Advanced Modelling, Simulation and Verification for Future Traffic Regulation Optimisation

(project paper)

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The SafeCap Approach

We are developing an approach that relies on formal models of the railway domain that allow the study of

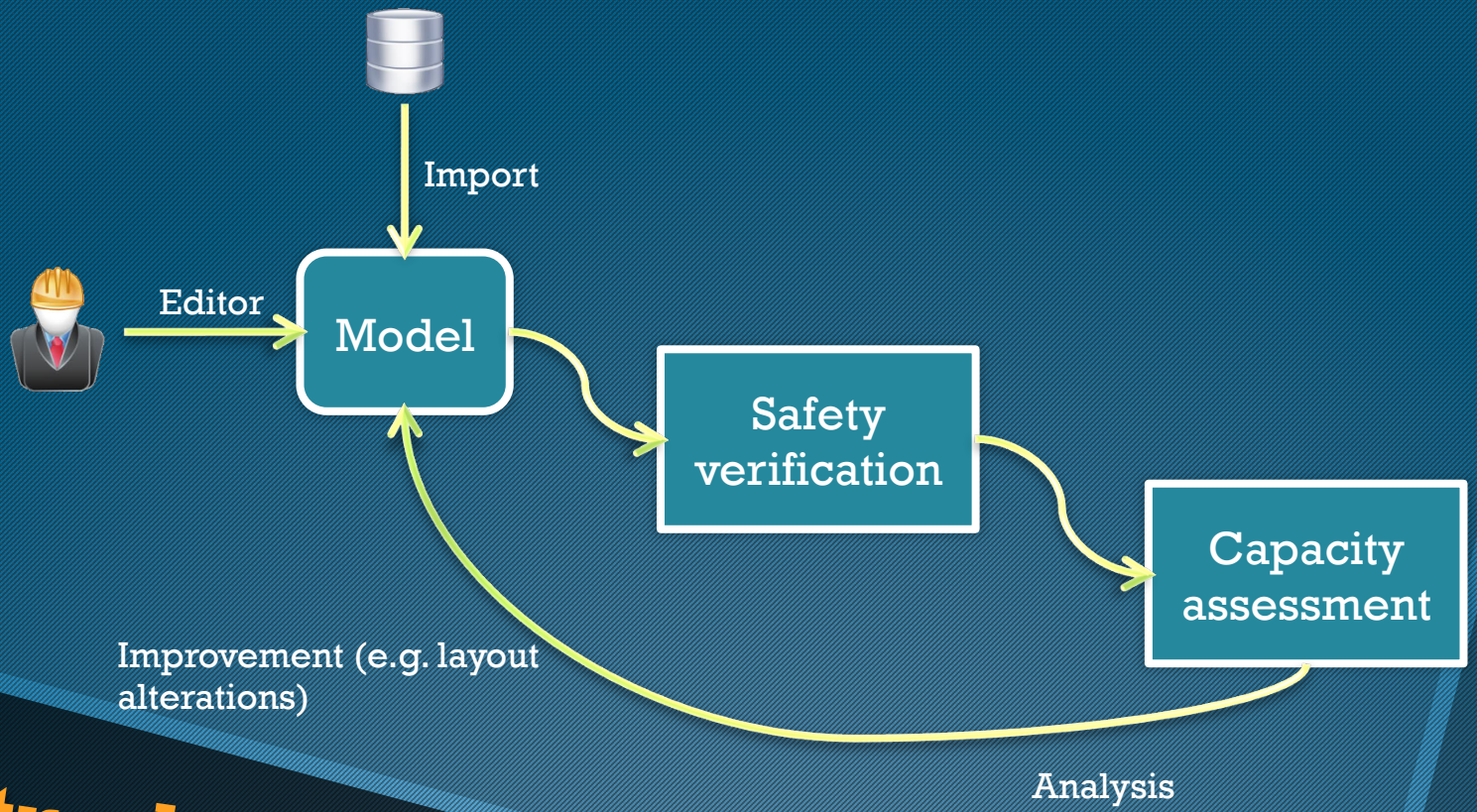
- safety and
- capacity

in an integrated way

It was initially proposed in the SafeCap project on *Overcoming the railway capacity challenges without undermining rail network safety*

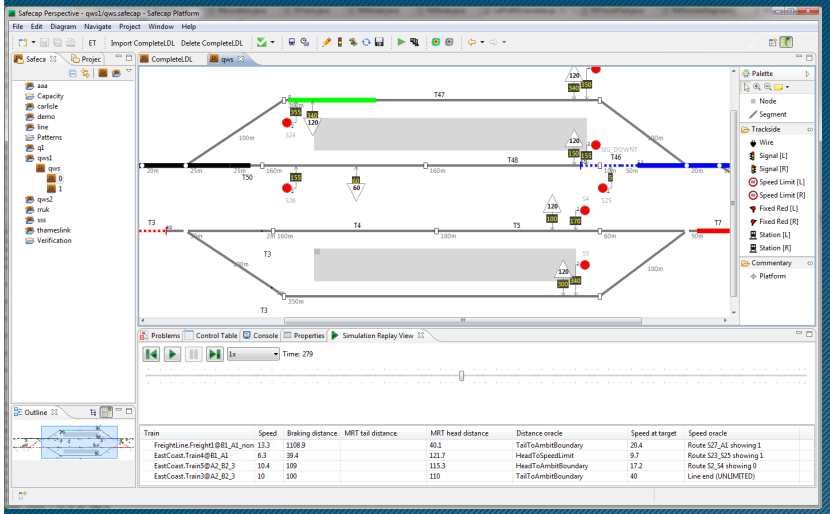
Introduction

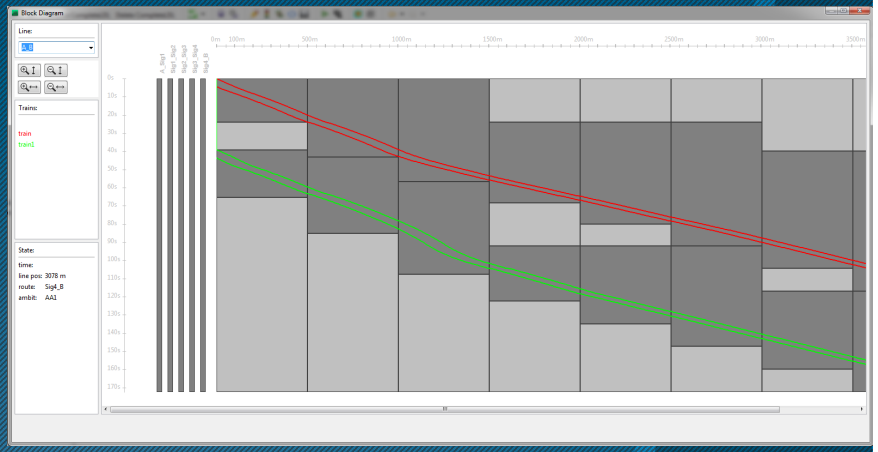
The SafeCap Method

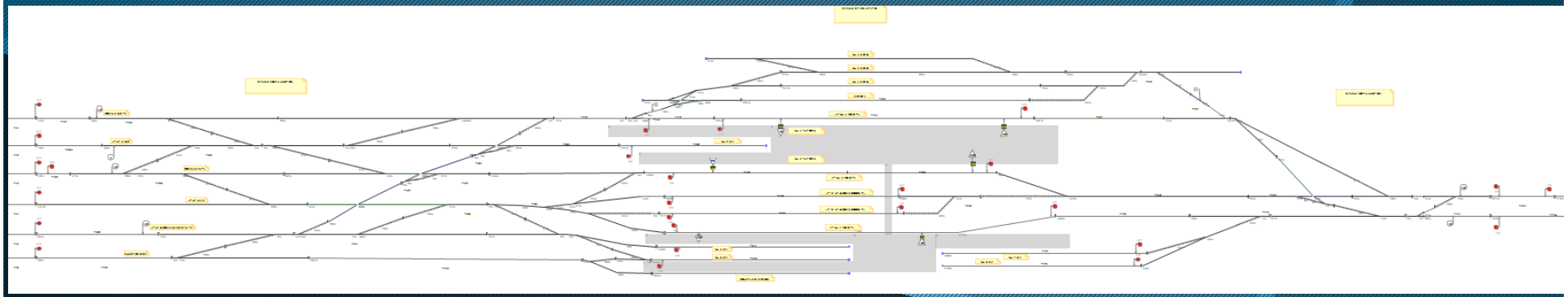


Introduction

The SafeCap Toolset







Introduction

New challenges

- Integrated modelling/verification at different system levels
- Efficient and scalable simulation and verification
- Reasoning about capacity/energy consumption and their interplay
- The heterogeneous nature of these systems
- Powerful tool support for efficient dealing with disturbances of different nature
- (Always) ensuring system safety

The SafeCap for FuTRO project

The aim is to develop novel modelling techniques and tools that support and explore integrated and efficient dynamic capacity and energy of networks and nodes while ensuring whole systems safety

Dates: 1/09/2014 – 31/10/2016

Funds: Rail Safety and Standards Board

Consortium: **Newcastle University (UK)**

School of Computing Science &

NewRail Research Centre

Siemens Rail Automation

About

Objectives

- To support independent control rules for multiple mixed traffic operation scenarios
- To compute real-time optimum strategies for traffic flow at nodes
- To model the energy usage impact on performance of real-time optimum strategies for traffic flow at nodes
- To define a whole systems modelling approach to integrated capacity, safety and energy strategies at multiple nodes scaling up to a regional network

About

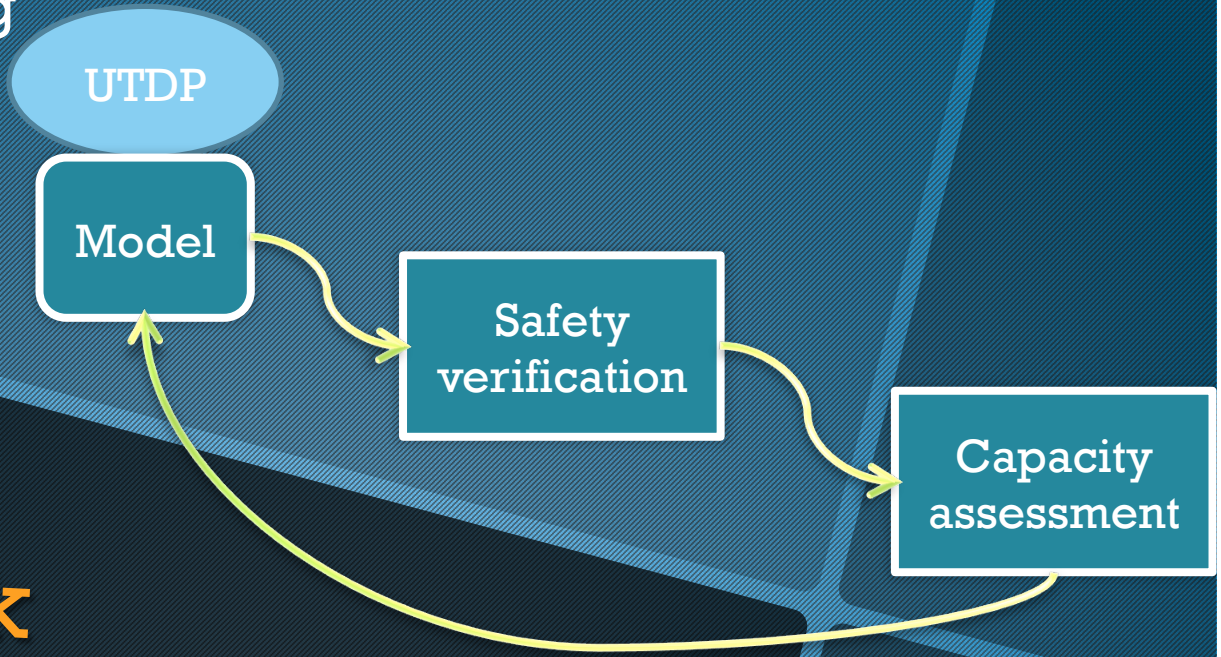
Mixed traffic modelling and verification

Capturing the logic of out-dated, modern and emerging signalling and train operation principles and allowing reasoning about system safety, capacity and energy consumption

Ongoing work

Unified train driving policy

- A formal language that captures in a uniform manner the concepts that are treated separately: track topology and gradients, signalling, fixed speed regime, platform assignment, dynamic re-routing, train dwelling times, etc.
- It allows definitions of all existing signalling techniques, including
  - route-based
  - ERTMS 3



Ongoing work

Advisory system

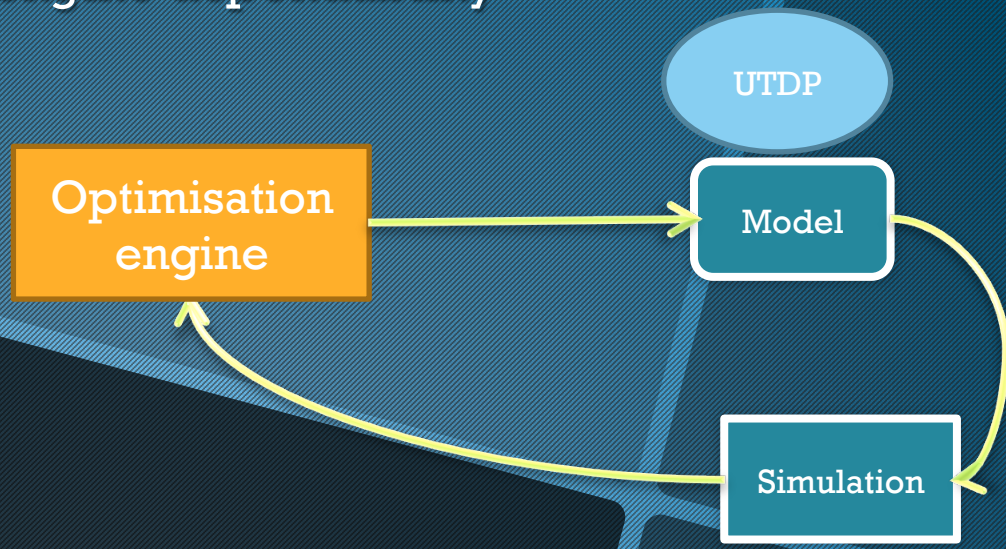
We are now working on developing an ultra-fast high-fidelity large-scale railway simulation that can be used in runtime for traffic optimisation

Dealing with disturbances (run-time changes) in a safe and optimal manner

Ongoing work

Optimisation engine

- Fast simulator (~10^4 simulations per second)
- Alterations to schedules, priorities, speed limits, etc.
- Could be used for any target function (energy, stability, maximal capacity)
- Real-time optimisation:
  - Parallelisation in GPUs and engine dependability
  - AI



Ongoing work

Modelling Energy

The impact of energy on capacity (performance) without undermining safety

Our previous work: on evaluating the energy consumption for different node layouts and service patterns

Ongoing work

Energy Optimisation

- Aqualitative model to capture train energy expenditure
- Energy consumption as an optimisation criterion
- Strategies for optimal regenerative braking
- Energy-aware signalling and the automatic train operation technology (ATO).

- Extensions of the SafeCap Eclispe-based environemnt

Ongoing work

Whole System Modelling

Complexity of railway systems

- multiple layers
- multiple stakeholders
- different QoS criteria
- multiple methods and tools for modelling (microscopic, macroscopic) with very poor inter-operability

Scalability, scoping, compositional reasoning, abstractions

Ongoing work

Whole-system modelling

- Develop a modelling layer to combine railway nodes into local and regional railway networks
- Design of a provably correct compositional approach to safety verification and capacity assessment
- Analyse macro- and microscopic capacity consumption and investigation of causal links of performance bottlenecks
- Investigate the connections with other railway operation activities: staff allocation, maintenance, etc.

Ongoing work

SE and CS

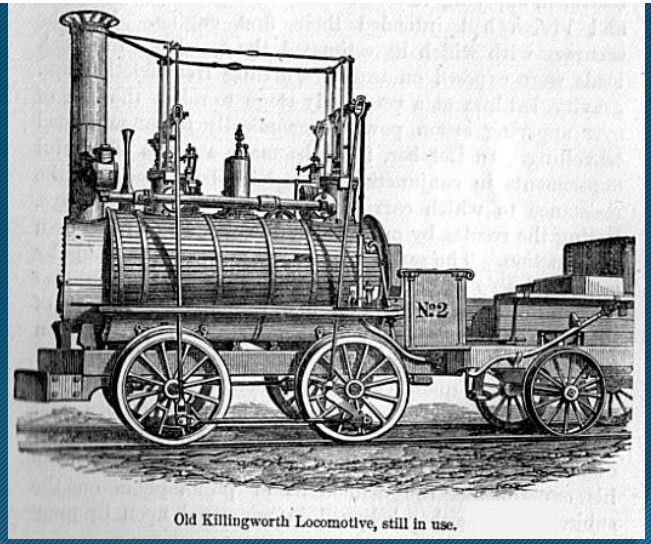
- scalable and efficient safety verification
- domain-specific modelling
- open-source extendable tool support
- scalable and dependable GPU-based parallelisation of complex computation in the railway domain
- artificial intelligence for the run time decisions
- integrated modelling of energy consumption and system capacity
- development of formal foundation for reasoning about complex railway systems

Software Engineering

Resilience of railway systems

- Verified safety
- Dealing with disturbances (changes) in a safe and optimal manner
- Energy and capacity optimisation without undermining safety
- Moving to using the artifacts from the SafeCap modelling for certification

Resilience



Old Killingworth Locomotive, still in use.

SafeCap

More info, documentation, videos, examples & tool download:

safecap.sourceforge.net

www.safecap.co.uk