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Real World Applications using Parallel Computing for Dynamic Traffic Assignment and Shortest Path Search

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Introduction

- The Objective:

To implement a functional solution to take on the

Dynamic Traffic Assignment Problem

Route Choice + Flow Propagation

In a *time and resource efficient* manner.

Problem #1 Definition

Dynamic Shortest Path Search Parallelisation

How to best exploit parallel computing to:

- Reduce calculation time for *individual* requests
- Achieve a high level of service

Shortest Path Search

- Test Application:

  VAO : Verkehrsauskunft Österreich

  Hyperpath based Multi-modal Route planning for Austria

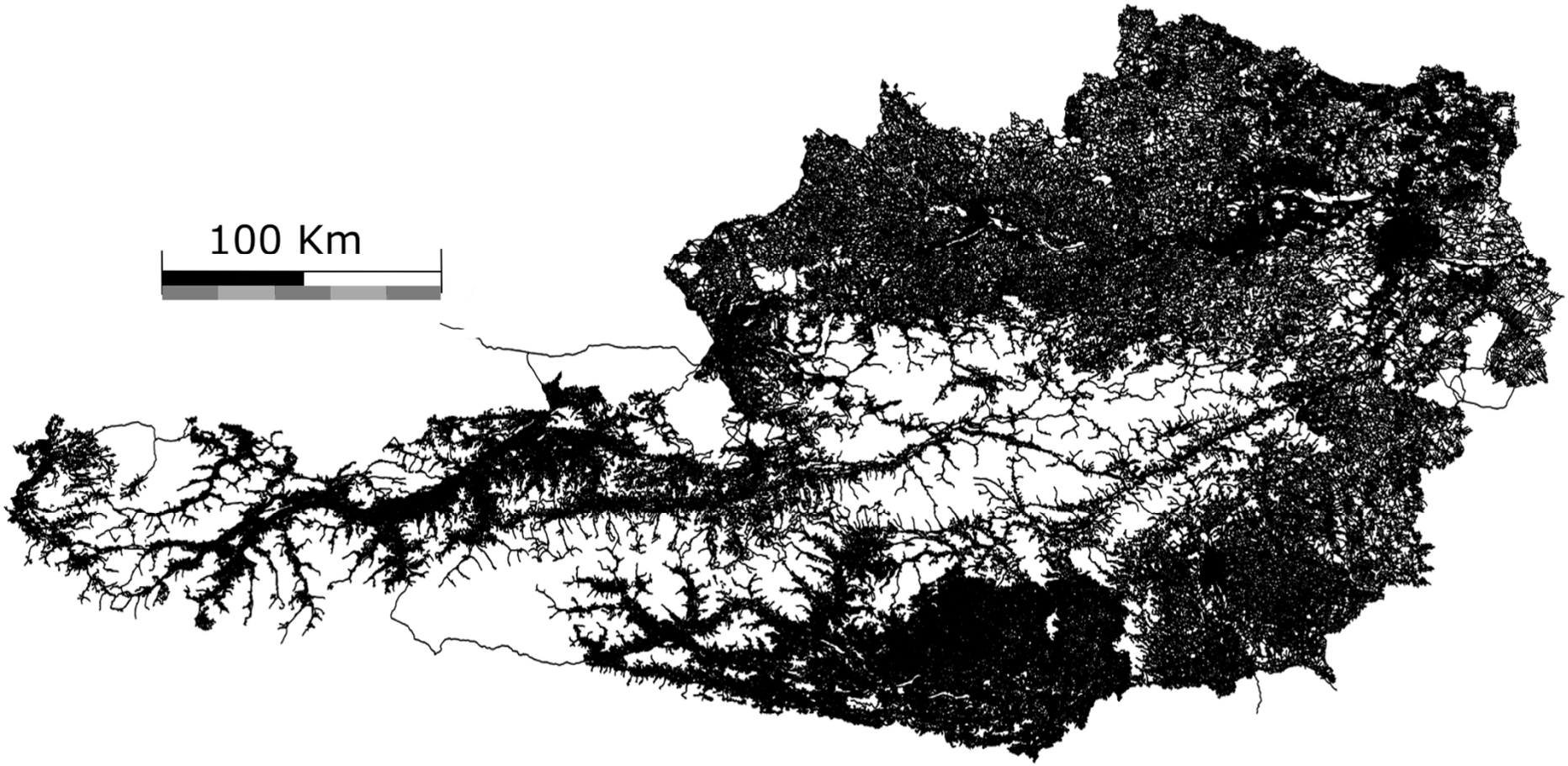
- Network Size:

  1.1 Million Nodes

  2.6 Million Arcs

Shortest Path Search

- Test Network



Shortest Path Search

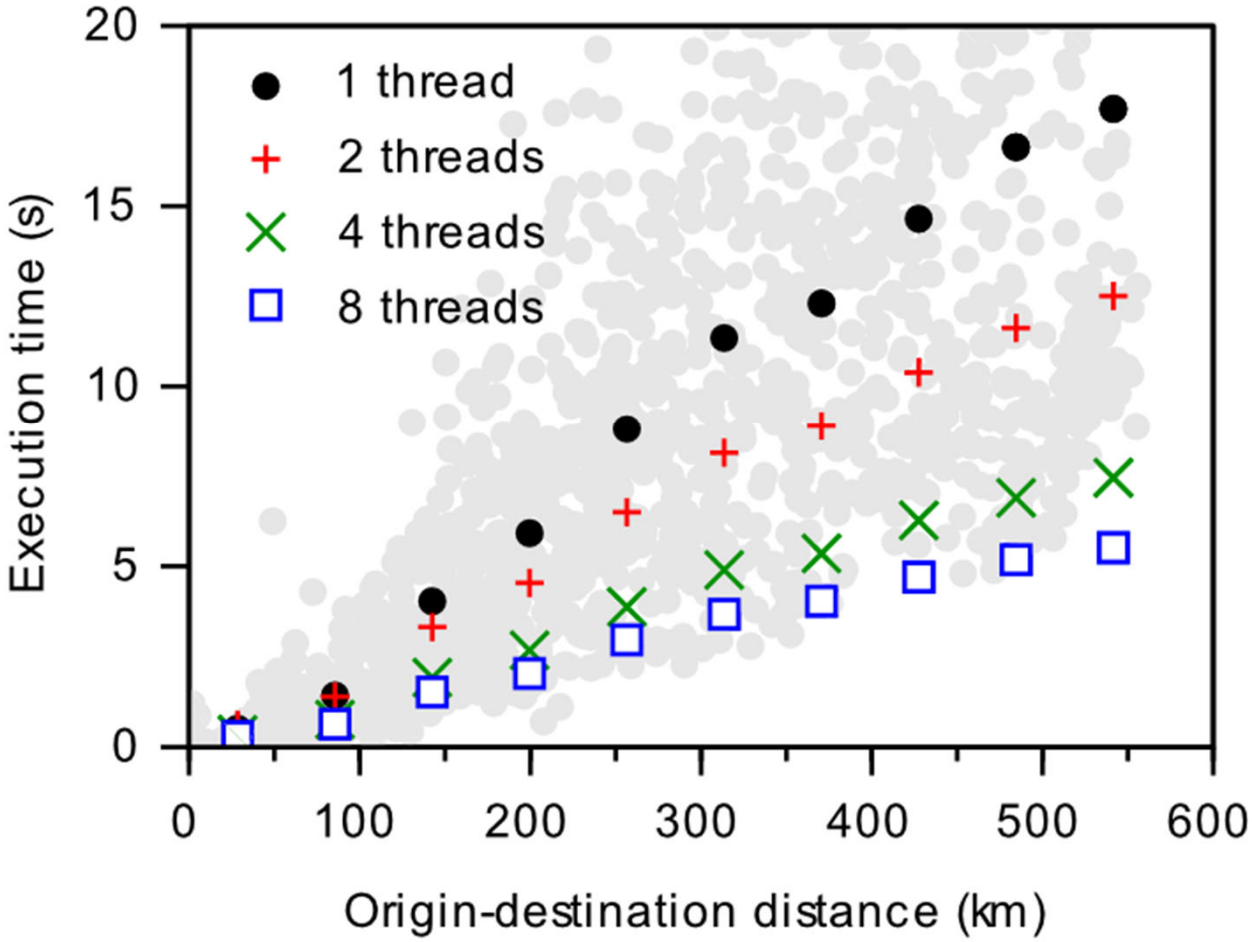
- A* Shortest Path Algorithm:
  - Explore nodes in sequence, lower cost first
  - Similar to Dijkstra, distance as additional cost *estimate*
  - Bucket list to avoid sorting, label correcting
- Parallelisation Strategy:
  - Parallel threads extract one node each

Shortest Path Search

1500 Requests

Execution time:

- End user waiting time considerably reduced
- Faster, but not *exceptionally* faster
- Time vs Distance *looks* sub-linear



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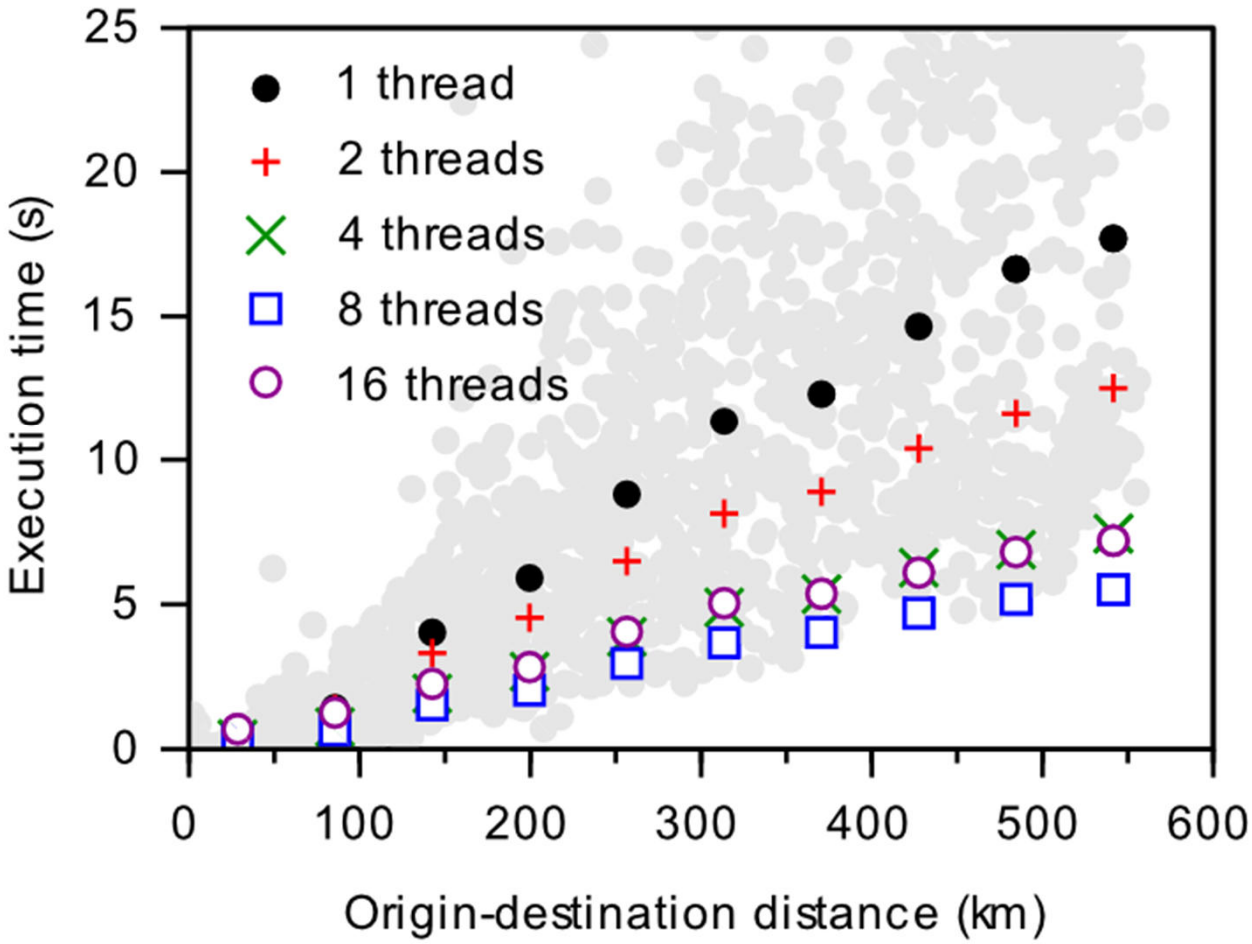
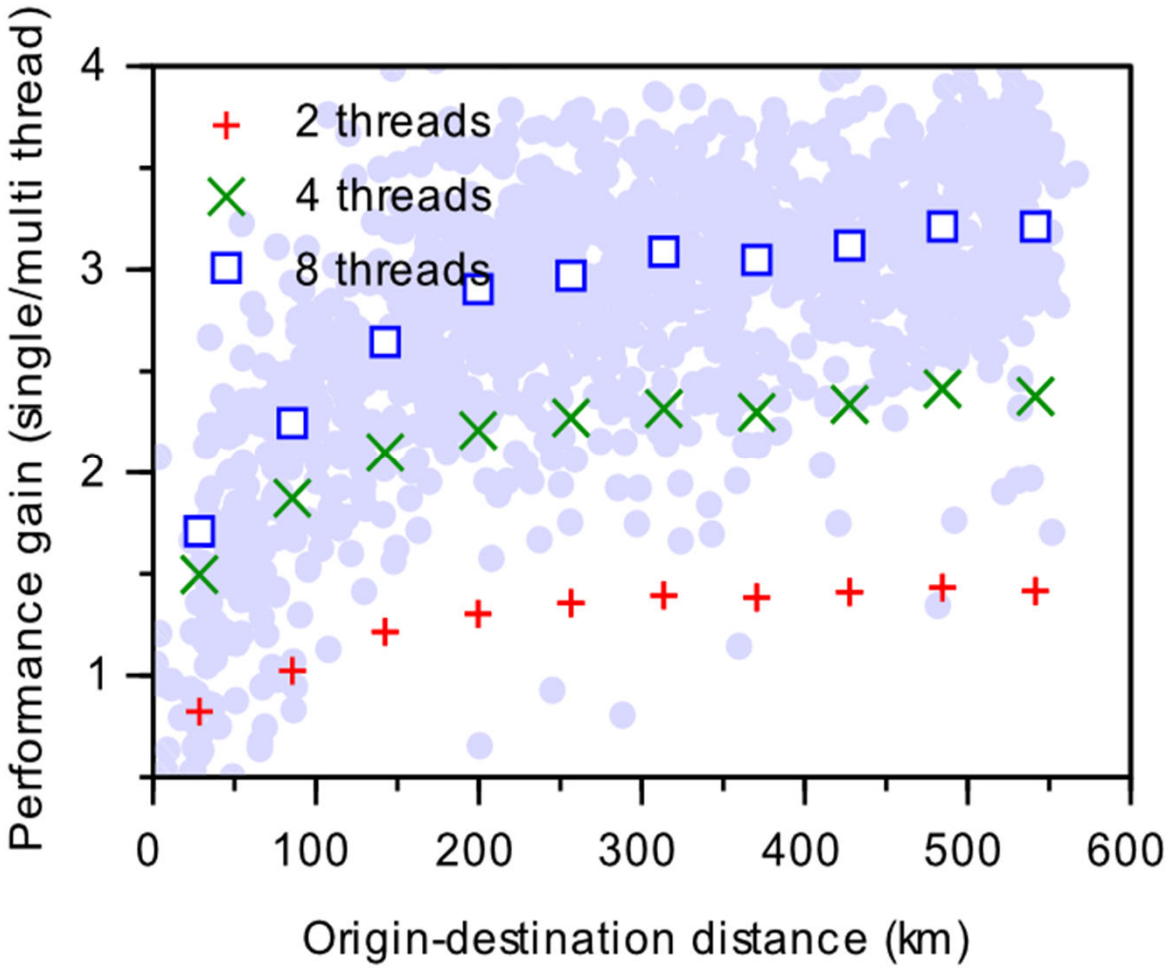
- Gains up to 8 threads



Shortest Path Search

1500 Requests Performance Gain:

- 8 thread performance 2 to 4 times faster
- *Better* results for *more complex* requests



Problem #2 Definition

Dynamic Traffic Assignment Parallelisation

How to best exploit parallel computing to:

- Reduce total computation time of Route Choice Model + Flow Propagation
- Achieve Real-Time compatible performance on large real-world networks

Dynamic Traffic Assignment

Parallelisation Strategy

- Route Choice (DSP):
  - each DSP search is handled by a single thread
  - parallel threads carry out simultaneous path searches

- Flow Propagation (GLTM):
  - parallel threads compute flow splitting and redirection at individual nodes based solely on previous states
  - after processing a node, the same thread performs flow propagation on the FS and BS of that node, link by link

Dynamic Traffic Assignment

- Benchmark Network Metrics

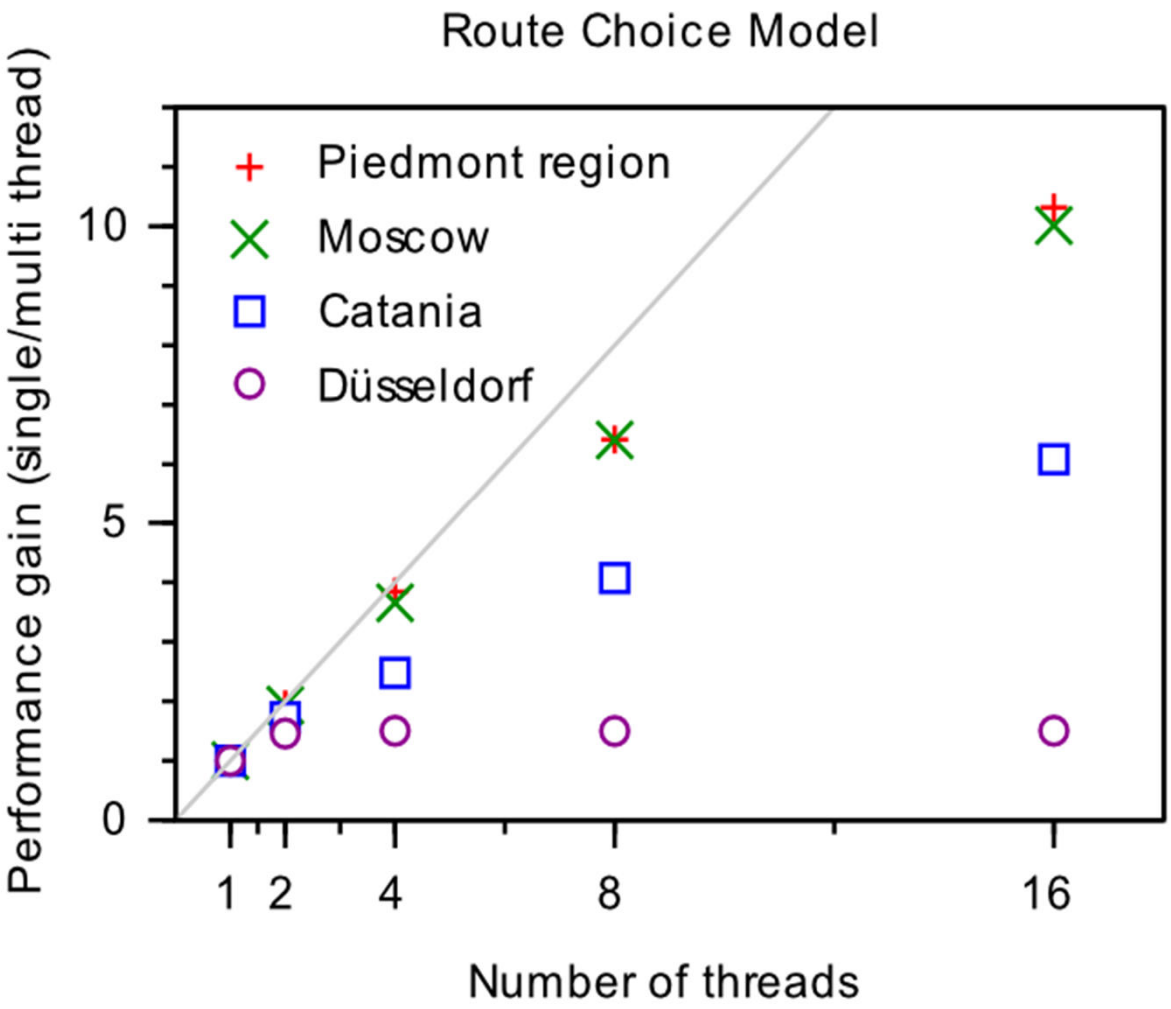
Network Metrics			
Region	N. of nodes	N. of links	N. of zones
5T-Piedimont	34606	95794	2009
Moscow	18749	46334	644
Catania	2052	6006	89
Düsseldorf South	656	1696	155

	Total computation time by number of threads [s]				
Region	1 Thr	2 Thr	4 Thr	8 Thr	16 Thr
5T-Piedimont	227	135	65	42	29
Moscow	102	57	31	18	13
Catania	7.2	4.3	2.6	1.8	1.3
Düsseldorf South	2.1	1.5	1.1	0.87	0.73

Dynamic Traffic Assignment

1 DTA Iteration
Route Choice Phase

- Gains nearly linear for 2 and 4 threads
- Best results for larger networks
- MUCH more efficient than parallelised A*
- Saturation onset is considerably delayed

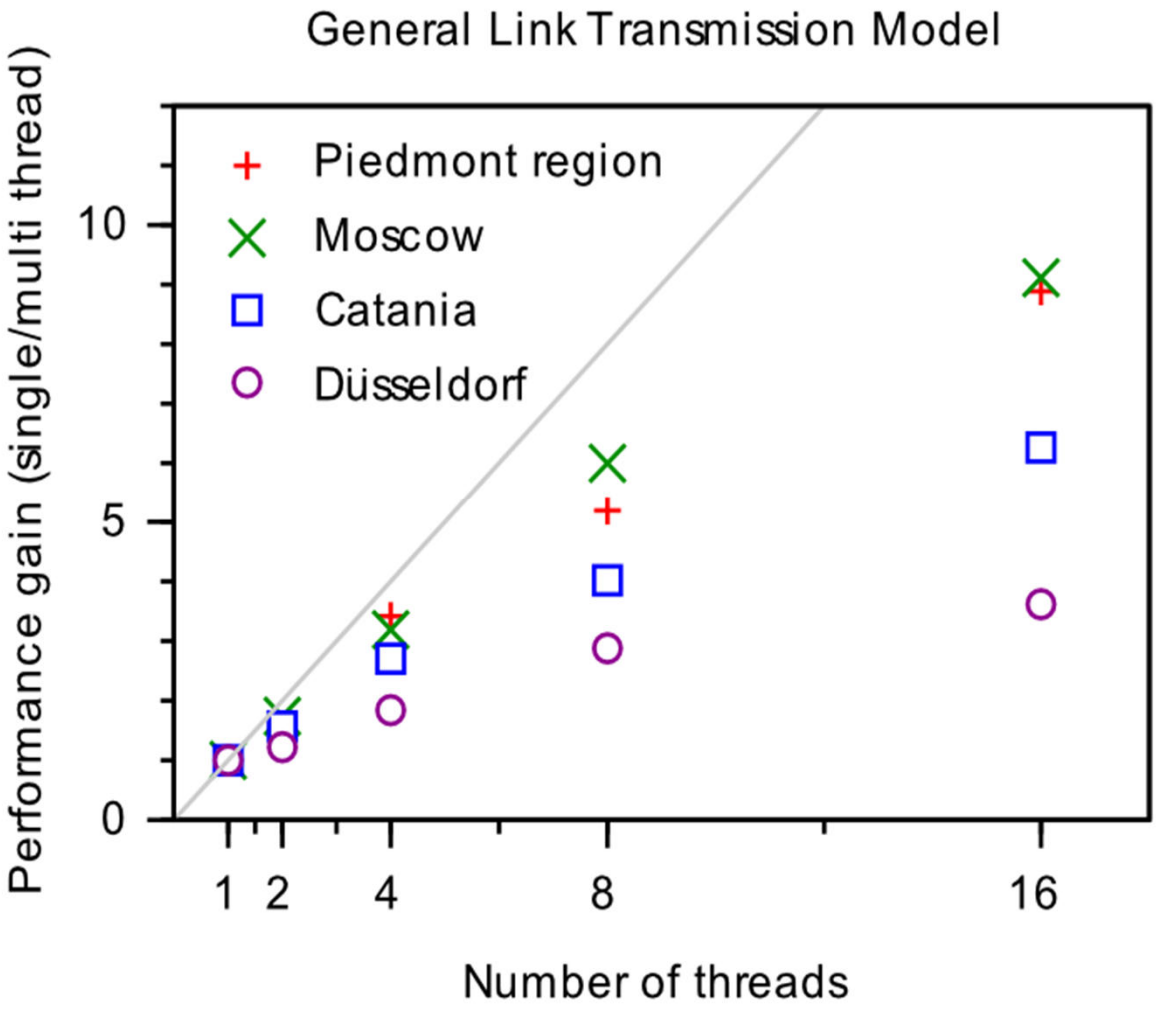


Dynamic Traffic Assignment

1 DTA Iteration

Flow Propagation Phase

- Gains sub-linear but still very significant
- Best results for larger networks



Dynamic Traffic Assignment

- Complete DTA Iteration Results:
  - Route Choice + Flow Generation + Flow Propagation
  - Simulation horizon 75 minutes
  - Time step 12 seconds

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…on an AMD Opteron 6272
16 core CPU @2.1GHz – 128GB RAM

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Thank you for your attention