Simulation of Urban Train Systems with Regulation
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Regulation

Metro operators are committed to quality of service: punctuality (w.r.t. fixed schedules), regularity of trains, nb. users transported. ...

**Incidents** cause **delays** in trains operation. Small to medium delays can be recovered by application of regulation techniques:
- increase trains speed,
- reduce dwell times…

**But:**
- Metro architecture influences performance
- Regulation is part of the design of a line
- QOS objectives differ for each project
- No a priori clue to choose a regulation algorithm or set its parameters

Need for **evaluation & early decision tools**

SIMSTORS[3,4]

A simulator for regulated train systems. The heart of the software is a variant of **Stochastic Time Petri nets**[2]

- with ad-hoc semantics, and
- random distributions over trip times, dwell times, and incidents

**Results**

- A **formal** design framework
- A fully operational **simulator** : SIMSTORS
  - case study: **Santiago Line 1** with early recovery regulation algorithm
  - Fast **symbolic** simulation:
    - 4 hours of operation/50 trains/24 stations in 19s.

**Objective**

- Success story for a concurrent stochastic timed DES model
- Ongoing transfer at ALSTOM

**T-Plan**

Adaptation of bus bunching avoidance[1] techniques to urban train systems.

Regulation seen as **event based control**

Simplified problem: ring topologies

Optimal command = optimal speeds

Future Directions

- Complex topologies: forks, shuffled lines, insertion, extraction…
- Toward higher-level control, directed by objectives (rescheduling of missions, partial line closures, fast train extraction…)

References


Objectives

Regulation is largely automated: several **algorithms** can be used

But:
- Metro architecture influences performance
- Regulation is part of the design of a line
- QOS objectives differ for each project
- No a priori clue to choose a regulation algorithm or set its parameters

Need for **evaluation & early decision tools**

Contribution of SUMO

- Use of formal methods and concurrency models to evaluate and compare performance of regulation algorithms
- bunching avoidance
  - Optimal control in feedback loops
- Development of simulation tools

Industrial Context

Joint research lab between **INRIA** and **ALSTOM**

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**Project P22**
Regulation Policies in Urban Rail Systems

CIFRE Grant (2015-2018)

Ongoing transfer of results to **ALSTOM**

Future Directions

- Validation of the model with complex scenarios, multiple regulation algorithms
- Finer simulation of train interactions in interstation zones
- From performance evaluation to advice on best strategy to apply
- Optimal control w.r.t. quality criteria
- Application for planning

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P22 : Regulation Policies for Urban Train Systems – ALSTOM & INRIA, SUMO