Scalability of Route Planning Techniques

Johannes Blum and Sabine Storandt

Julius-Maximilians-Universität Würzburg, Germany

Research Question

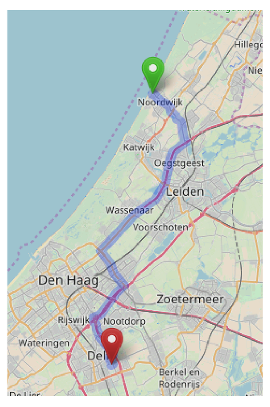
How do Route Planning Techniques scale on Road Networks?

Shortest Path Problem

Given graph $G(V, E)$

Query source $s \in V$, target $t \in V$

Goal distance of shortest path from s to t

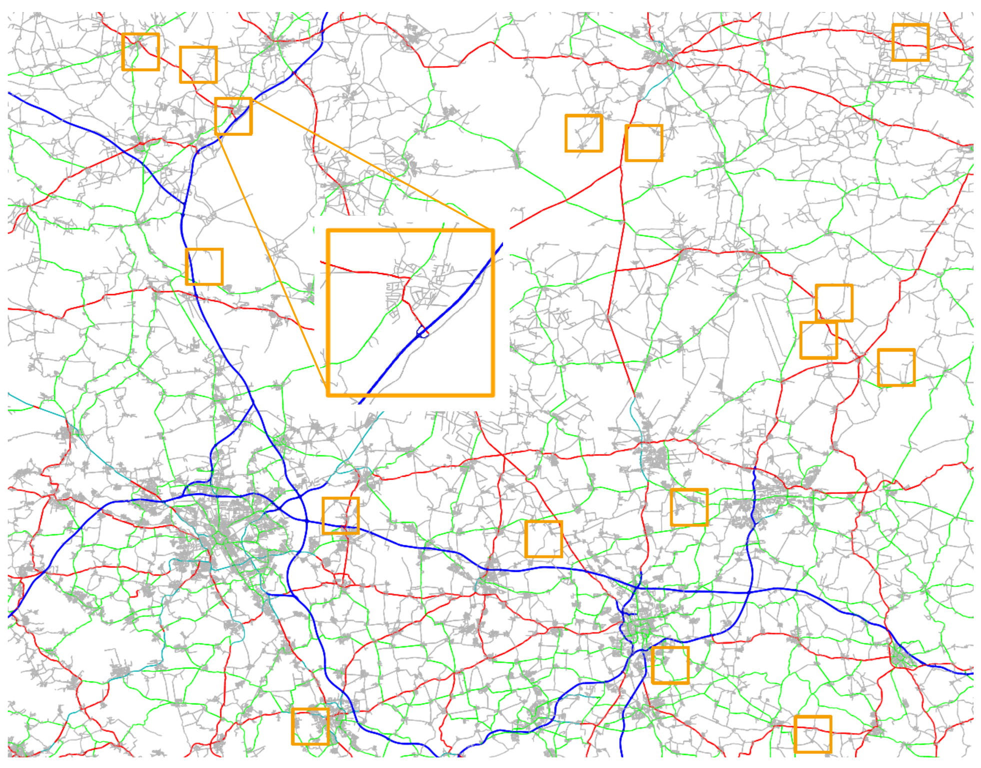


Route Planning Techniques on Western Europe

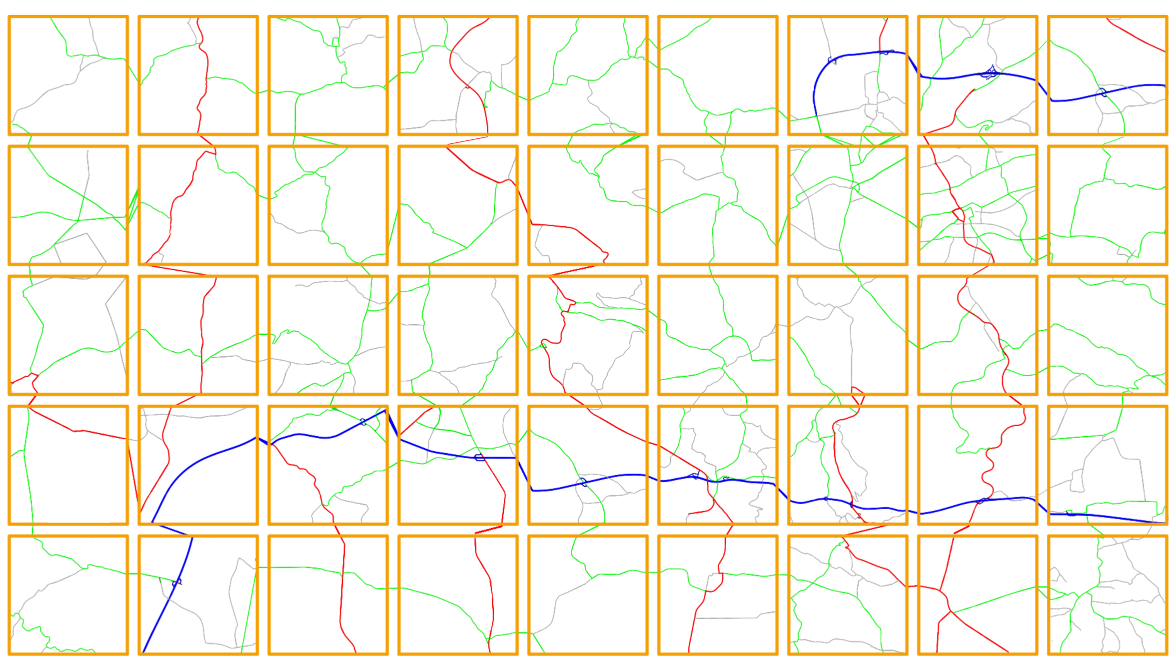
	Contraction Hierarchies		Transit Nodes		Hub Labels
query	110 μs	>	2.09 μs	>	0.56 μs
space	0.4 GB	<	2.5 GB	<	18.8 GB

Road Network Generator

Step I: Cut Tiles from Real-World Network



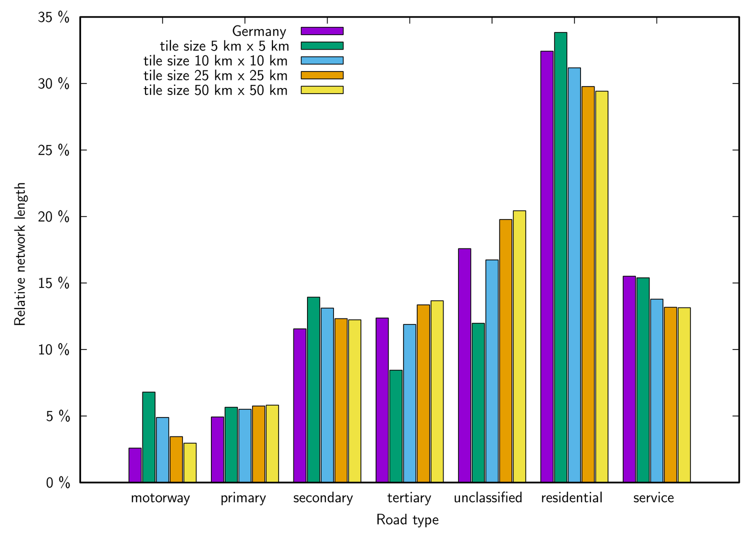
Step II: Combine Tiles



800 million nodes: 110 min / 7.5 GB

few parameters required

Validation



Relative network length of road types

network	degree 1	2	3	4	≥ 5
Germany	6.5%	75.5%	15.6%	2.2%	0.3%
Generated	6.2%	76.1%	15.3%	2.2%	0.3%

Relative frequency of node degrees (tile size 25 km $\times$ 25 km)

Scalability Study

Setup

Networks with 2 000 to 800 million nodes

Route Planning Techniques

- Contraction Hierachies (Edge Difference)
- Hub Labels (CH-based)
- Hub Labels (Skeleton-based)
- Transit Nodes (CH-based)

Model functions

polylogarithmic growth $f(x) = a \cdot \log_2(x)^b$

polynomial growth $g(x) = a \cdot x^b$

Fitting

Marquardt-Levenberg algorithm

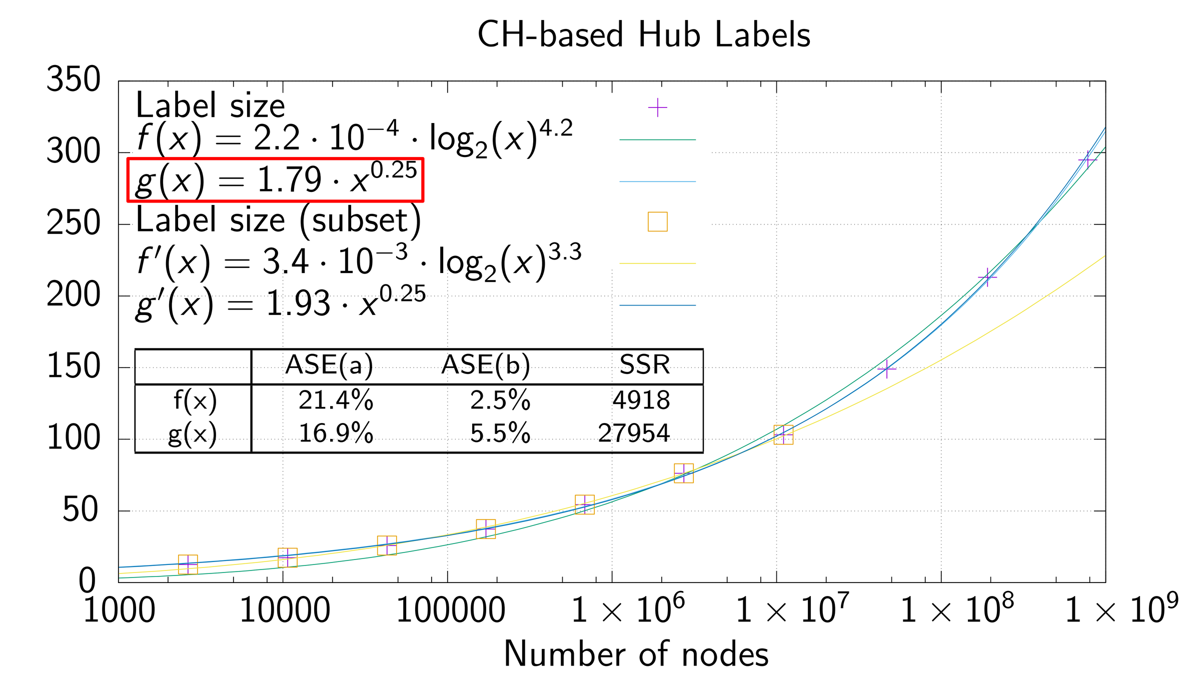
modifies parameters iteratively

Sum of squares of residuals (SSR)

gaps between data and fitted function

Aymptotic standard error (ASE)

approximation for the standard deviation



Results

	query	space
Hub Labels (CH-based)	$\mathcal{O}(n^{0.25})$	$\mathcal{O}(n^{1.25})$
Hub Labels (Skeleton-based)	$\mathcal{O}(\log^{0.26} n)$	$\mathcal{O}(n \log^{0.26} n)$
	$\wedge$	$\vee$
Contraction Hierachies	$\mathcal{O}(\sqrt{n})$	$\mathcal{O}(n)$
Transit Nodes	$\mathcal{O}(n)$	$\mathcal{O}(n\sqrt{n})$