VSB TECHNICAL UNIVERSITY OF OSTRAVA | IT4INNOVATIONS NATIONAL SUPERCOMPUTING CENTER

Sygic

Traffic Flow Optimization in Smart Cities

Leveraging HPC Resources for Automatic Design Space Exploration

Martin Šurkovský, Jakub Beránek, Kateřina Slaninová, Jan Martinovič (IT4Innovations, VSB - Technical University of Ostrava), Radim Cmar (Sygic)

Concept and Approach

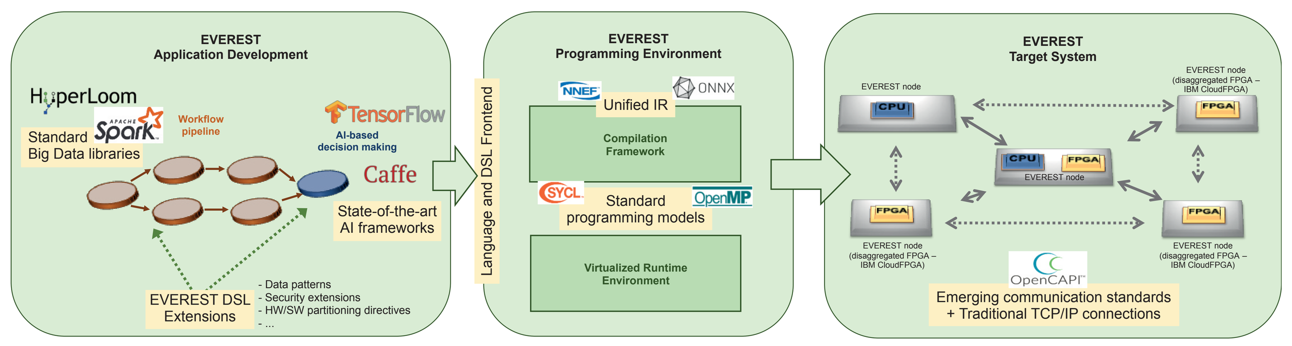
EVEREST focuses on High Performance Big Data Analytics (HPDA) applications.

- Future Big Data systems will be data-driven.
- Complex heterogeneous and reconfigurable architectures are difficult to program.

The EVEREST project aims at developing a holistic approach for co-designing computation and communication in a heterogeneous, distributed, scalable, and secure system for HPDA.

Main features:

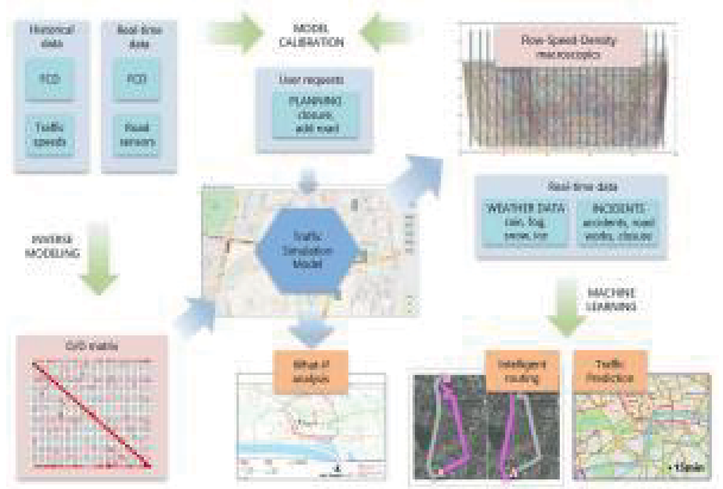
- Combination of compiler transformations, high-level synthesis, and memory management;
- Efficient monitoring of the execution with a virtualization-based environment.



EVEREST proposes a design environment that combines state-of-the-art, stable programming models, and emerging communication standards with novel and dedicated domain-specific extensions.

Application Use Case: Advanced Traffic Modeling for Smart Cities

Sygic provides the mobility platform for supporting cities with advanced traffic modeling. The platform absorbs big data and deploys traffic services.



Data Sources

- Origin-destination matrix (ODM) defining mobility of daily commuters across the city grid;
- Historical and real-time Floating car data (FCD) from navigation devices defining GPS position, timestamp, speed and bearing (typically with 5 second period);
- Road network graph including road restrictions;
- Historical weather data (temperature, precipitation).

Traffic Services

- What-if traffic analysis for a given hypothetical scenario, such as road closure;
- Intelligent routing for a large amount of vehicles towards a global optimum;
- Traffic prediction for major road elements of cities.

Deterministic Traffic Simulator

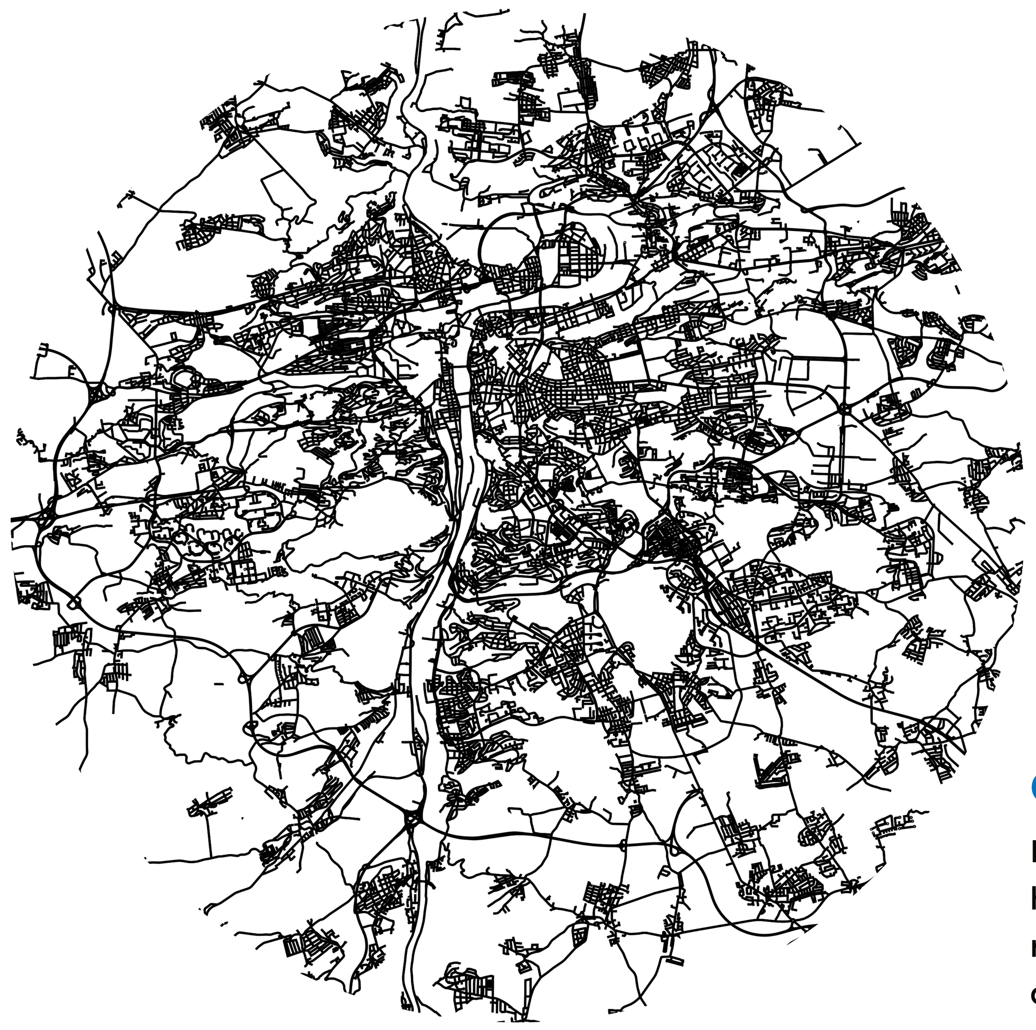
- Simulates movement of vehicles over the routing network.
- Each vehicle moves in regular time steps and for every step the route is computed again from the current position.
- Reproducible simulations; simulation with the same input parameters produces the same result.
- Open sourced at GitHub
- Written in Python with compute intensive algorithms in Rust

Origin/Destination Matrix

- Anonymized mobility data provided by T-Mobile operator.
- O/D matrix calibrated by the mobility data. Contains 36298 records covering time interval from 7 AM to 10 AM at Jun 6 2021.

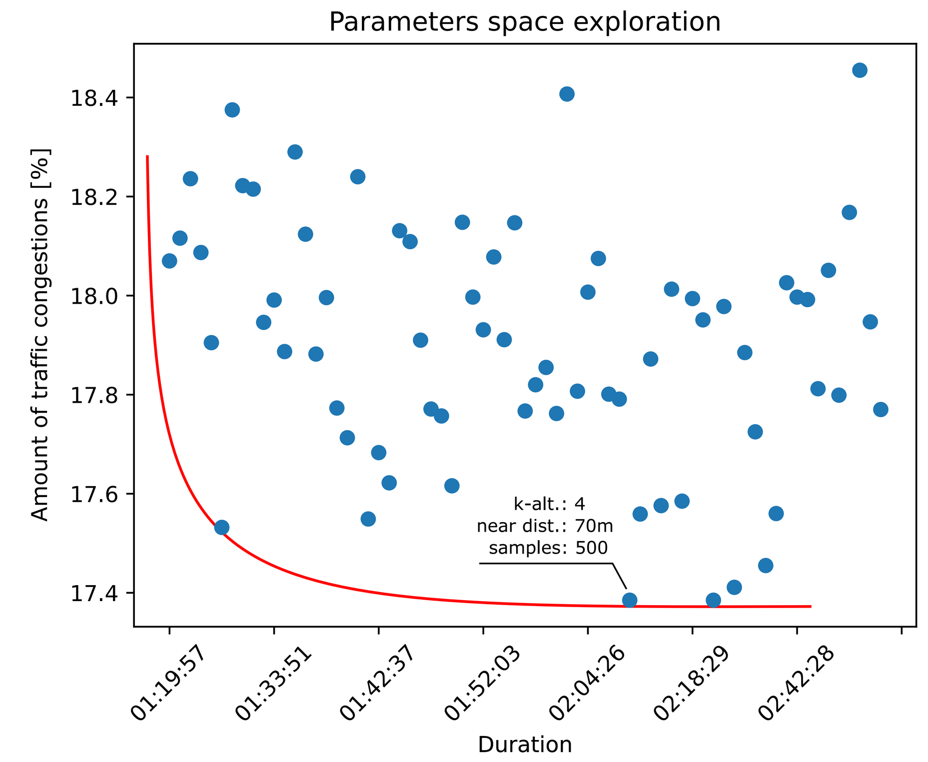
Routing Network

- The simulations were performed in Prague, Czech Republic and its neighborhoods (Central Bohemian region)
- The size of routing graph is: 29,729 nodes and 69,450 edges.
- Benchmark with setting is available at Zenodo.



Simulator's Parameter Space Exploration

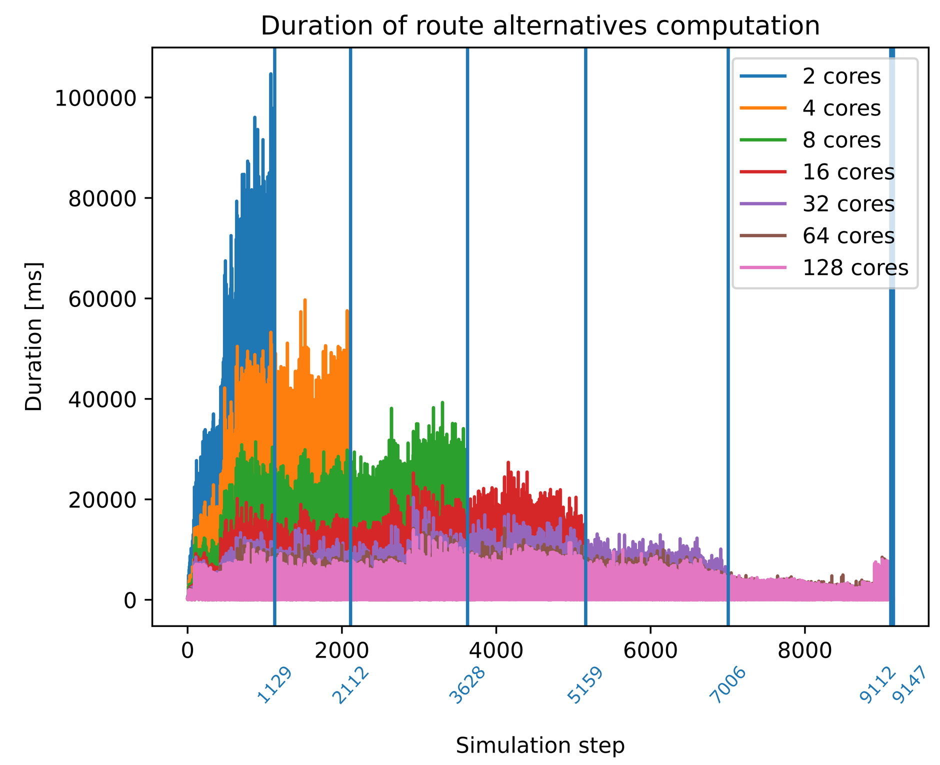
- The input parameters can influence the results in terms of quality and performance.
- To find the appropriate simulator's settings is not straightforward.
- 75 simulations for different variants of input parameters.
- Orchestration of the simulations on HPC cluster done by HyperQueue.
- The results can be seen in Graph 1. The red line outlines the most appropriate input settings. Setting above the line are worse in quality or performance.



Graph 1. Parameters space exploration

Scalability

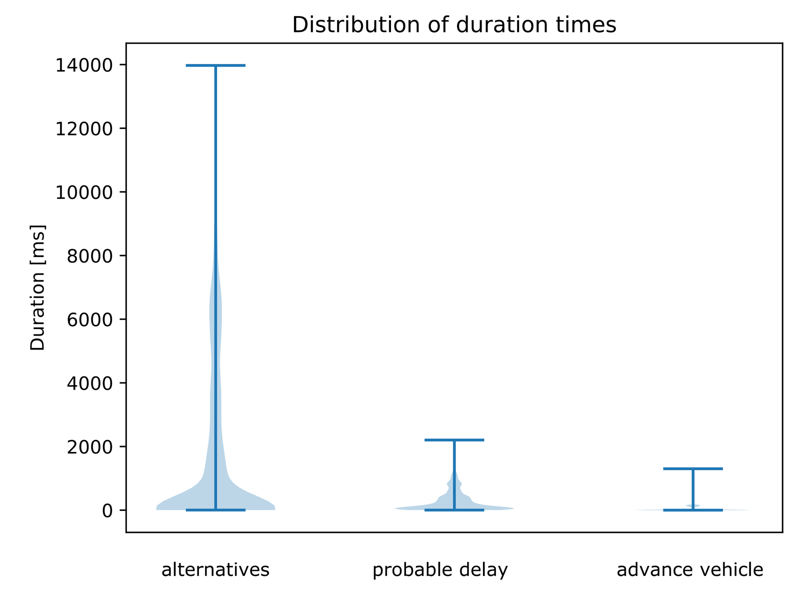
- With the most appropriate setting we have performed the scalability experiment.
- We have run 7 simulations with the use of 128, 64, 32, 16, 8, 4, and 2 cores and measure the duration of alternative route computation as it is the most demanding part.
- All the variants run for the same amount of time. The results can be seen in Graph 2.
- The simulator scales up to 64 cores. But this is influenced by the amount of active vehicles in one step. The benchmark contains 1269 active vehicles at a peak.
- The overall performance is also influenced by the input data, particularly the length of routes; the longer routes the longer the simulation.



Graph 2. Duration of route alternatives computation

Performance Profiling

- Profiling of PTDR (Probabilistic Time Dependent Routing) algorithm.
- Three step algorithm:
  1. Compute route alternatives
  2. Rank the alternative (compute probable delay)
  3. Move the vehicle on a chosen route
- Results in Graph 3.



Graph 3. Distribution of duration times

Conclusion

Based on the simulator's parameter space exploration the most appropriate settings for the simulator was identified. With this setting we have also performed a test of scalability. The algorithm would most likely scale up with higher number of vehicles in the routing network. The route alternatives algorithm is a good candidate for porting it to Rust to improve the performance. Future work is focused on optimizing most demanding parts of the simulators with help of new accelerators such as FPGAs using EVEREST SDK.

GRANT NUMBER: 957269
TOPIC: ICT-51-2020 – BIG DATA TECHNOLOGIES AND EXTREME-SCALE ANALYTICS
FUNDING SCHEME: RIA

START: 1 October 2020
END: 30 September 2023
EU FUNDING: 5 037 372,50 EUR

EVEREST

DESIGN ENVIRONMENT FOR EXTREME-SCALE BIG DATA ANALYTICS ON HETEROGENEOUS PLATFORMS

WWW.EVEREST-H2020.EU
EVEREST-INFO@A.ALARI.CH
WWW.LINKEDIN.COM/COMPANY/EVEREST-H2020
WWW.FACEBOOK.COM/EVERESTH2020

PROJECT COORDINATOR: CHRISTOPH HAGLEITNER (IBM ZURICH) | **SCIENTIFIC COORDINATOR:** CHRISTIAN PILATO (POLITECNICO DI MILANO)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957269.

MINISTRY OF EDUCATION, YOUTH AND SPORTS

This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic through the e-INFRA CZ (ID:90140).

This work was supported by the LIGATE project. This project has received funding from the European High-Performance Computing Joint Undertaking (JU) under grant agreement No 956137. The JU receives support from the European Union's Horizon 2020 research and innovation programme and Italy, Sweden, Austria, the Czech Republic, Switzerland. This project has received funding from the Ministry of Education, Youth and Sports of the Czech Republic (ID: MC2102).