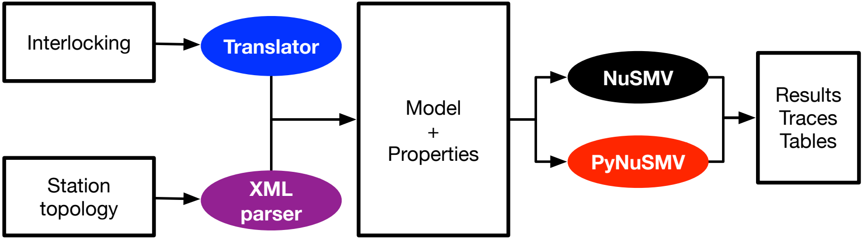
Research subject

```
*Q_R(C_101)
  if  R_C_101 xs
    P_01A cfn , P_01B cfn,
        P_02AB cfr, P_02B cfr
    U_IR(01A) f , U_IR(02B) f
  then  R_C_101 s
    P_01A cn , P_01B cn , P_02A
        cr , P_02B cr ,
    U_IR(01A)  l , U_IR(02B) l
    U_CBSPA(101) l
    S_C clear bpull
```

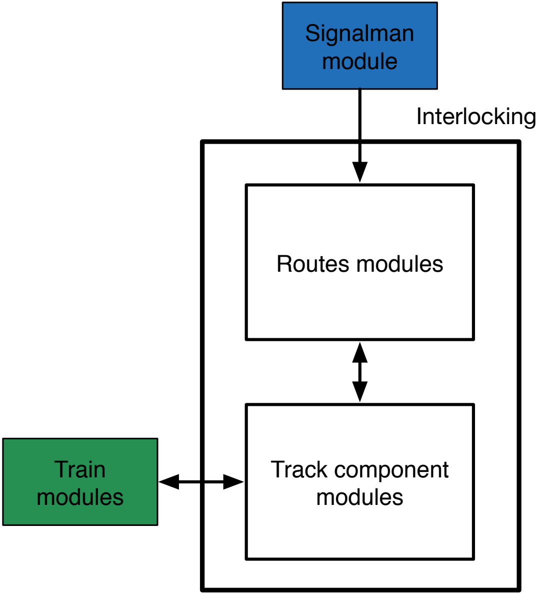
V&V:

- Combinatorial testing
- ≥ 2 month/int.
- Tedious job
- Error prone

Process of verification



Model - high level hierarchy



Model checking - Formal foundations

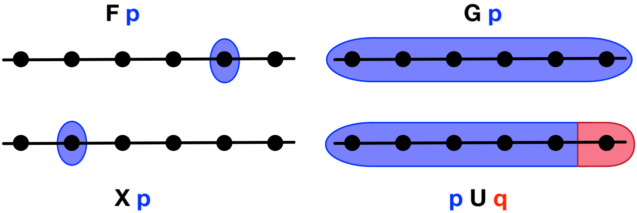
Model checking [2] Given a model of a system, exhaustively and automatically check whether this model meets a given property.

$$M, s \models P \text{ with } P \text{ a property}$$

[1] define a **Kripke structure** over AP as a 4-tuple $M = (S, I, R, L)$ consisting of:

- a finite set of states S.
- a set of initial states $I \subseteq S$.
- a transition relation $R \subseteq S \times S$ (i.e., $\forall s \in S \; \exists s' \in S$ such that $(s, s') \in R$).
- a labeling function $L : S \rightarrow 2AP$ with AP a set of atomic propositions.

Properties (MC [4], invariants, temporal logic (e.g.; LTL)



```
   INVARSPEC !(train_collision)
   INVARSPEC (train_on_switch -> !switch_moves)
   LTLSPEC   G(train_enters -> X signal_goes_red)
```

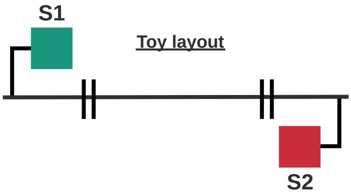
A toy example

```
MODULE main
VAR
S1 : {red, green};
S2 : {red, green};

ASSIGN
init(S1) := red;
init(S2) := red;

next(S1) :=
 case
  S1 = red : {red, green};
  TRUE     : red;
 esac;
next(S2) :=
 case
  S2 = red : {red, green};
  TRUE     : red;
 esac;

--INVARSPEC !(S1 = green &
     S2 = green)
```



A toy example

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  S2 = red  : {red, green};
  TRUE      : red;
 esac;

--INVARSPEC !(S1 = green &
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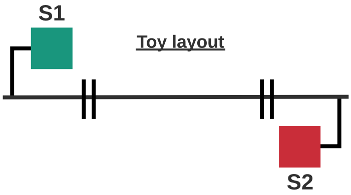
```



```
nuXmv > check_invar
-- invariant !(S1 =
    green & S2 = green)
      is false
Trace Type:
    Counterexample
  -> State: 1.1 <-
    S1 = red
    S2 = red
  -> State: 1.2 <-
    S1 = green
    S2 = green
```

Conclusions and questions

- From Interlocking to model in SMV
  - Namêche
  - Braine l'Alleud
  - Ottignies
- Compositional approach for larger stations [3]
- Bottleneck → Space state explosion

→ **Questions**

Biblio

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