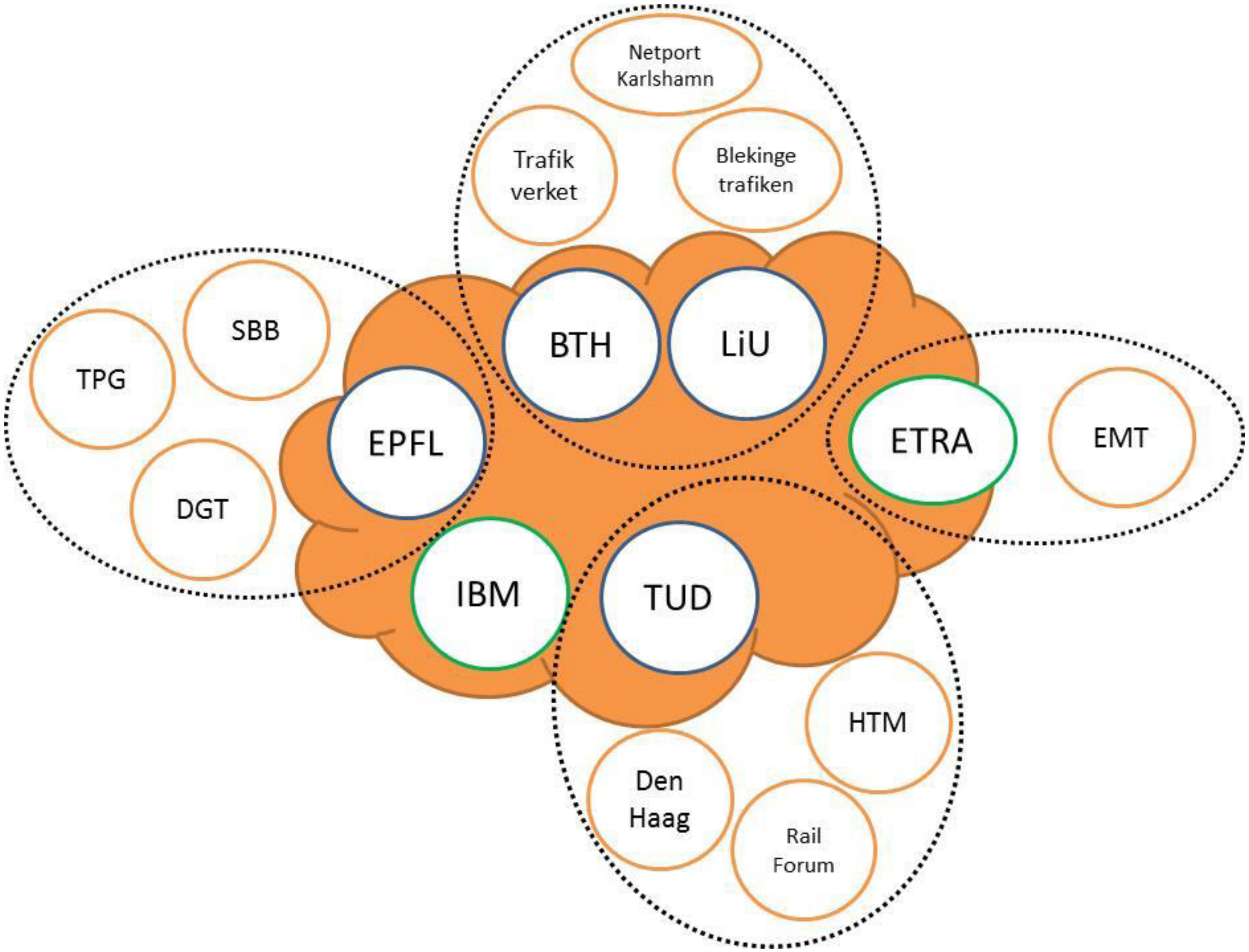
KAJT day 2018

TRANS-FORM – Smart transfers through unraveling urban form and travel flow dynamics

Sai Prashanth Josyula, Johanna Törnquist Krasemann

Blekinge Institute of Technology, Sweden

About TRANS-FORM



Source: https://www.bth.se/wp-content/uploads/2017/10/Transform.png

About TRANS-FORM

- Granted in the ERA-NET Co-fund Smart Cities and Communities (ENSCC) call.
- Scope: 3 years.
- Budget: 1.8 million € for the six participating organizations.

Project Goals:

- To better understand transferring dynamics in multi-modal public transport systems.
- To develop insights, strategies and methods for decision-making in public transport.

- **A data-driven decision making tool.**
- **Behavioral modelling +**
  Passenger flow forecasting +
  Network state predictions +
  Real-time operations (e.g. Real-time train rescheduling).

Punctuality of trains

Importance of punctuality:

One of the main goals of the Swedish railway industry:

By year 2020, 95% of all trains should arrive at the latest within five minutes of the initially planned arrival time (Trafikverket Annual Report 2015).

Factors affecting punctuality:

(1) the occurrence of disturbances,

(2) the robustness of the train schedules and the associated ability to recover from delays,

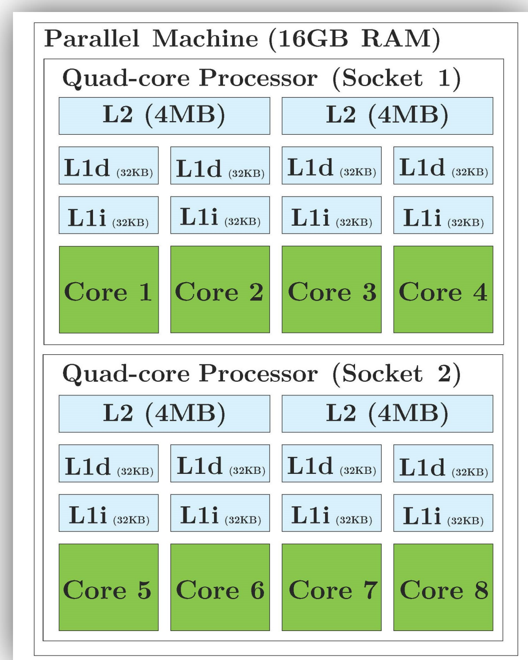
(3) the ability to effectively reschedule trains when disturbances occur, so that delays are minimized.

Challenges:

- The railway traffic rescheduling problem is a complex task to solve.
- Practical problems have very large search space.
- Time-consuming to solve even for state-of-the-art optimization solvers.

Advances in computer hardware (Multi-core processors)

- Advances in computer hardware have made powerful multi-core processors affordable and commonly available.
- To make best use of available processor cores, efficient parallel algorithms must be designed!
- Commercial solvers (e.g. Gurobi) have been designed to make use of multi-core processors.



Parallelizing an algorithmic approach (Real-time Train Rescheduling)

- Not much research that explores the opportunities and challenges in parallelizing the algorithmic approaches for real-time railway rescheduling.

Purpose of our research:
To design and implement an algorithm in order…

- To benefit from the advances in computer hardware.
- To compute relevant alternative revised schedules of good quality faster.
- To support the train traffic dispatchers in the real-time decision-making.

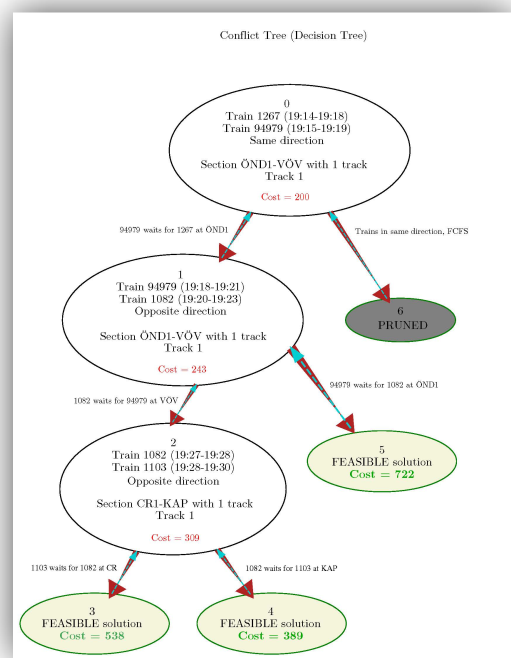
The algorithm serves to act as a computational **support** for the dispatchers and **suggest alternative** re-scheduling and management actions.

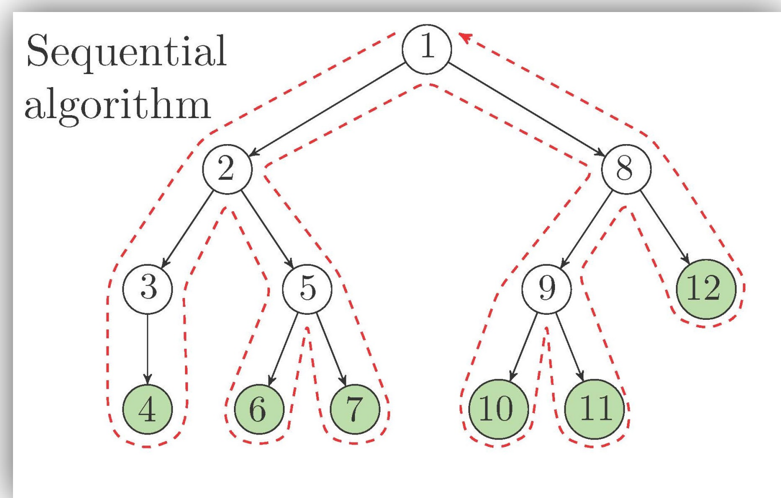
Research at BTH

We devised:

(1) an effective way to represent the solution space as a binary tree.

(2) a sequential heuristic algorithm based on a depth-first search (DFS) strategy that quickly traverses the tree.

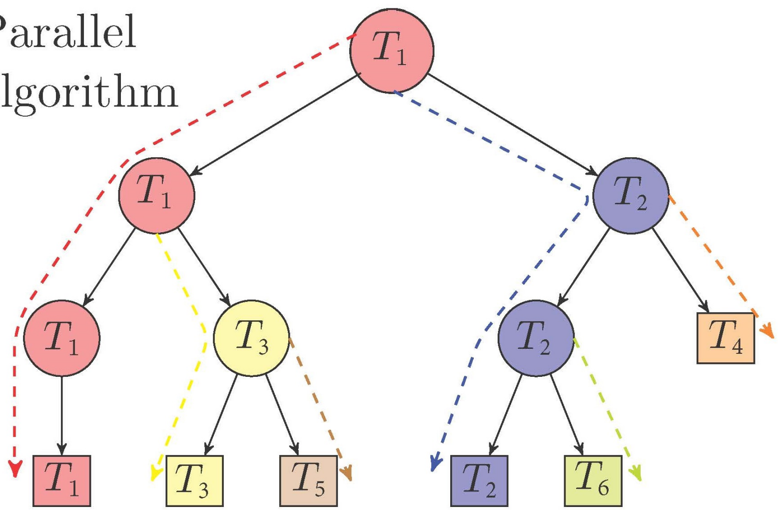




Research at BTH

(3) A parallel train rescheduling algorithm for a multi-core architecture.

Parallel algorithm



A Parallel Algorithm for Train Rescheduling

Sai Prashanth Josyula[a], Johanna Törnquist Krasemann[a], Lars Lundberg[a]

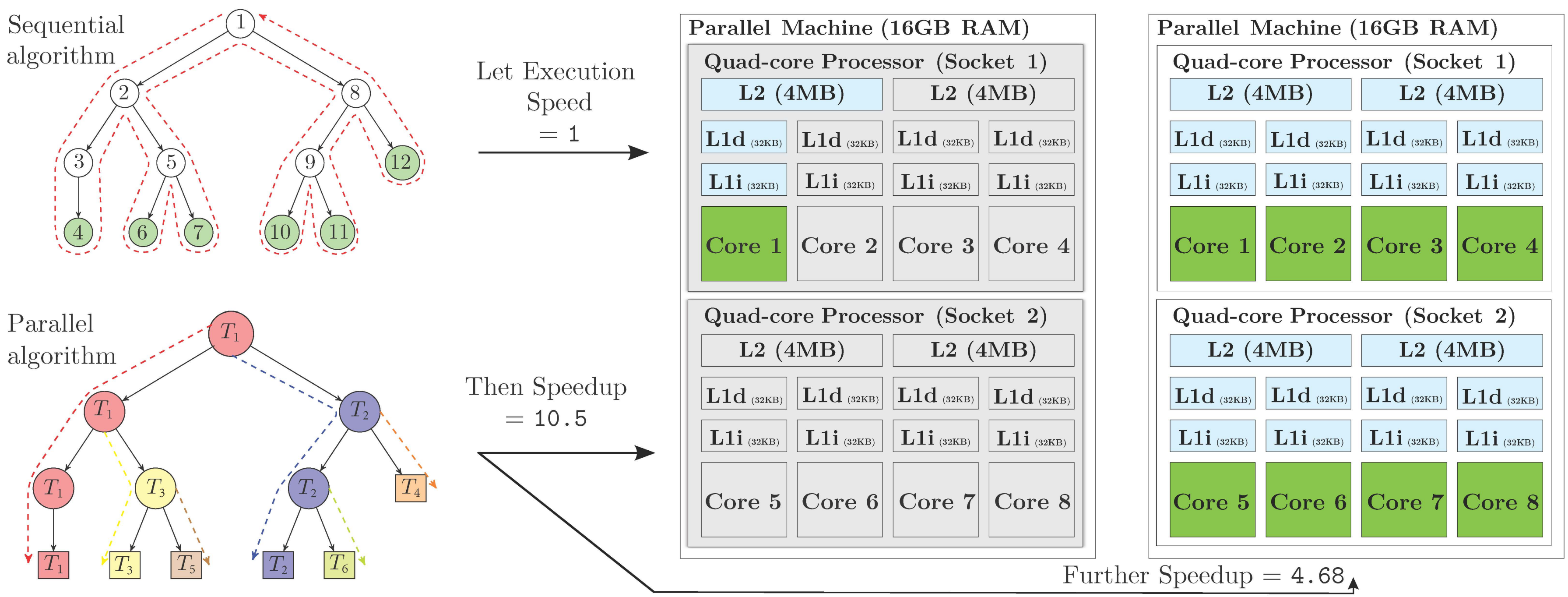
[a]*Department of Computer Science, Blekinge Institute of Technology, Valhallavägen 1, 371 41 Karlskrona, Sweden.*

Abstract

One of the crucial factors in achieving a high punctuality in railway traffic systems, is the ability to effectively reschedule the trains when disturbances occur. The railway traffic rescheduling problem is a complex task to solve both from a practical and a computational perspective. Problems of practically relevant sizes have typically a very large search space, making them time-consuming to solve even for state-of-the-art optimization solvers. Though competitive algorithmic approaches are a widespread topic of research, not much research has been done to explore the opportunities and challenges in parallelizing them. This paper presents a parallel algorithm to efficiently solve the real-time railway rescheduling problem on a multi-core parallel architecture. We devised (1) an effective way to represent the solution space as a binary tree and (2) a novel sequential heuristic algorithm based on a depth-first search (DFS) strategy that quickly traverses the tree. Based on that, we designed a parallel algorithm for a multi-core architecture, which proved to be 10.5 times faster than the sequential algorithm even when run on a single processing core. When executed on a parallel machine with 8 cores, the speed further increased by a factor of 4.68 and every disturbance scenario in the considered case study was solved within 6 seconds. We conclude that for the problem under consideration, a sequential DFS approach though is fast in several disturbance scenarios, is notably slower in many other disturbance scenarios. The parallel DFS approach that combines a DFS with simultaneous breadth-wise tree exploration, while being much faster on an average, is also consistently fast across all scenarios.

Index terms— Railway traffic, Rescheduling, Parallel Depth-first search, Optimization.

Results of recently concluded work



Ongoing Work…
Graphics Processing Units (GPUs)

- Used for achieving massive speedups for several optimization problems.
- But… GPUs are designed for identical calculations on different data.

- Not well-suited for solvers like Gurobi (Dr. Greg Glockner, Gurobi).
- Yet… Parallel algorithmic approaches to train rescheduling on the GPU are possible!

Thank you!

Contact:

sai.p.josyula@bth.se

For further details about the TRANS-FORM project, please visit:

http://www.trans-form-project.org