A Continuous Query System for Dynamic Route Planning

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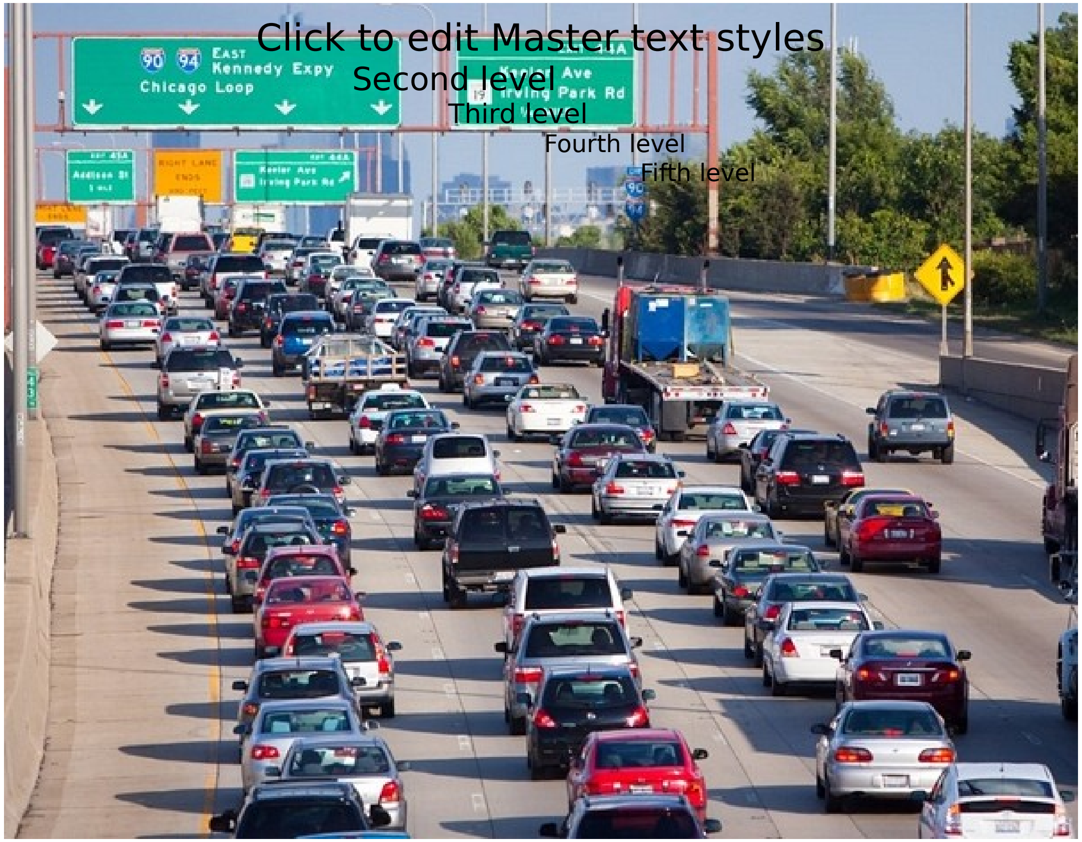
Traffic congestion is a real problem

- $115 billion congestion cost in 2009 (in USA)
- 34 hours of yearly peak delay for average commuter



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Continuous Routing Queries

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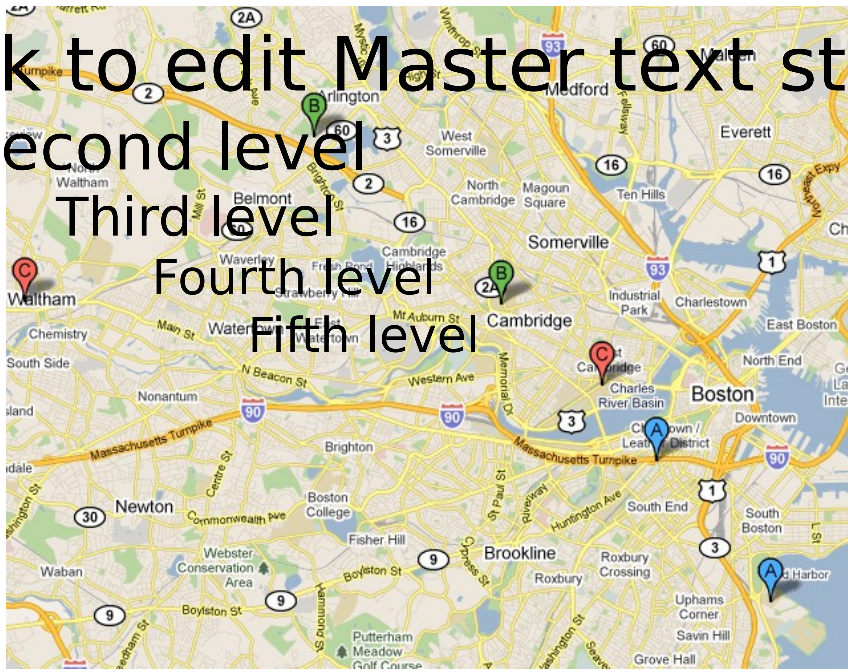
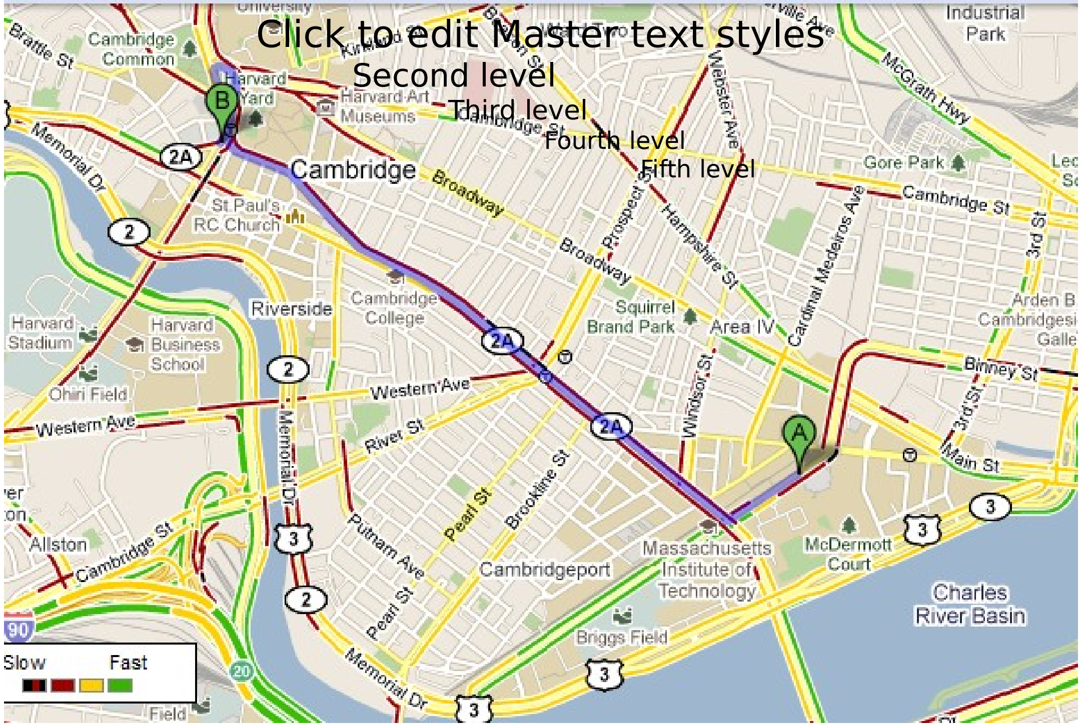


A traffic aware *dynamic* route planning service

- User registers pair <source *s*, destination *t*>
- Continuously monitors *s-t* routes as traffic delays change
- Keeps user updated with a *near-optimal s-t* route
- Scalable

Doesn't Google Maps solve this problem already?

- Routing based on pre-processed edge weights
- Ad-hoc routing only
- Real time traffic layer overlay for visualization



Roadblocks

Can't do repeated shortest-path recalculation

- Not *scalable*

Academic work on *incremental* SP algorithms

- High space overhead (memory-resident)
- High computation overhead
- Tries to get optimal (which is not critical here)

Solution: A Continuous Query System

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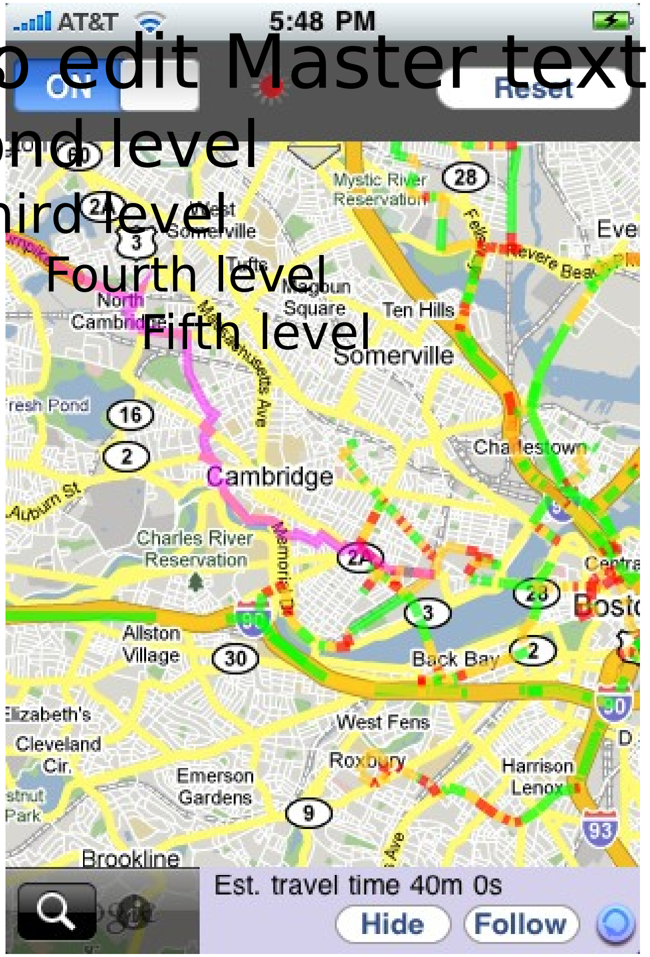

Key Ideas

Traffic updates affect only a small part of the road network
Mix of pre-computation and on-the-fly route calculation
Update only when there are significant delay changes

Our Algorithms

K-Candidate-Paths

Proximity-based approach

K candidate paths

Pre-compute K different routes
Dynamically select the best candidate as delays change
- Re-computation limited to K routes

Want changes in traffic delays to not adversely affect all K routes simultaneously
Different strategies for computing K paths

Yen's algorithm

Find the shortest path
Pick a vertex v from the path
Delete edges joining v in the path
Find the shortest path again

K-Variance

Perturb randomly the edge weights
For every perturbation, find the shortest path
Sample the edge cost from a Gaussian distribution
- Parameters learnt from history

Run the algorithm until K *distinct* paths are found
Lots of overlap in paths

Partially overlapping paths

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System Architecture

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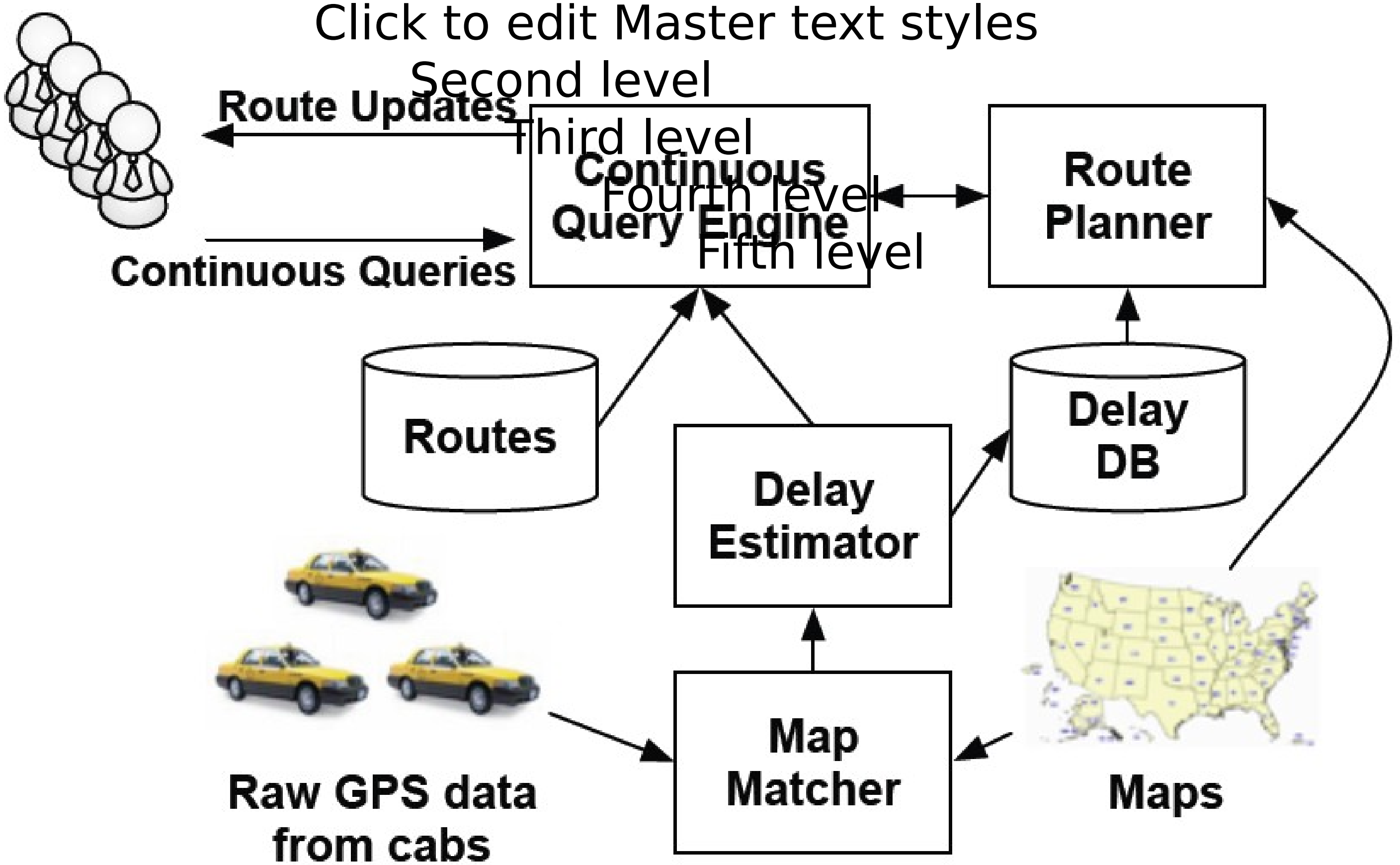


K-Statistical

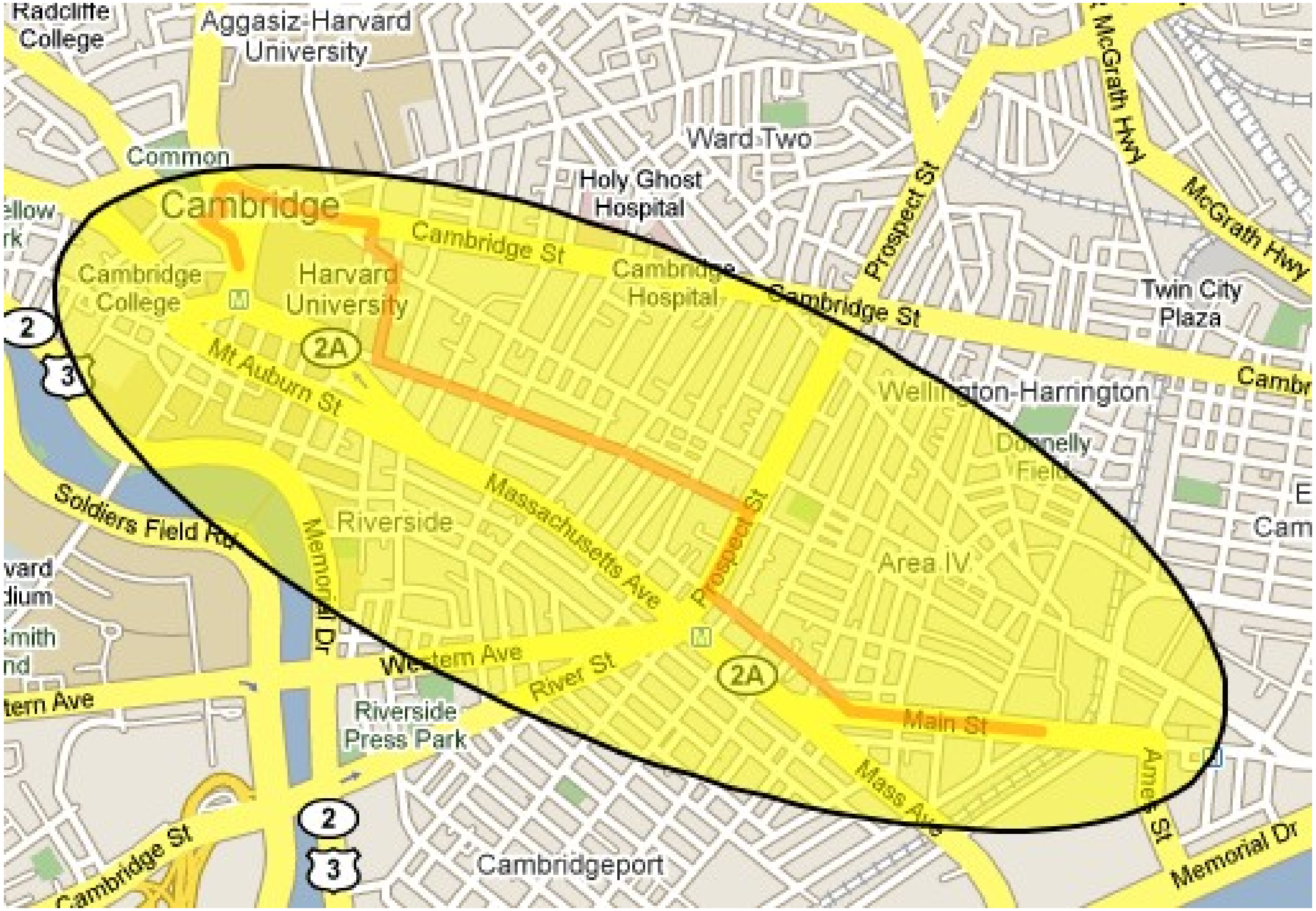
Variant of Yen's K shortest loopless paths algorithm
- Loopy paths, i.e., paths with cycle don't make sense

Delete each edge of the path found in the previous iterations with some probability
Re-do the shortest path calculation on the modified graph

Proximity-based

Compute shortest paths in a constrained region
Constraint on proximity
Shape of constrained region is ellipse
- Polygons take more space
- Ellipses better represent human behavior than rectangles

Proximity-based

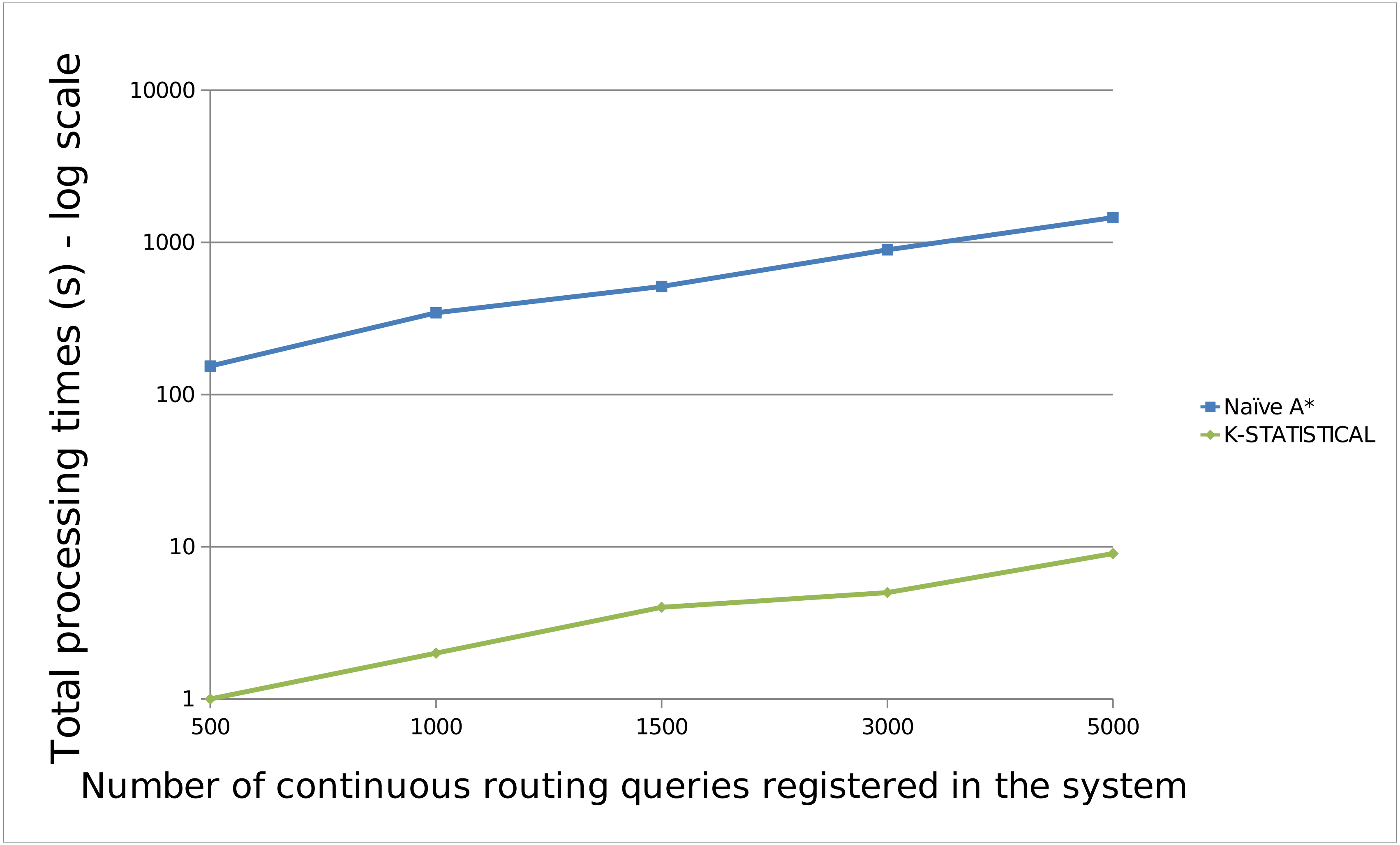


Results

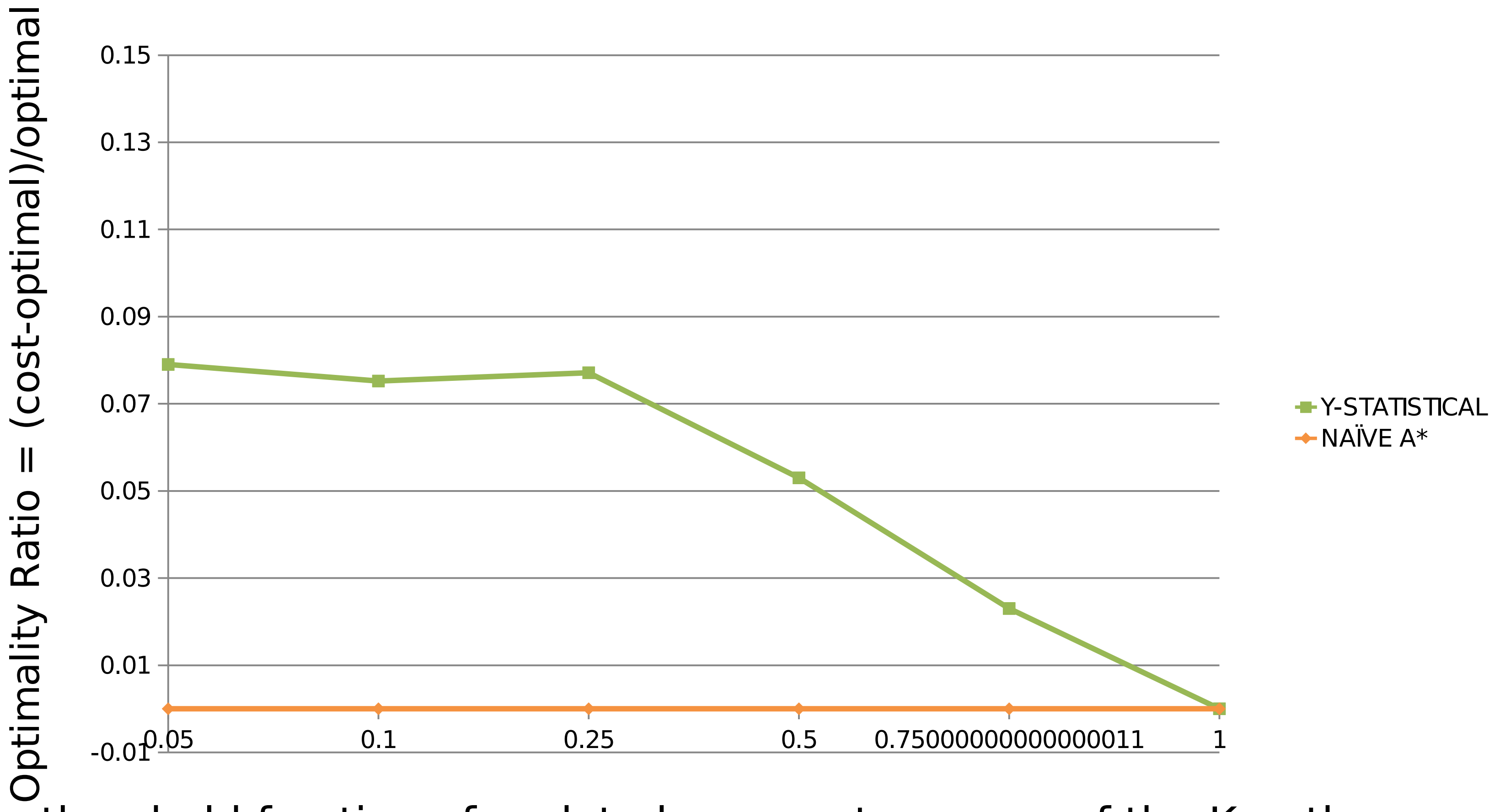
7,000 drives chosen from CarTel log containing 150,000 real drives
Replayed data from 2 months of our traffic delay database
Crucial parameters:

- ϵ: captures number of segments with delay updates
- Υ: captures degree of change in segment delay
- K: set to 5

Two orders of magnitude faster

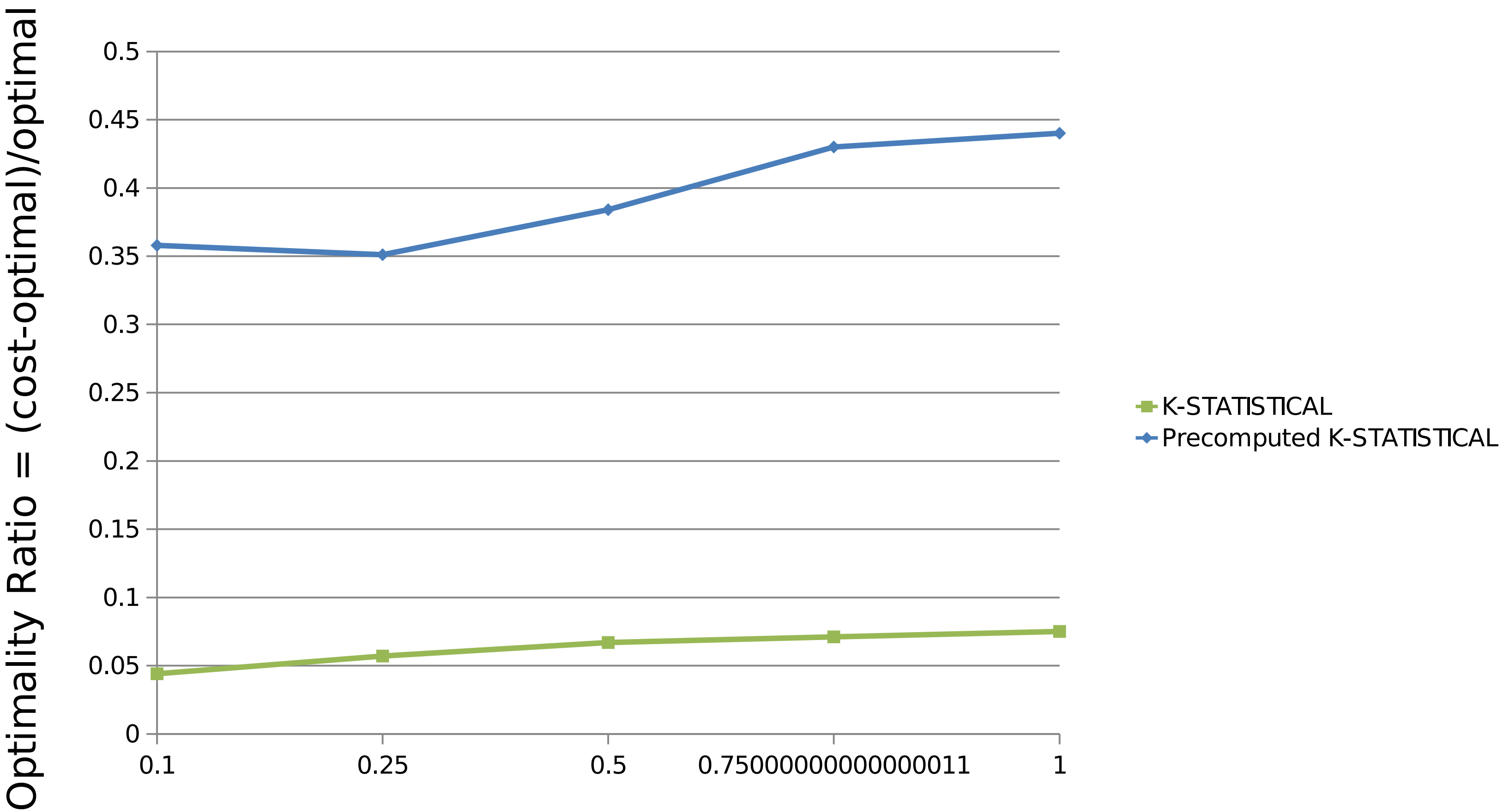


New routes are near optimal



ϵ : threshold fraction of updated segments on any of the K paths

Previously reported routes are near optimal on no update



ϵ : threshold fraction of updated segments on any of the K paths

Conclusions

- Fast and scalable continuous routing scheme which is accurate
- Routes delivered by our techniques are within 4-7% of the optimal
  - average optimality gap for pre-computed routes over 30% in all cases

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THANK YOU