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Fast shortest path computation in time-dependent traffic networks

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MATSim-T: Routing in agent based micro-simulations (2)

Task: Finding the time dependent least cost path from O to D
in a dynamically weighted, strongly connected di-graph.
➔ Complexity: $O(n^2)$

Street networks are sparse graphs.
➔ Complexity: $<O(n^2)$

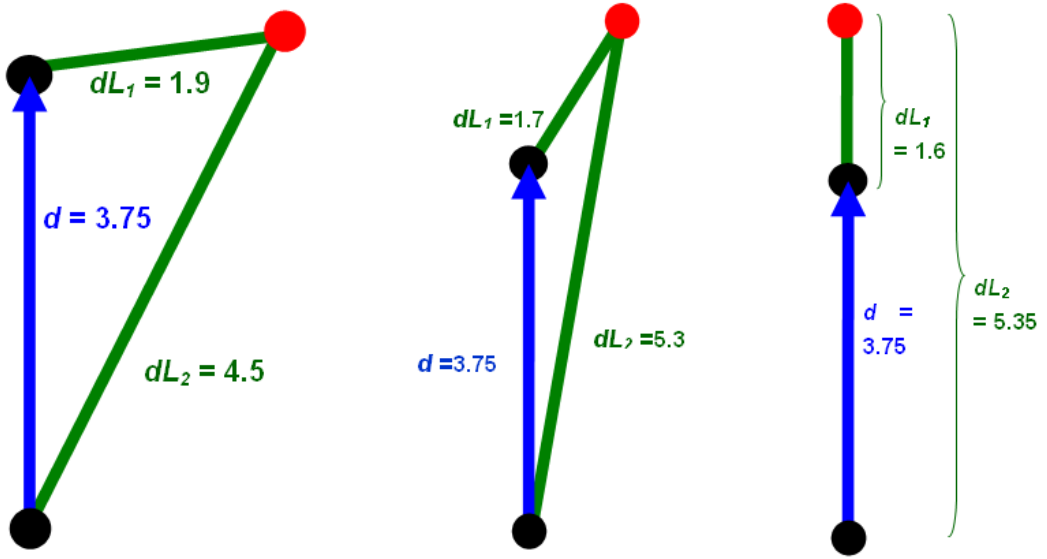
Number of routes to calculate (Example: Switzerland)
- ca. 7.5 Mio. inhabitants
- ca. 3 trips per person
- ca. 100 iterations with 10% re-routing (MATSim-T)

➔ ca. 225 Mio. routes to calculate

Landmarks A*-Algorithm (1)

A*-Algorithm:
Estimation of remaining cost ($h_D(x)$) during the route finding process.
Estimated cost at x: $c_x(O)+h_D(x)$
➔ Rule: $h_D(x)$ <= remaining cost ($c_D(x)$)

Landmarks A*-Algorithm:
$h_D(x)$ estimation via triangle inequality



5.5 – 1.9 = 2.6 < 3.75

5.3 – 1.7 = 3.6 < 3.75

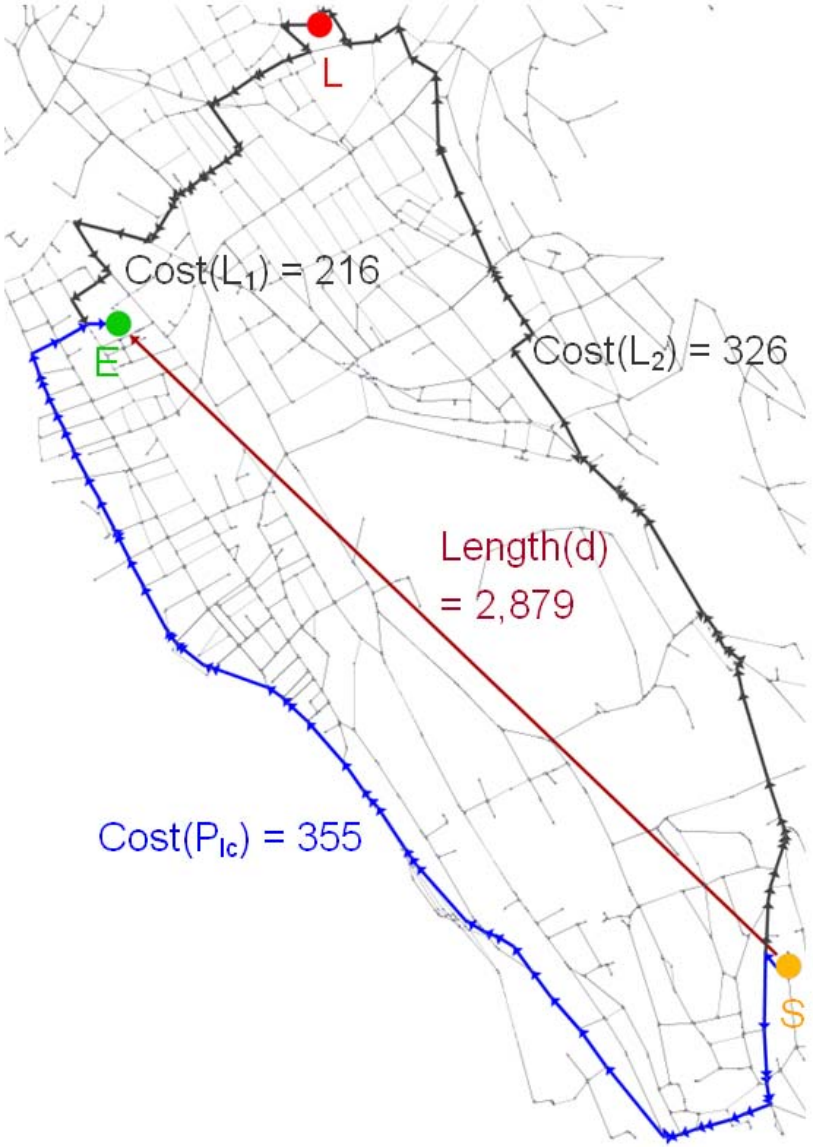
5.35 – 1.6 = 3.75

Landmarks A*-Algorithm (2)

Problems in travel time estimation in traffic networks:
- different free speed per link
- dynamic link travel time

To guarantee $h_D(x) <= c_D(x)$:
Cost(L_i) calculated on an unloaded network

Pre-process:
calculate and store Cost(L_i) from each node of the network.



Test Sets: Networks

Name	# nodes	# links	Avg. node degree	Detour Index	Avg. link length (m)	Avg. link free speed (m/s)	# dead-end nodes
Net1	7,377	20,252	5.49	1	1,816.82	14.20	1,025
Net2	14,803	39,372	5.32	0.90	1,218.43	19.40	1,776
Net3	408,636	882,120	4.32	0.97	96.68	11.00	127,904
Net4	471,879	1,053,259	4.47	0.95	108.49	9.29	142,238

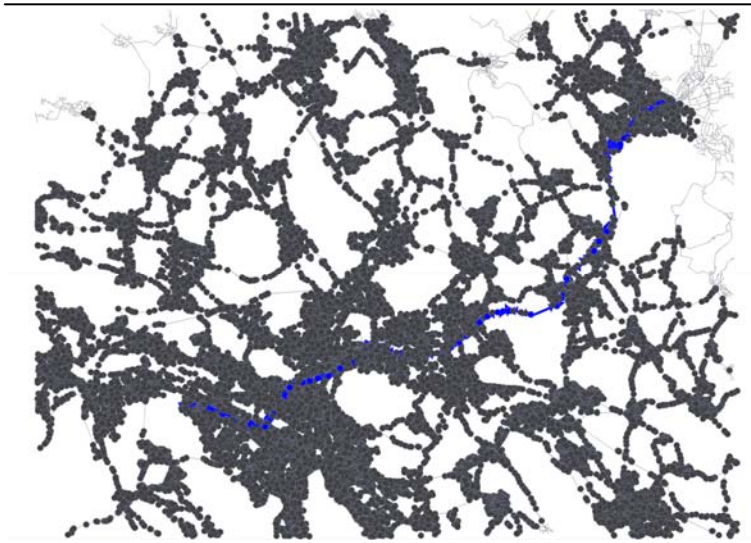
Test Sets: Routing Algorithms

- Basic Dijkstra (Dijk)
- Iteration-ID Dijkstra (It-ID Dijk)
- Iteration-ID Dijkstra with dead-end pruning (Prune Dijk)
- Euclidean A* (Euc A*)
- Landmarks A* (Landm A*)
- Overdo A* (Ov A* X, where X denotes the overdo factor)

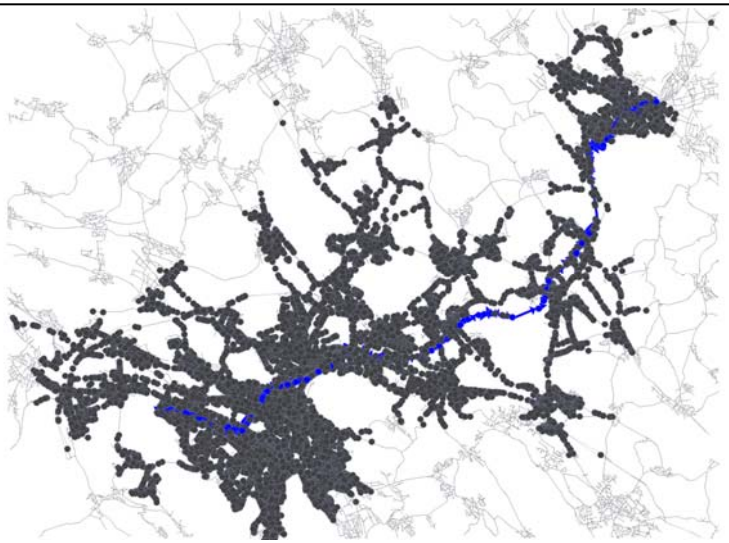
Test Sets: Demand (Trips)

Aimed from-to distance	Avg. from-to distance Net1	Avg. from-to distance Net2	Avg. from-to distance Net3	Avg. from-to distance Net4
1 km	1.86 km	1.68 km	1.17 km	1.17 km
5 km	5.27 km	5.38 km	5.06 km	5.06 km
25 km	25.29 km	25.21 km	25.06 km	25.06 km
50 km	49.98 km	50.00 km	50.02 km	50.02 km
100 km	99.83 km	100.01 km	100.02 km	100.02 km
150 km	149.67 km	150.20 km	150.03 km	150.03 km
200 km	200.36 km	200.20 km	200.04 km	200.04 km

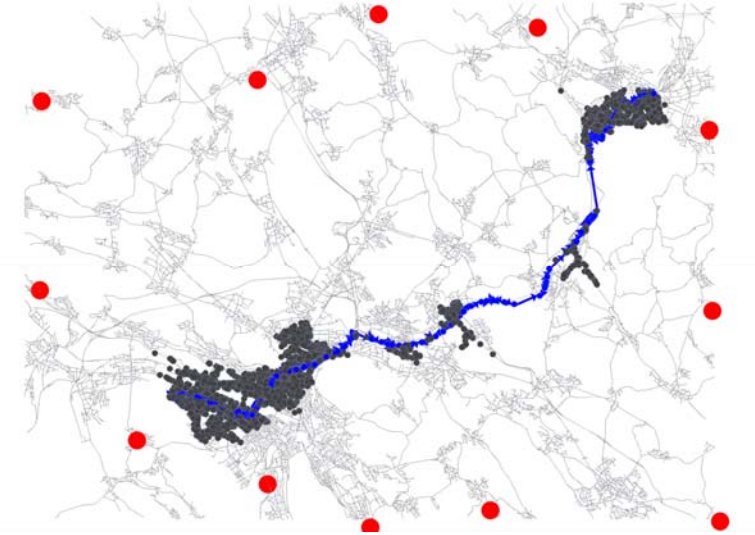
Performance



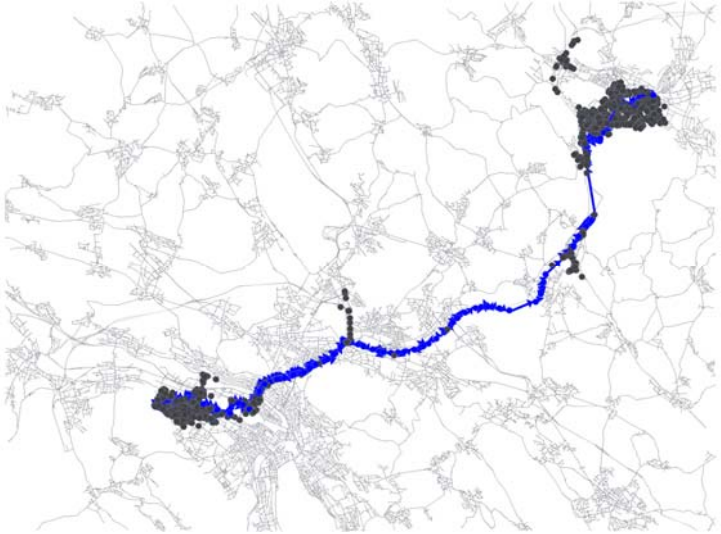
(It-ID) Dijk



Euc A*



Landm A* (12 L)

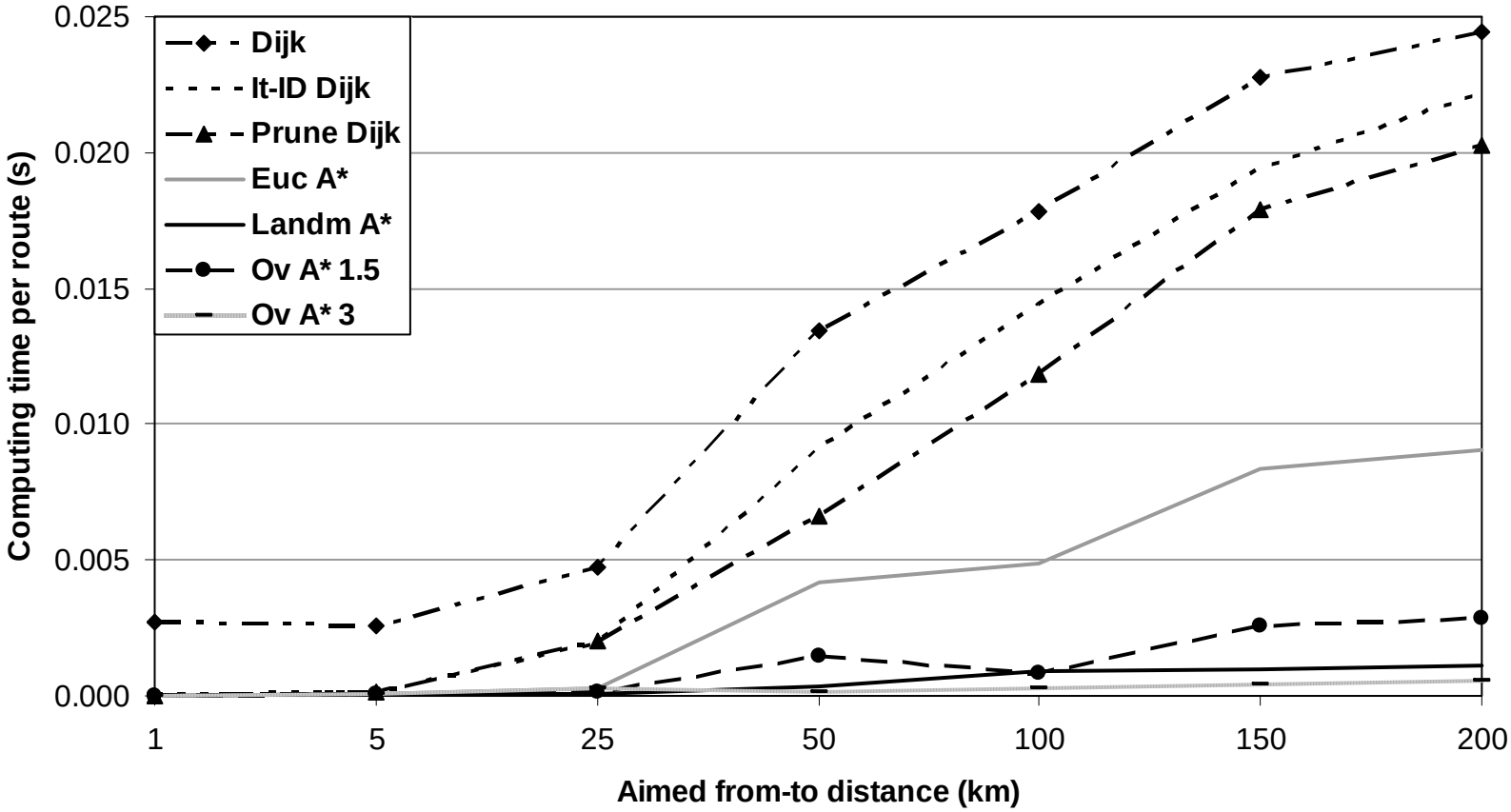


Ov A* 2

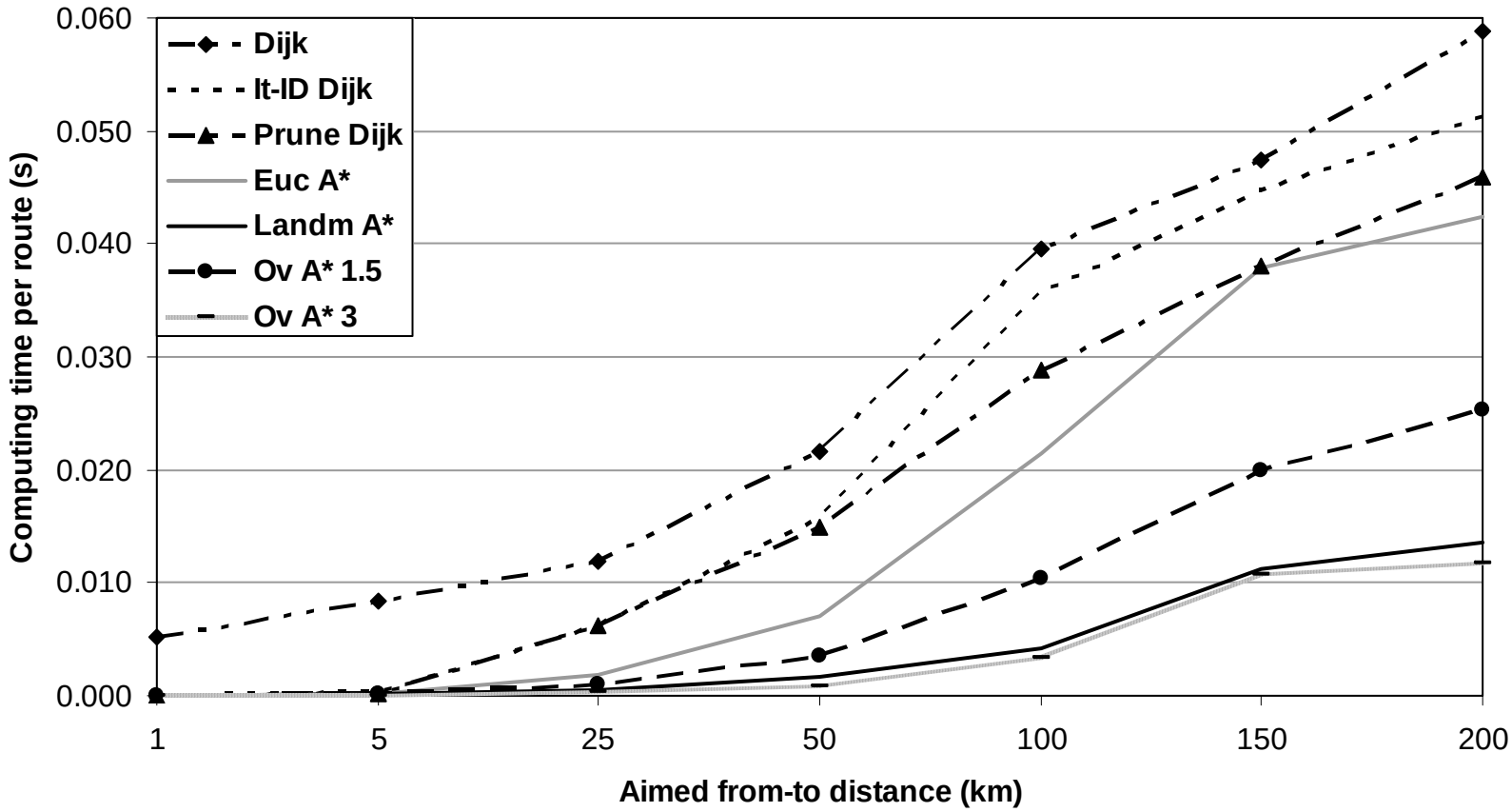
Performance: Pre-process

Algorithm	**Net1**	**Net2**	**Net3**	**Net4**
Dijk/It-ID Dijk	-	-	-	-
Prune Dijk/Euc A*/Ov A*	0.13 s	0.22 s	4.20 s	5.00 s
Landm A*	1.20 s	2.00 s	72.00 s	160.00 s

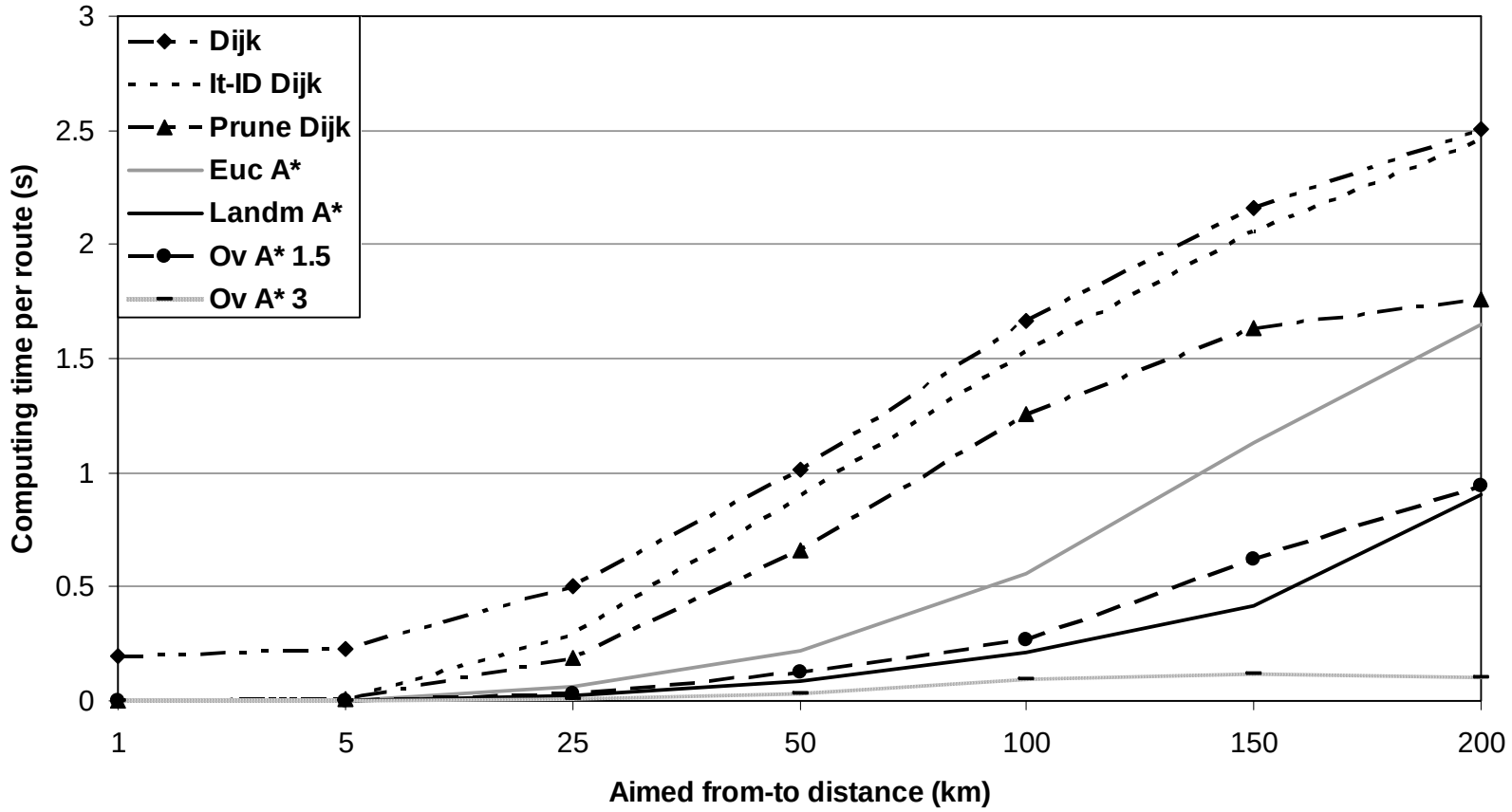
Performance: Free Flow (Net 1)



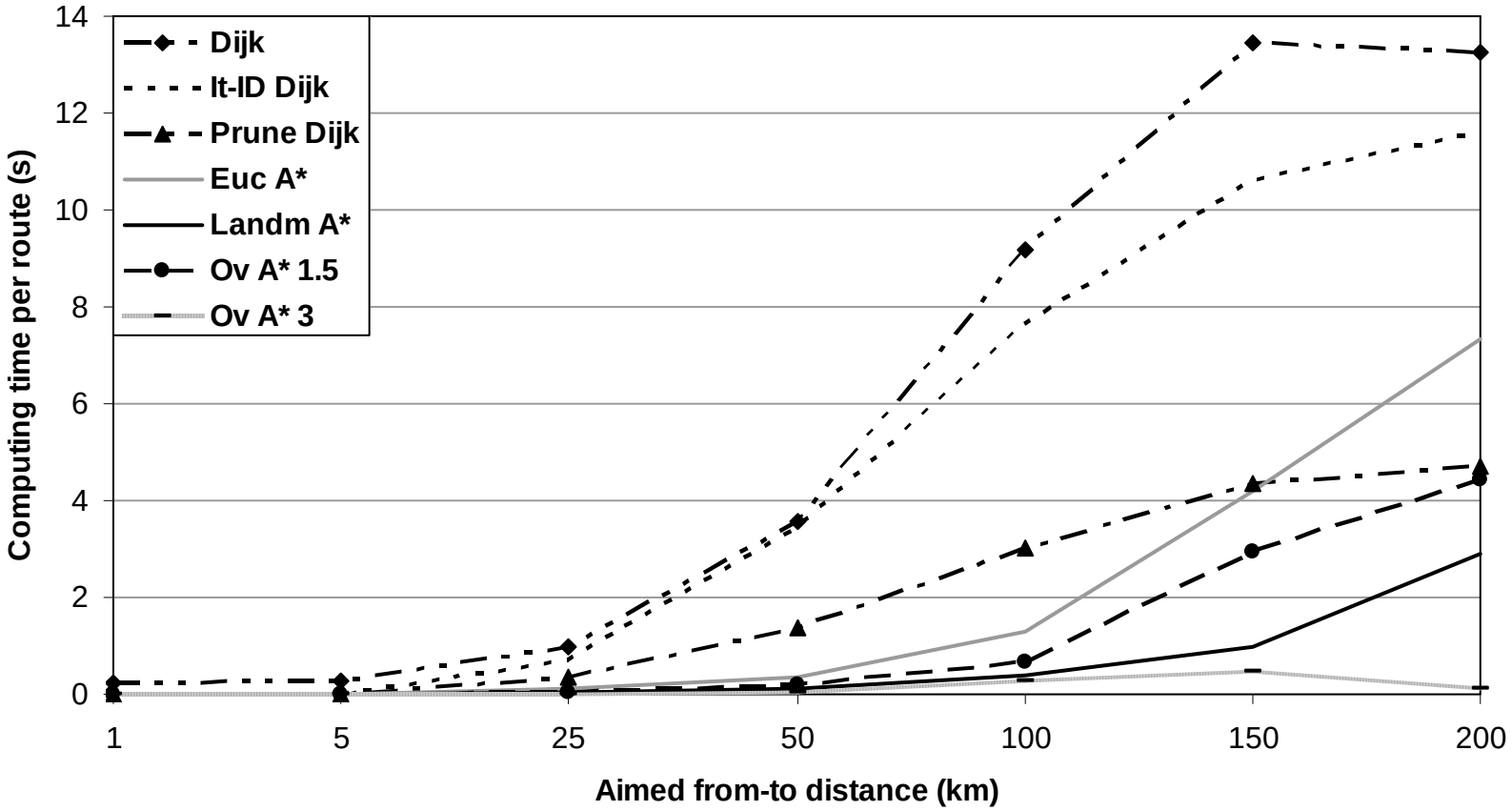
Performance: Free Flow (Net 2)



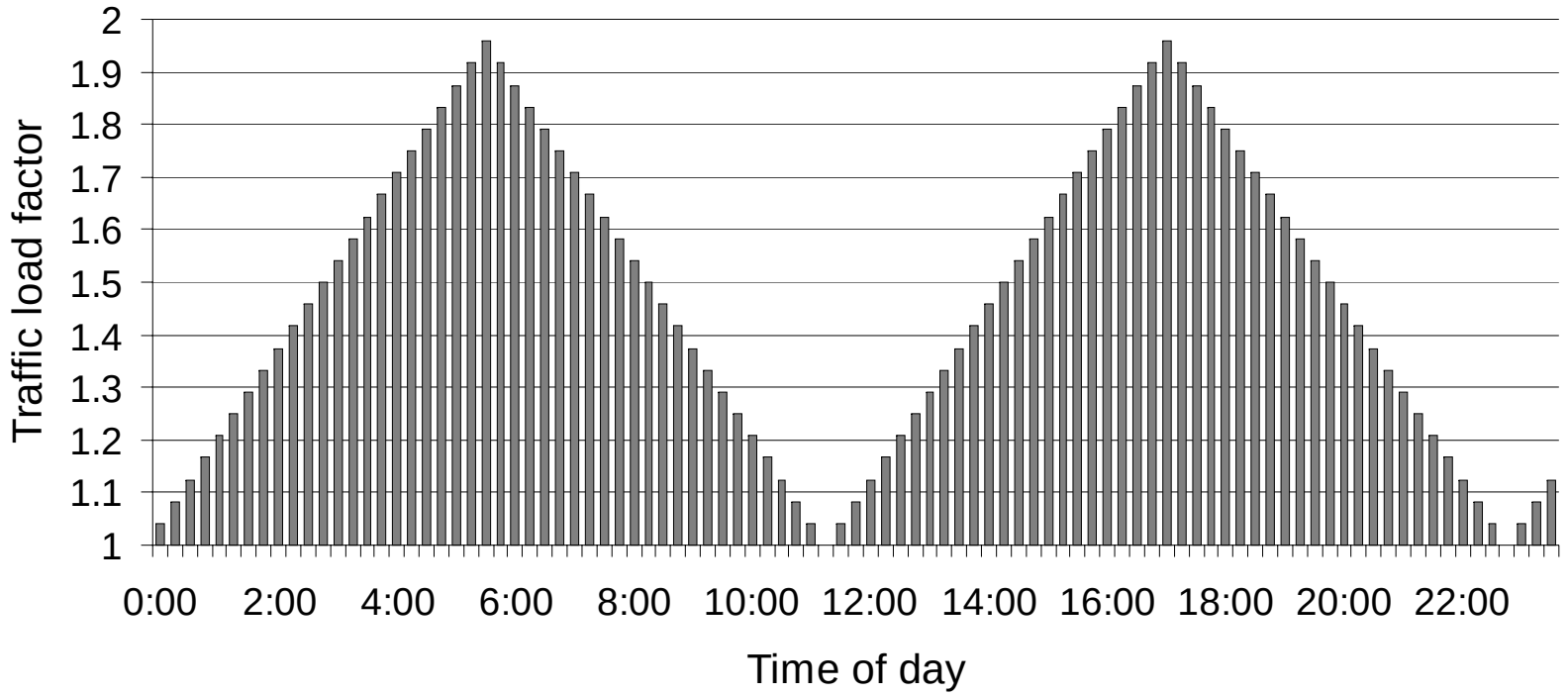
Performance: Free Flow (Net 3)



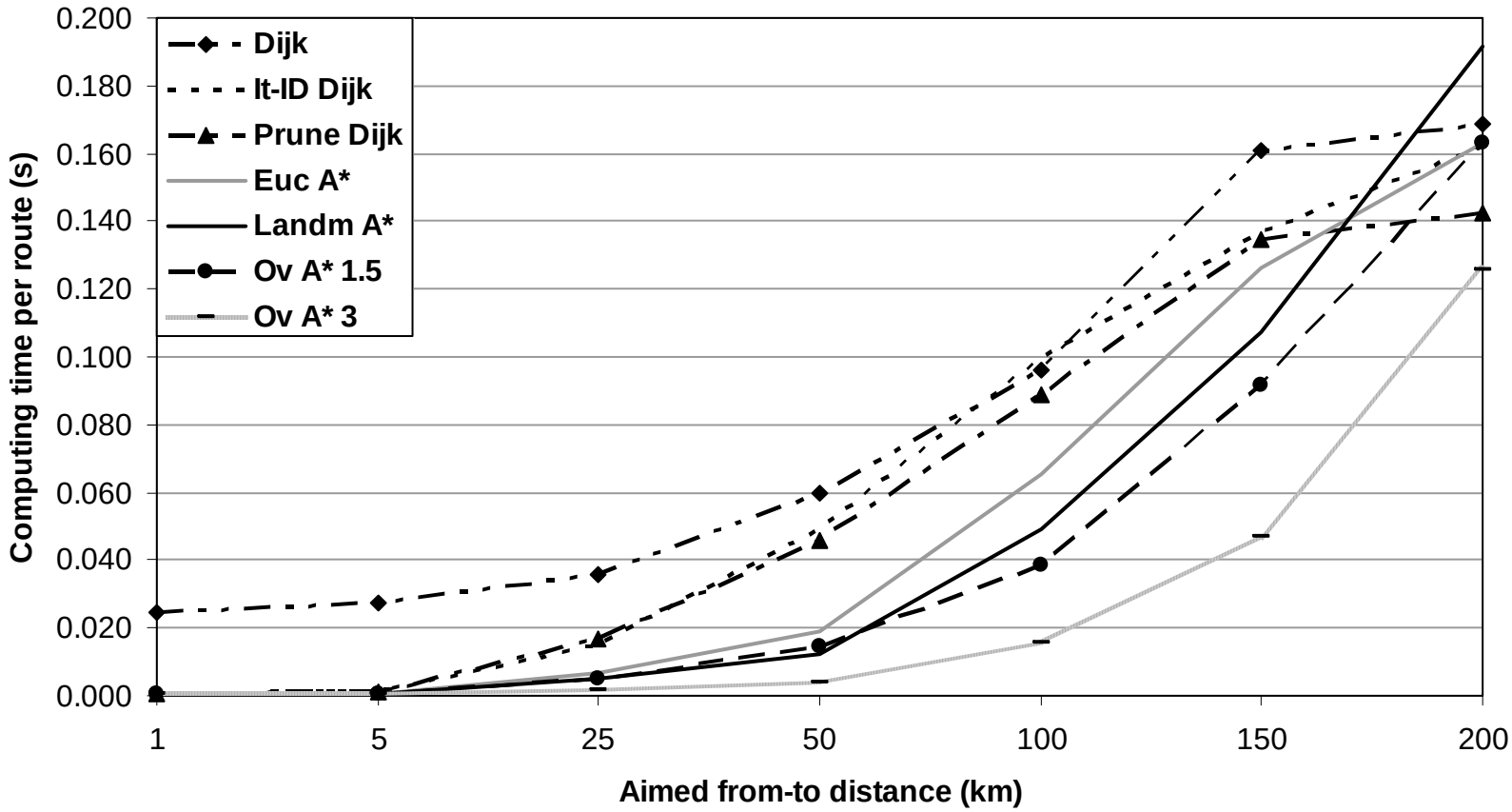
Performance: Free Flow (Net 4)



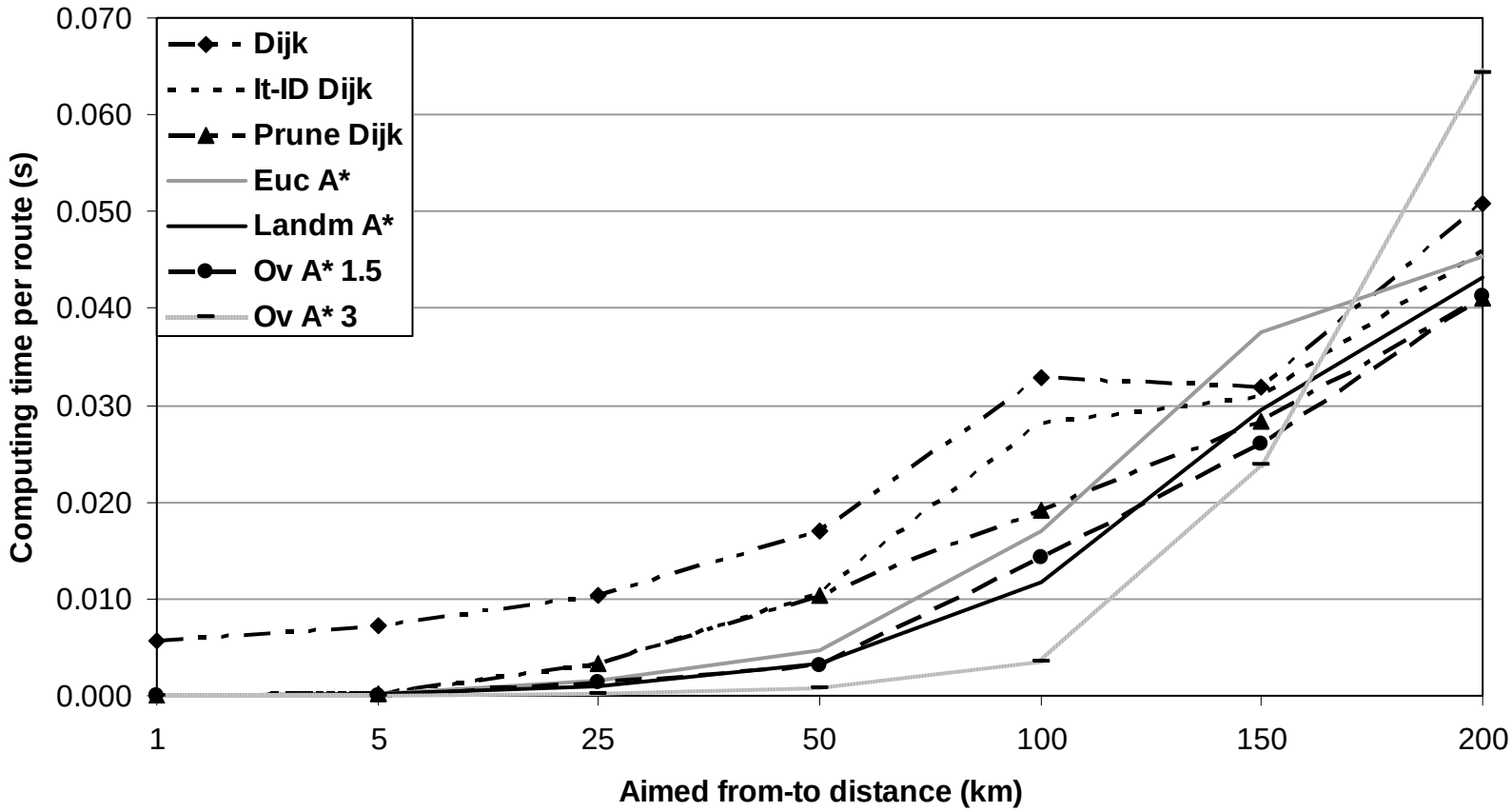
Performance: Loaded (synthetic)



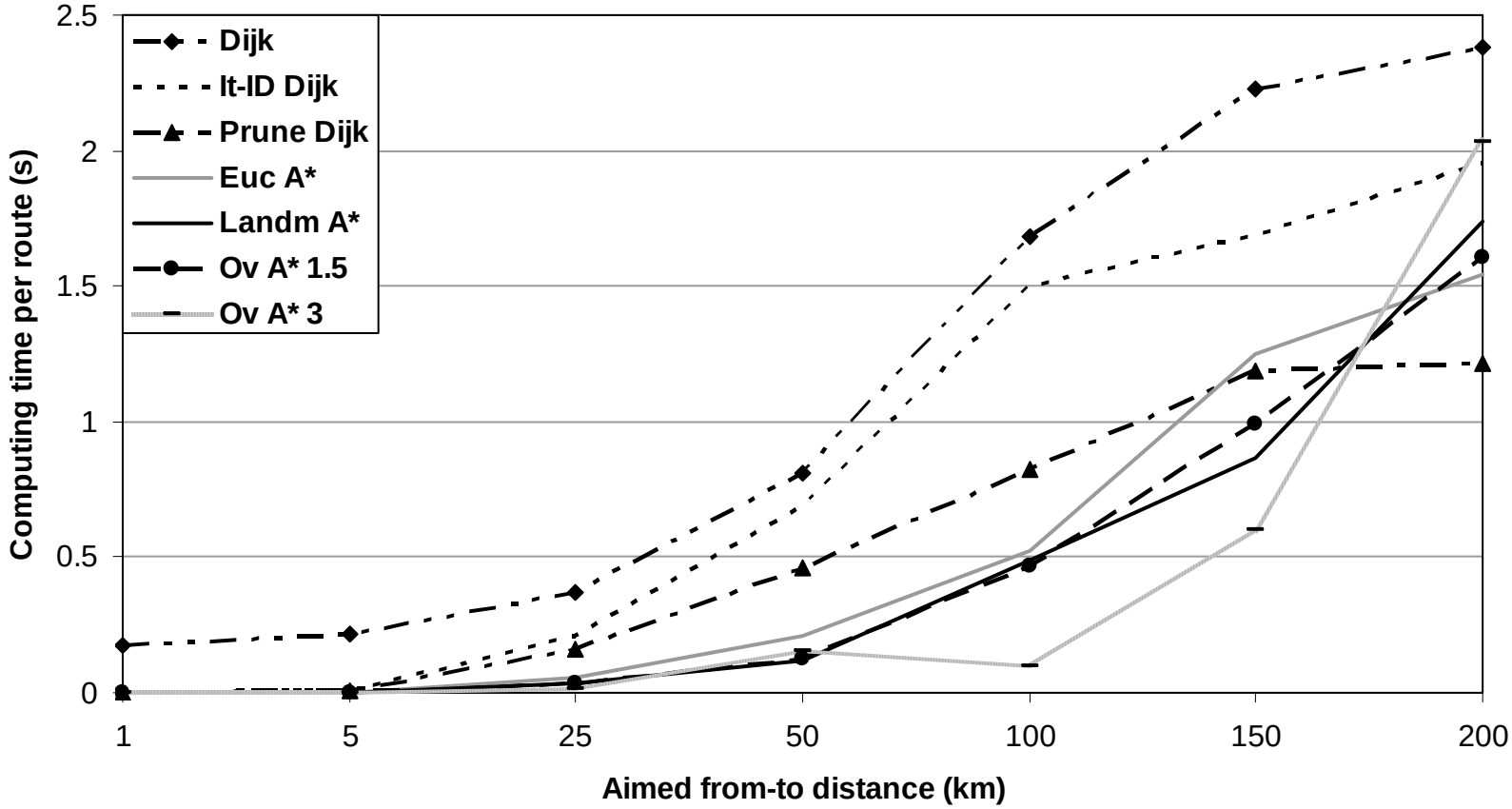
Performance: Loaded (Net 1)



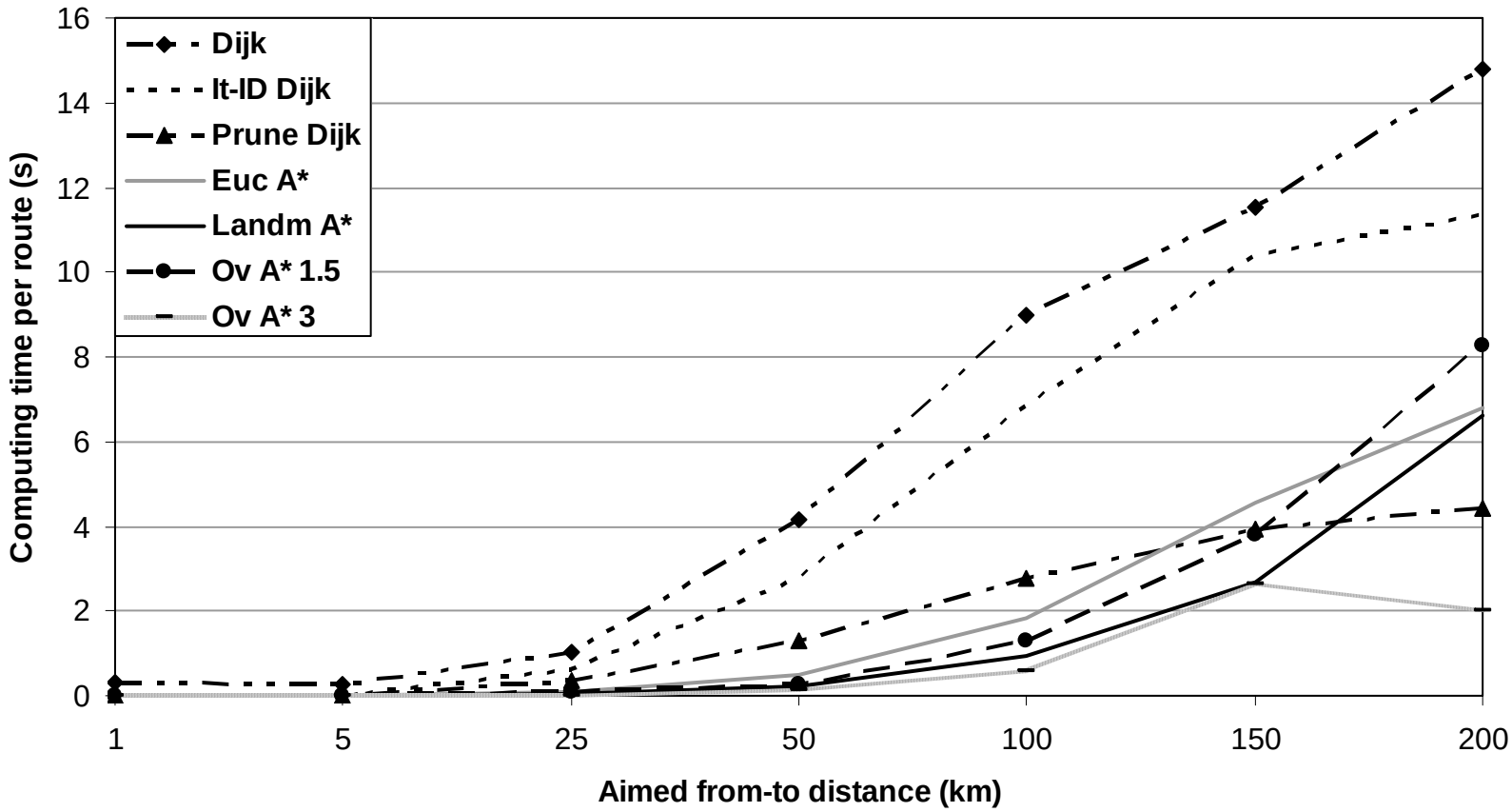
Performance: Loaded (Net 2)



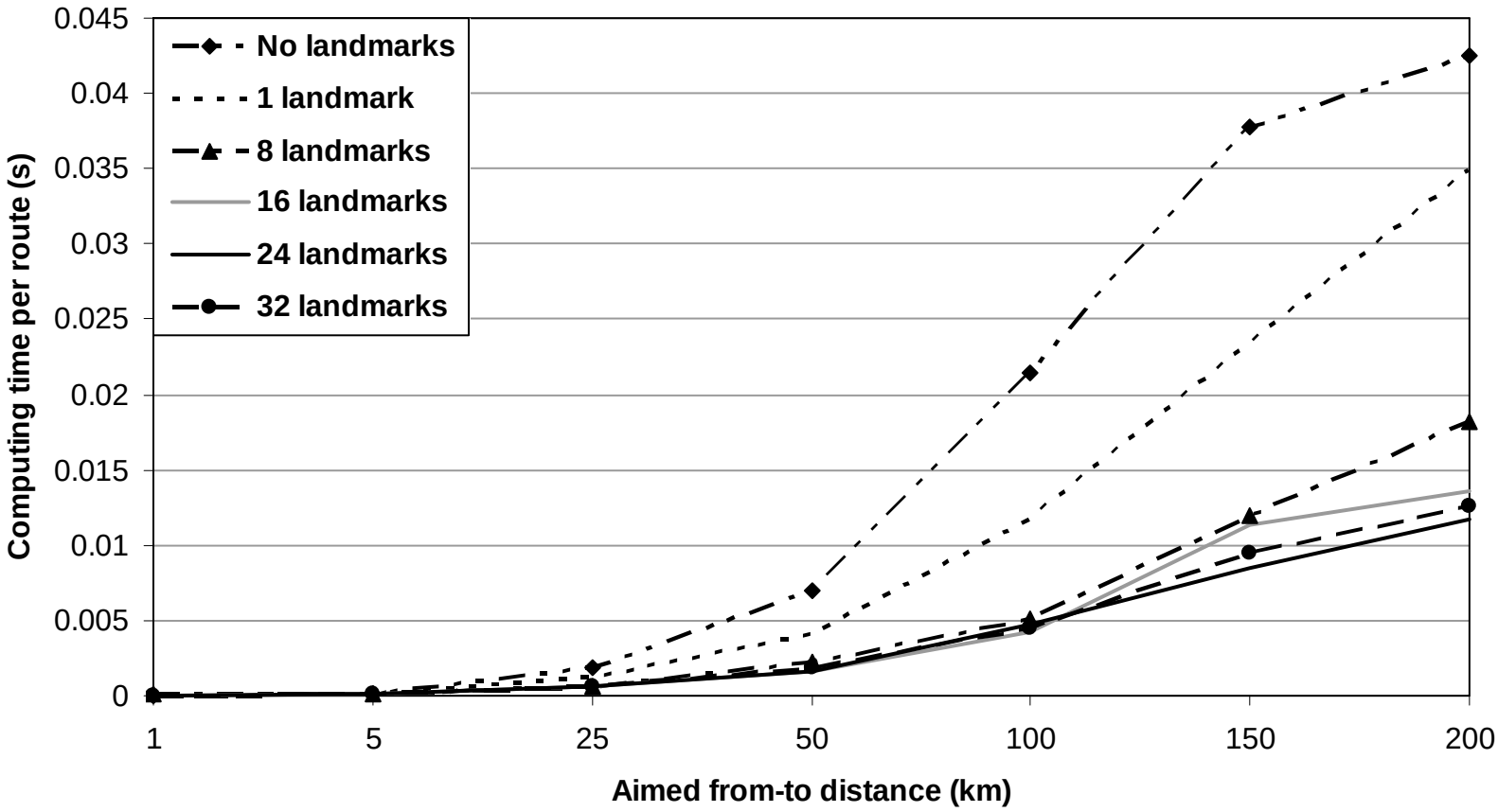
Performance: Loaded (Net 3)



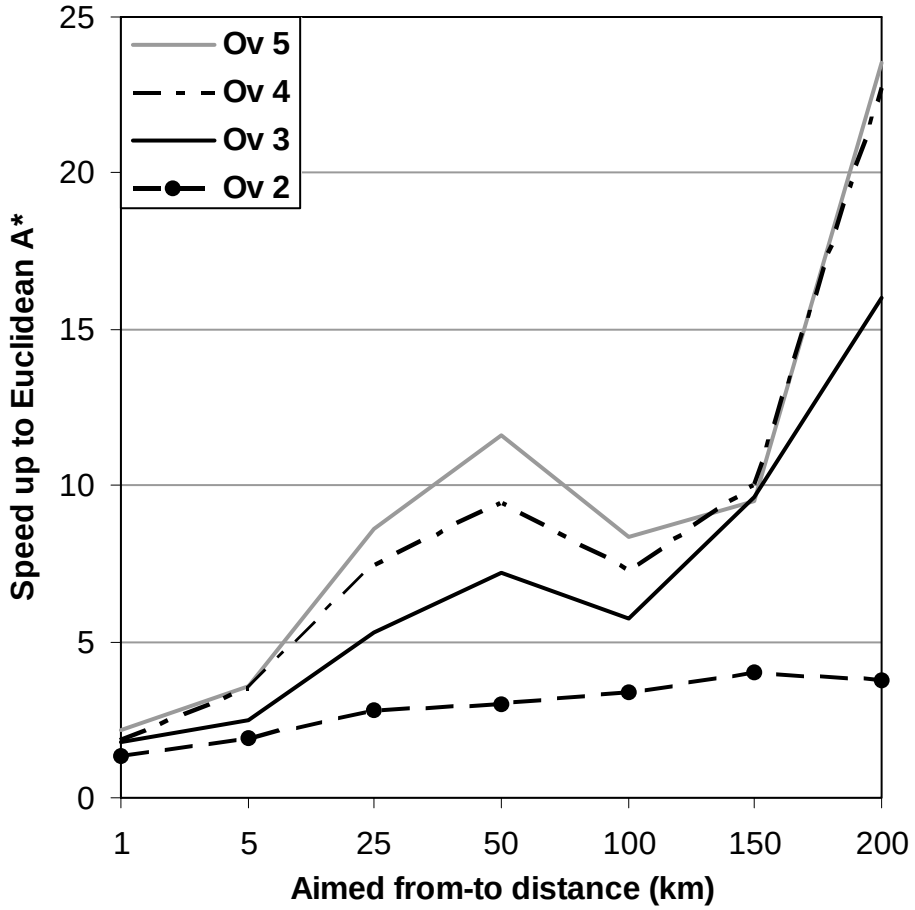
Performance: Loaded (Net 4)

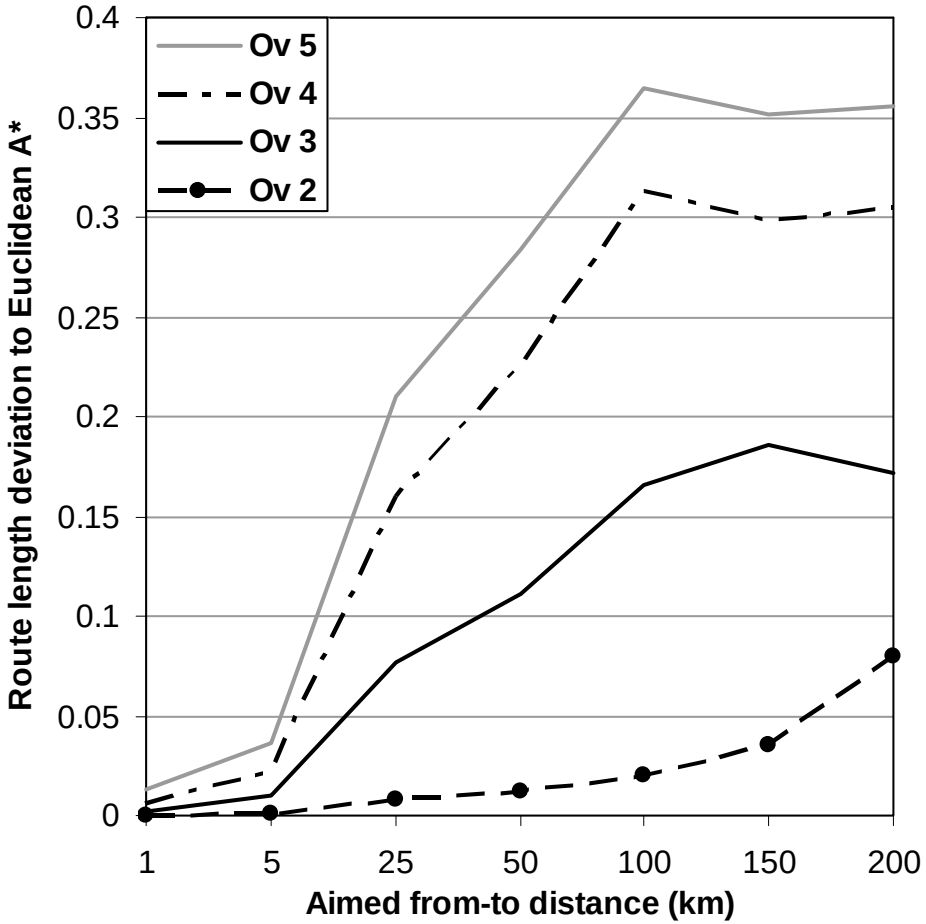


Performance: Landmarks (Free Flow, Net 2)



Performance: Overdo A* Vs. Euc A* (Free Flow, Net 3)

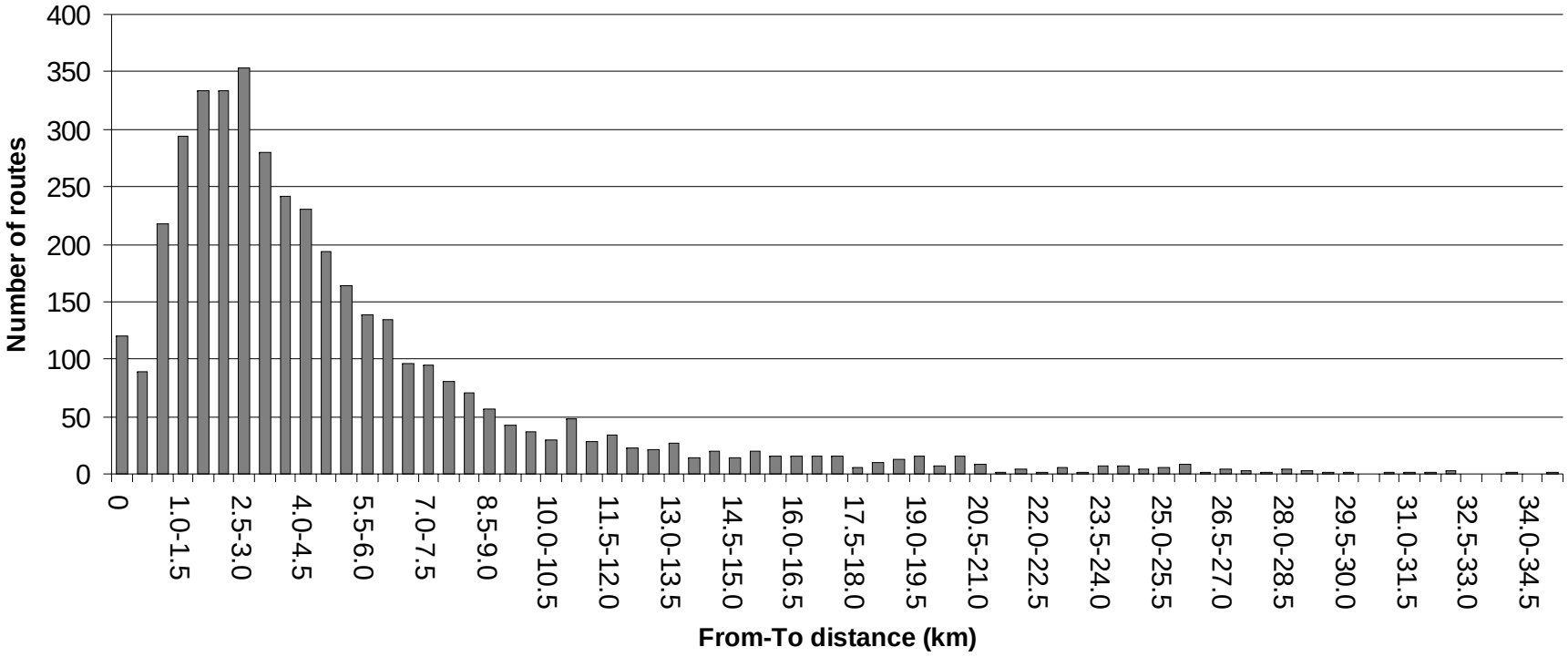




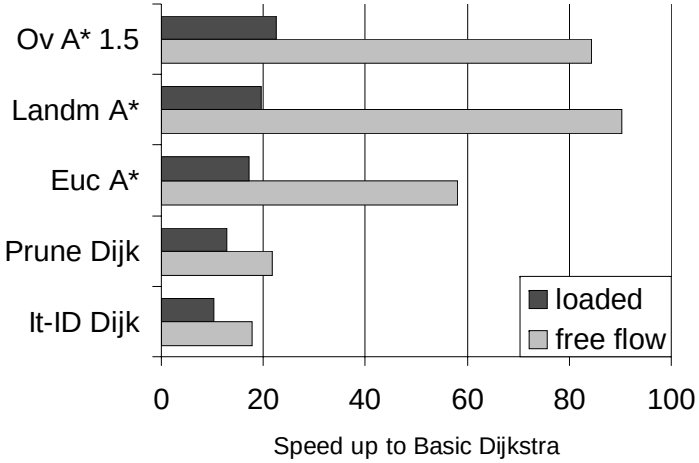
M. Balmer

Performance: Real World Example (1)

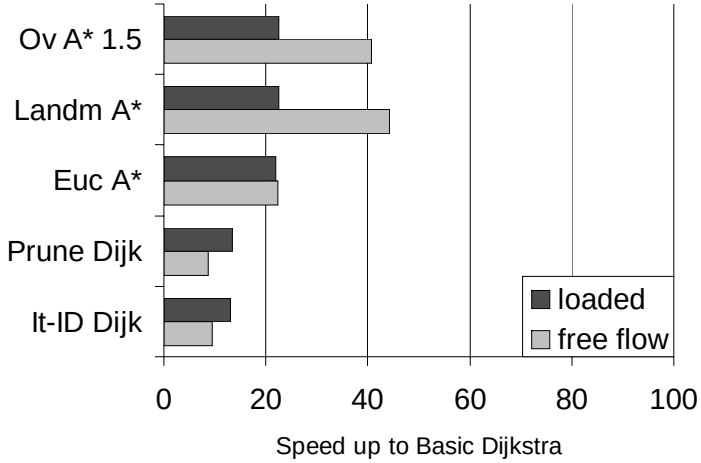
- Greater Zurich area
- Work-commuter population (sample of 10’000 trips)
- Free flow & loaded networks



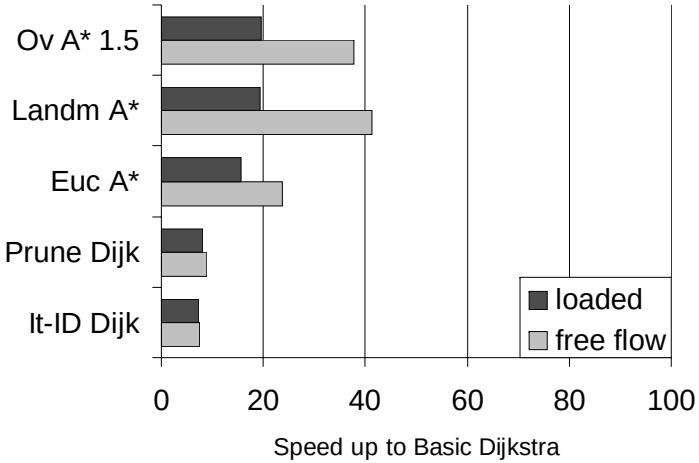
Performance: Real World Example (2)



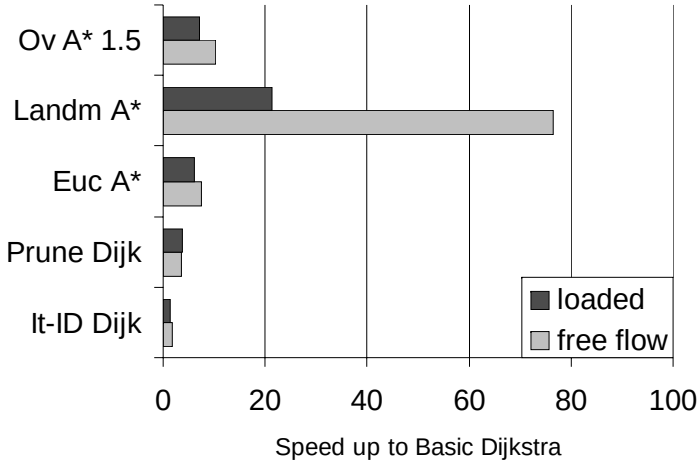
Net 1



Net 2



Net 3



Net 4

Performance: Latest Results

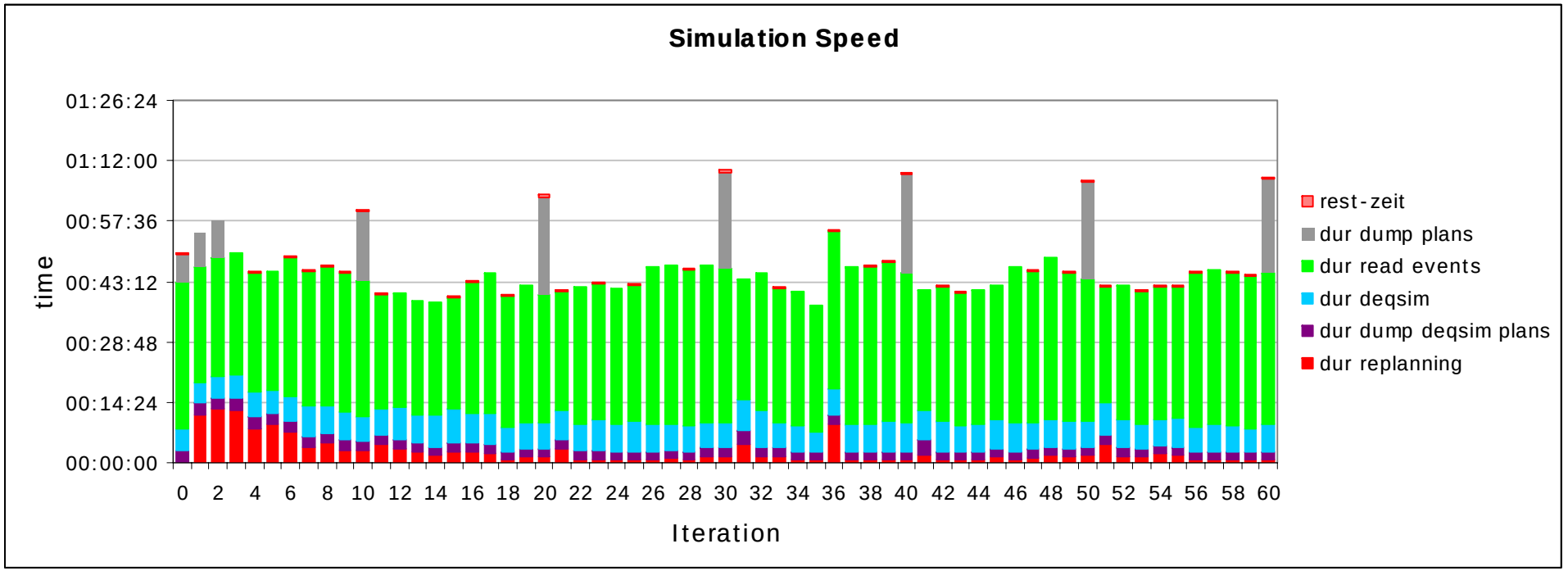
- Whole Switzerland

- Daily demand for ca. 2.3 million persons (ca. 7.6 Mio trips)

- “ivtch” net (national network model, ~60’000 links)

- 46 Iteration processes with MATSim-T (00:00 - 48:00 h)

Performance: Latest Results (2)



More about the Run...

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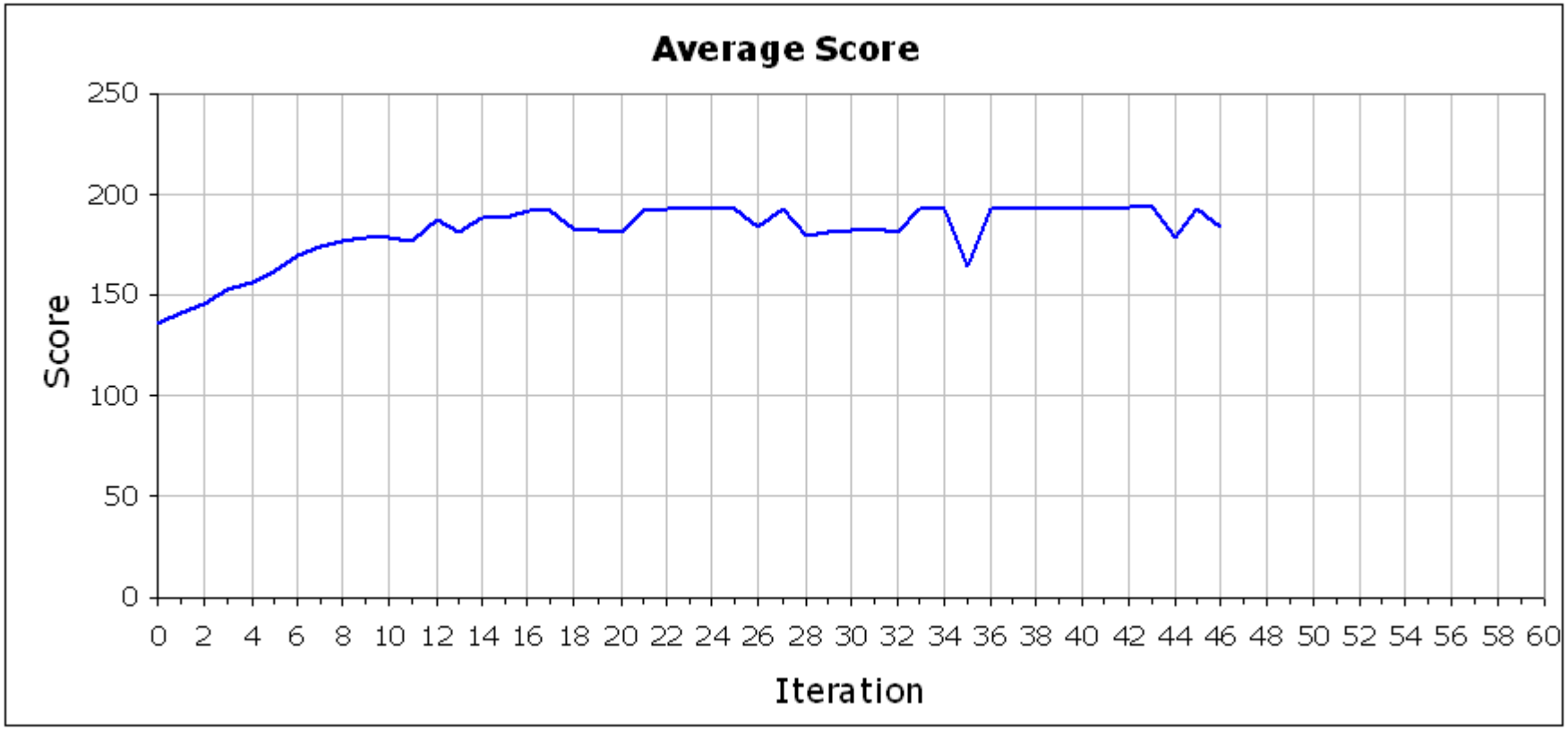
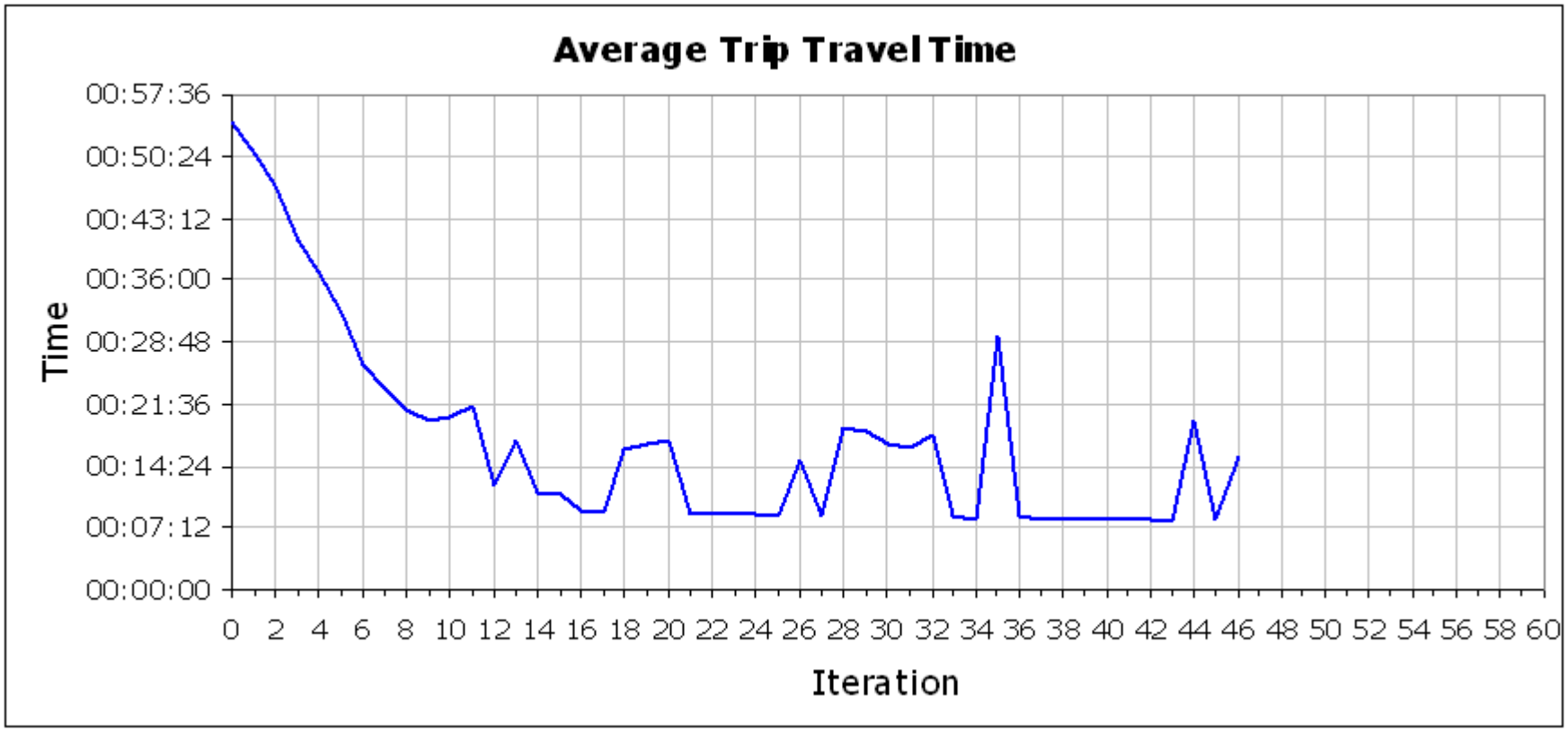
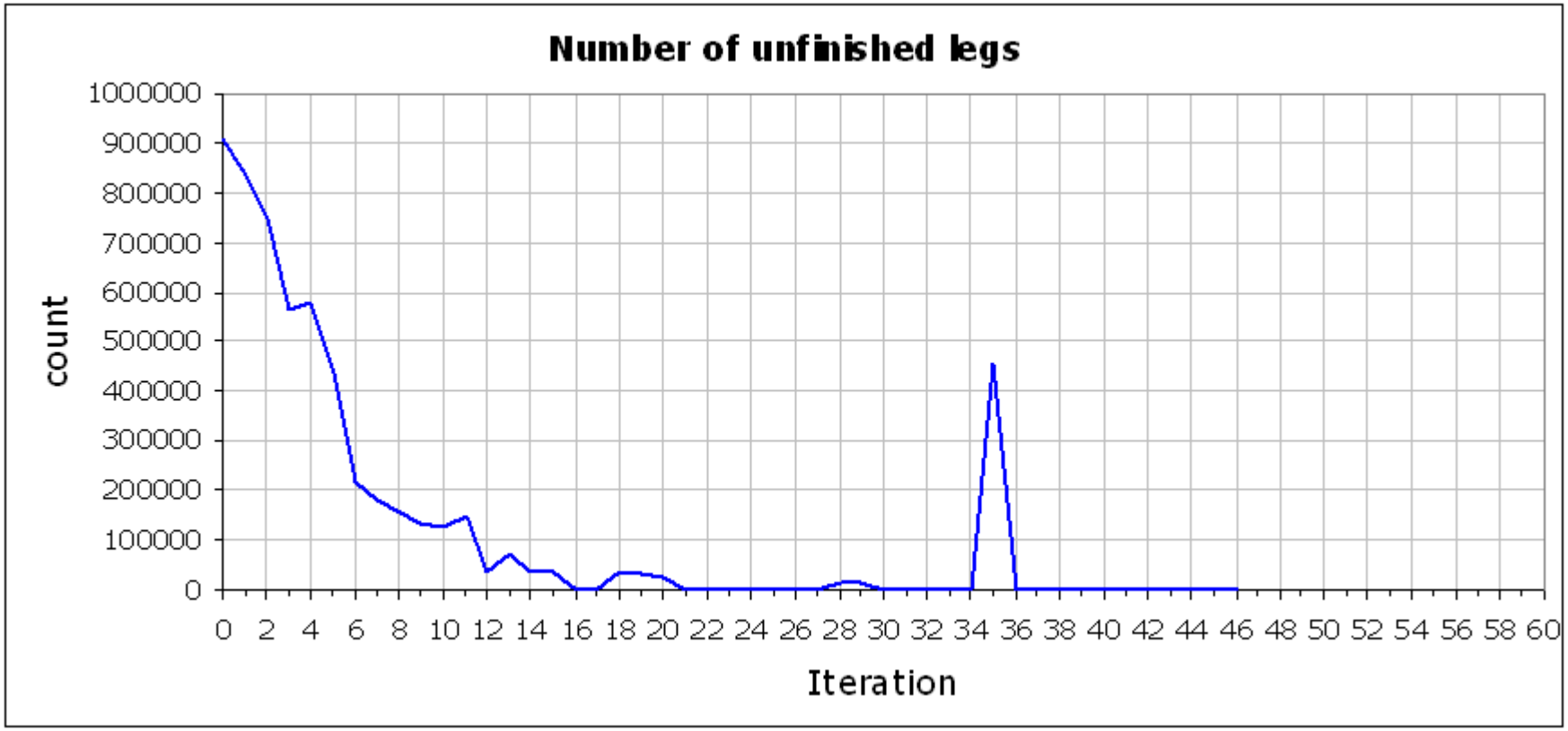


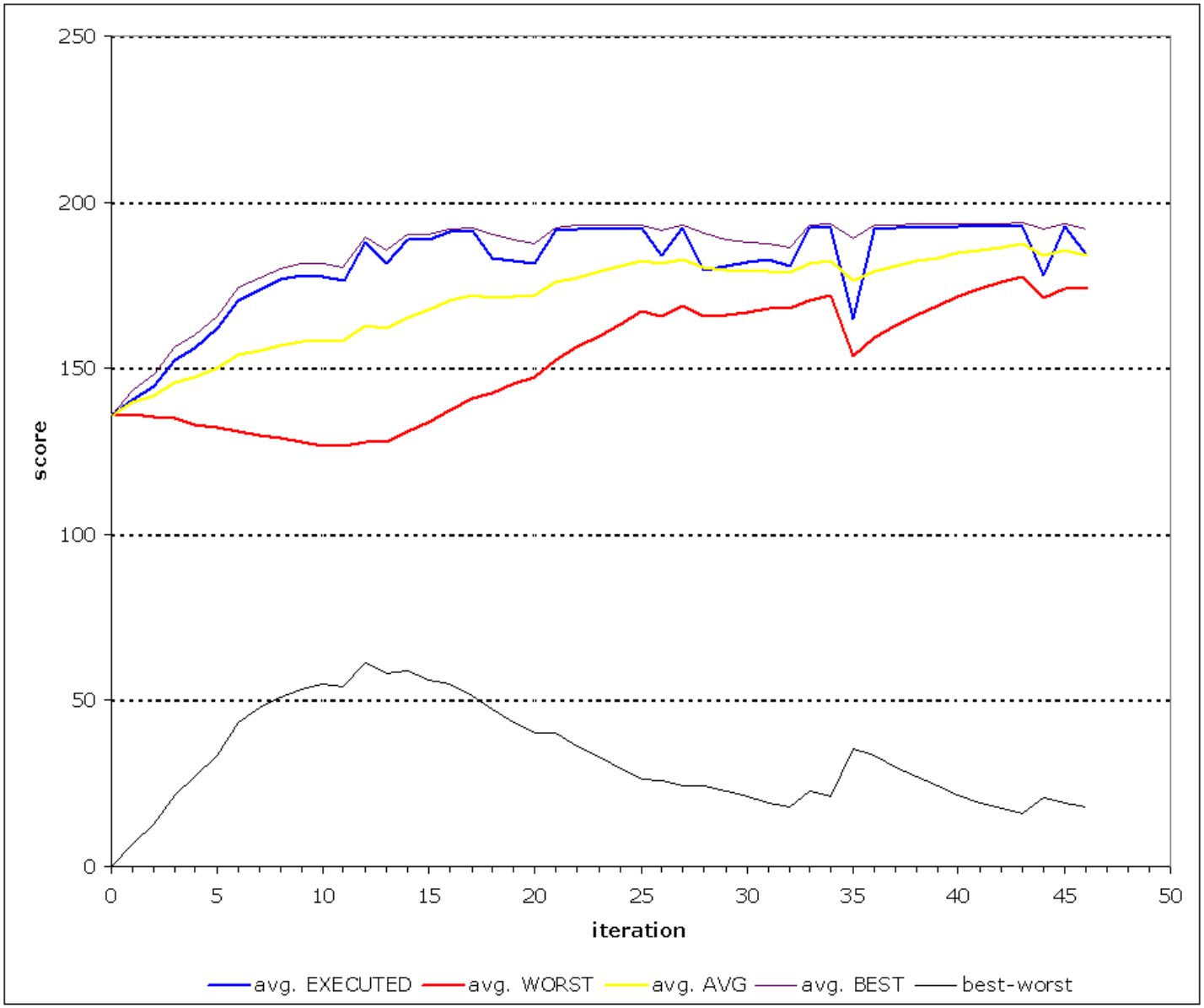
More about the Run...



More about the Run...



More about the Run...



More about the Run...

Departure, arrival, and “on route” histograms (5min time bin)

Thanks!

Literature

Balmer, M. (2007) Travel demand modeling for multi-agent traffic simulations: Algorithms and systems, Ph.D. Thesis, ETH Zurich, Zurich.

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