Accurate High-Performance Route Planning

Peter Sanders **Dominik Schultes**

Institut für Theoretische Informatik – Algorithmik II

Universität Karlsruhe (TH)

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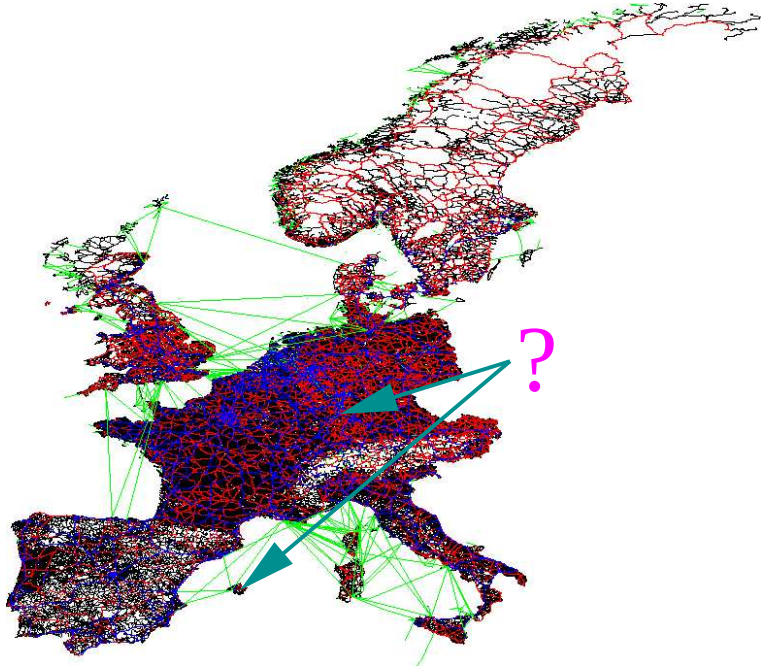
How to come from A to B ?

Applications

- Internet route planning (z.B. `www.map24.de`)
- car navigation systems
  (embedded, radio replacement, PDA,. . .)
- server based using mobile phone, . . .

Basic Requirements

- exact fastest routes
- fast queries
- low memory requirements

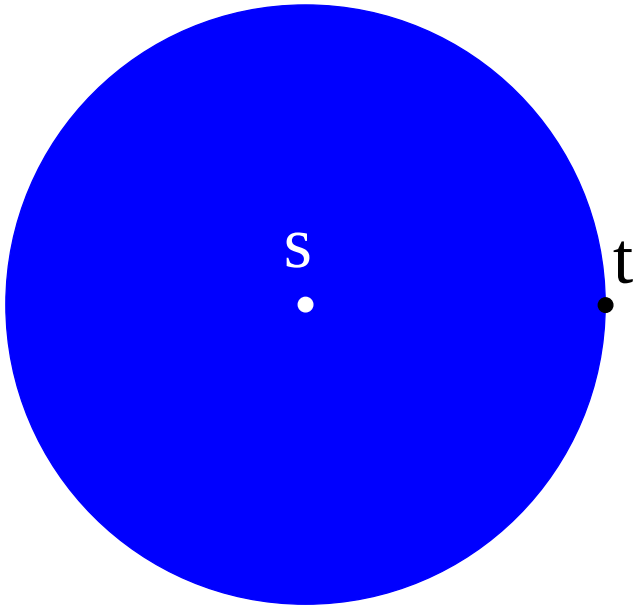


DIJKSTRA's Algorithm

classical approach from graph theory

for computing shortest paths

Dijkstra



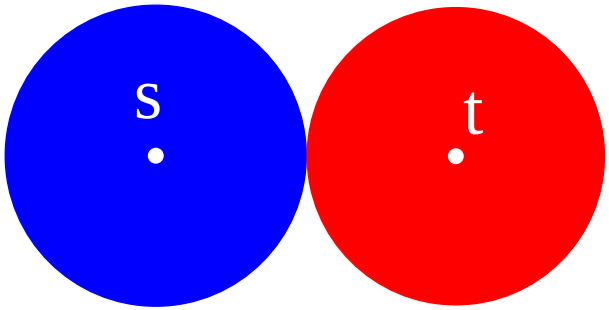
too expensive for large street networks

(e.g., Western Europe: 22 mill. roads)

Bidirectional Search

Improvement of DIJKSTRA's Algorithm

bidirectional Dijkstra



Halves search space,

but still too slow

Naive Route Planning

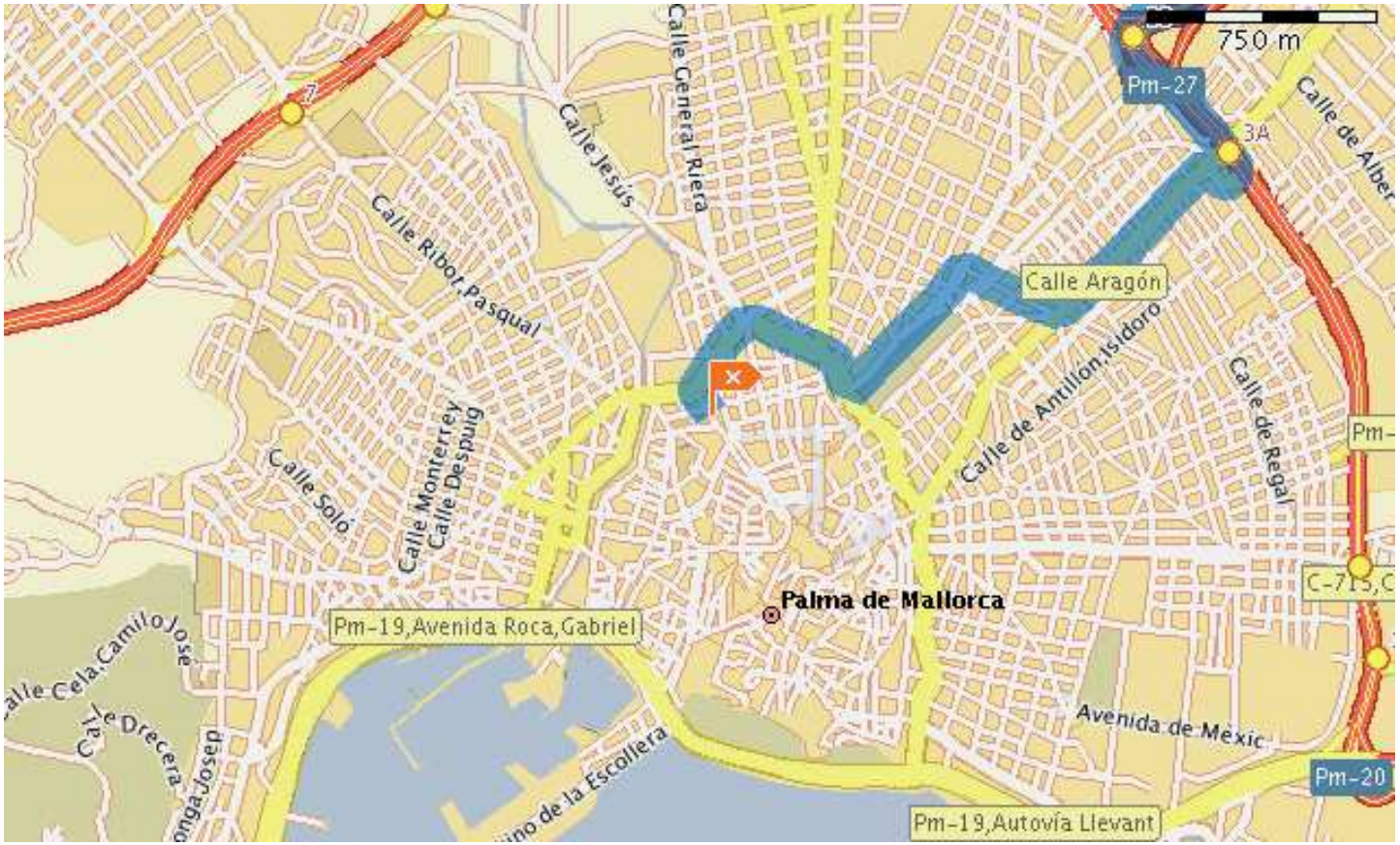
1. Look for next motorway entrance

Naive Route Planning

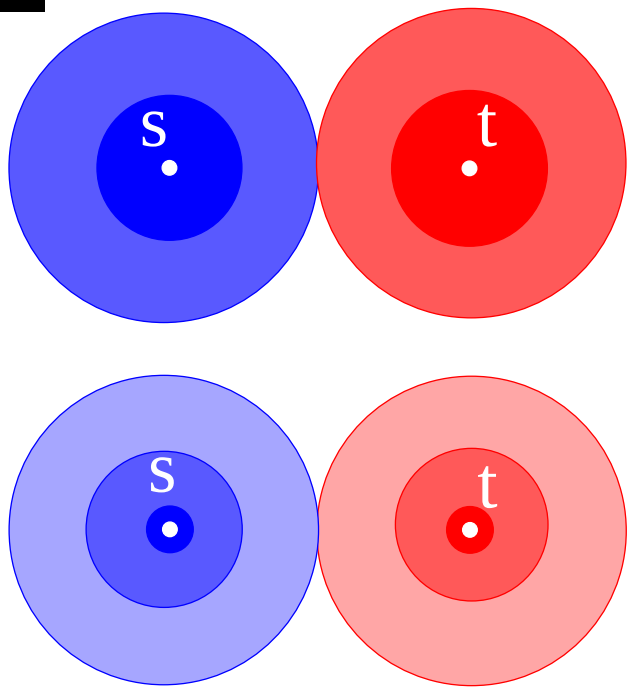
1. Look for next motorway entrance
2. Get as close to target as possible using motorways

Naive Route Planning

1. Look for next motorway entrance
2. Get as close to target as possible using motorways
3. Route from motorway exit to target



Commercial Approach



Heuristic Highway Hierarchy

- complete search in local area
- search in (more sparse) highway network
- iterate $\rightsquigarrow$ highway hierarchy

Defining the highway network:

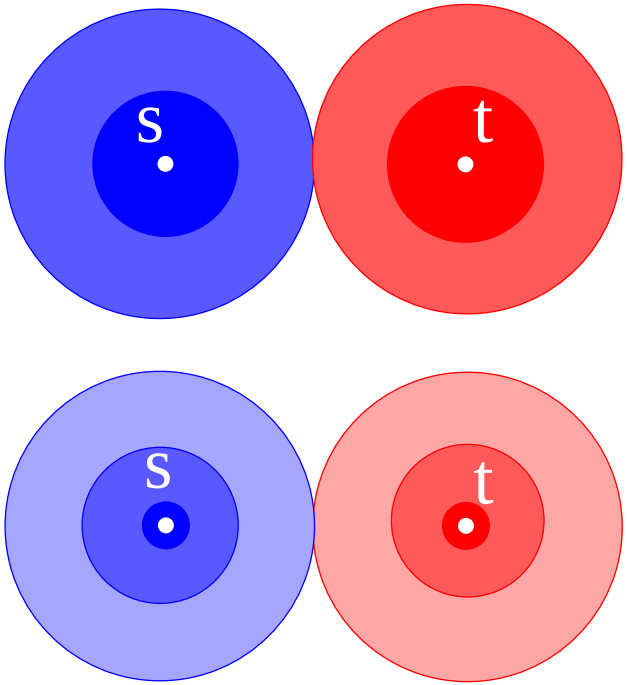
use road category (highway, federal highway, motorway,...)

$+$ manual rectifications

delicate compromise

speed $\Leftrightarrow$ accuracy

Our Approach



Exact Highway Hierarchy

- complete search in local area
- search in (more sparse) highway network
- iterate $\rightsquigarrow$ highway hierarchy

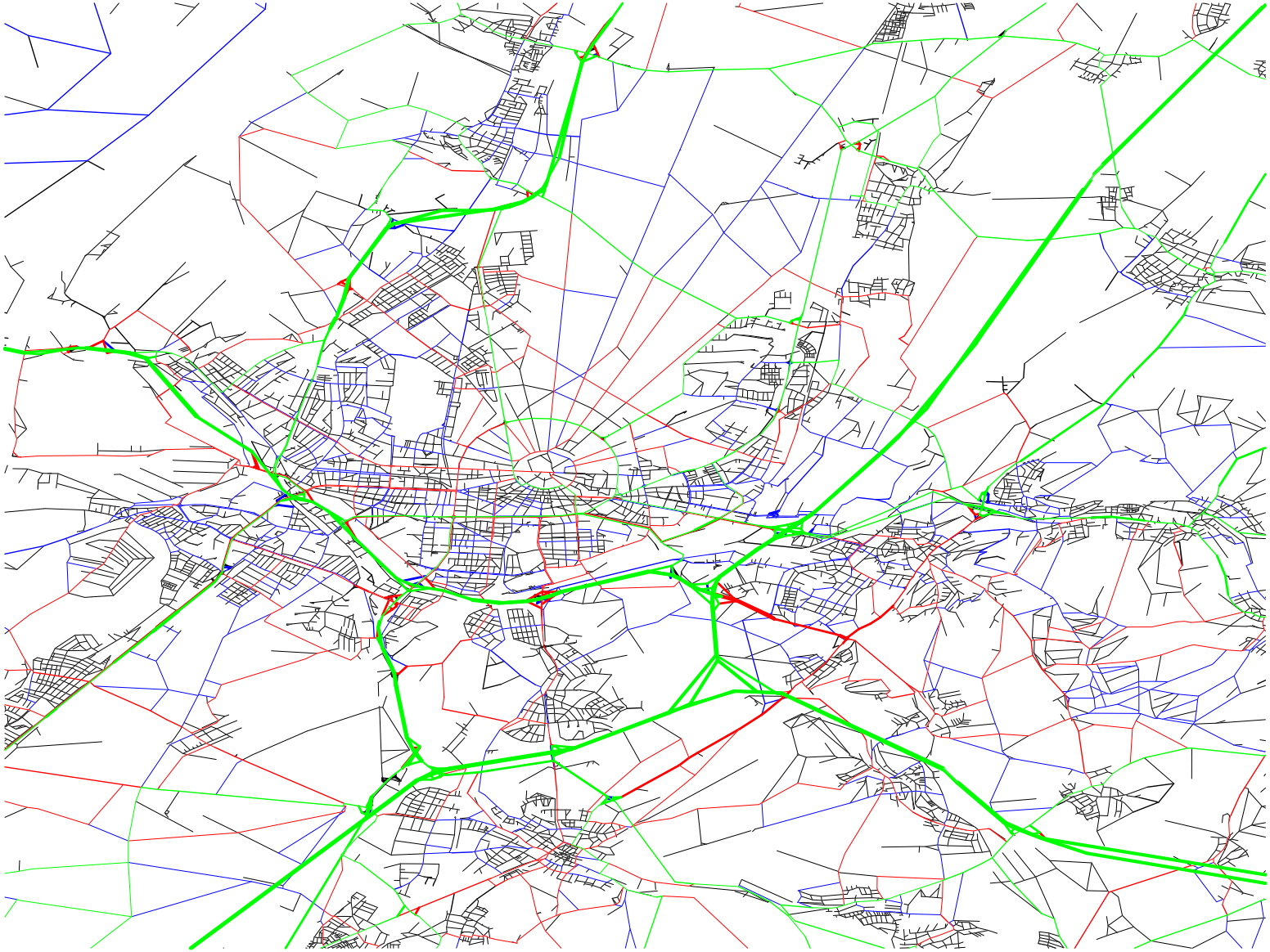
Defining the highway network:

minimal network,

that preserves all shortest paths.

+ fully automatic (just fix neighborhood size)
+ uncompromisingly fast

Example: Karlsruhe

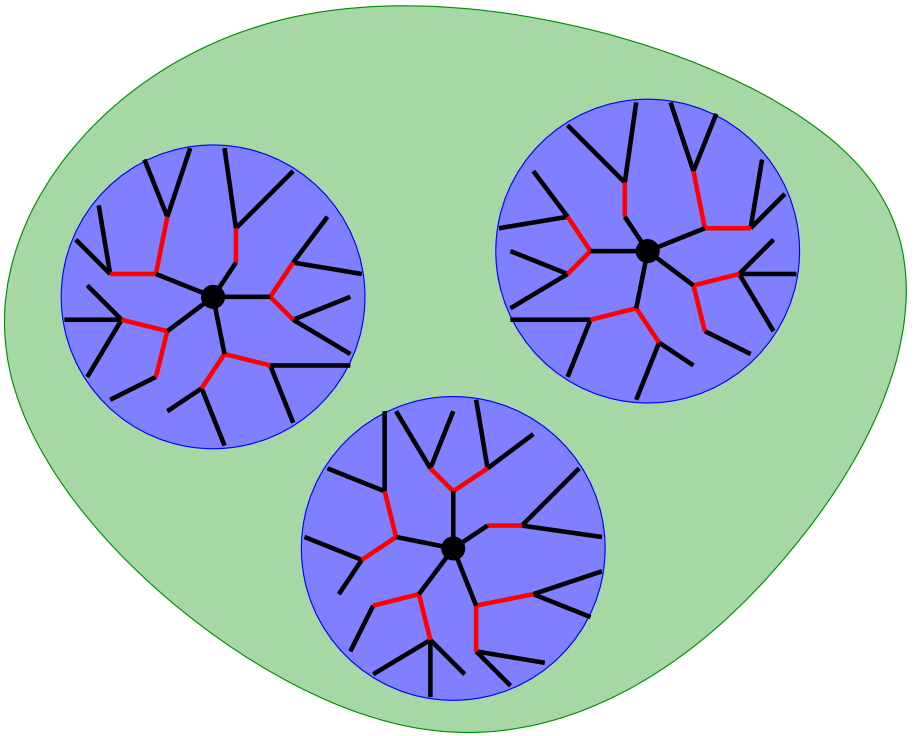


Fast Construction

Challenge

Avoid precomputation of shortest paths

between all node pairs



Solution

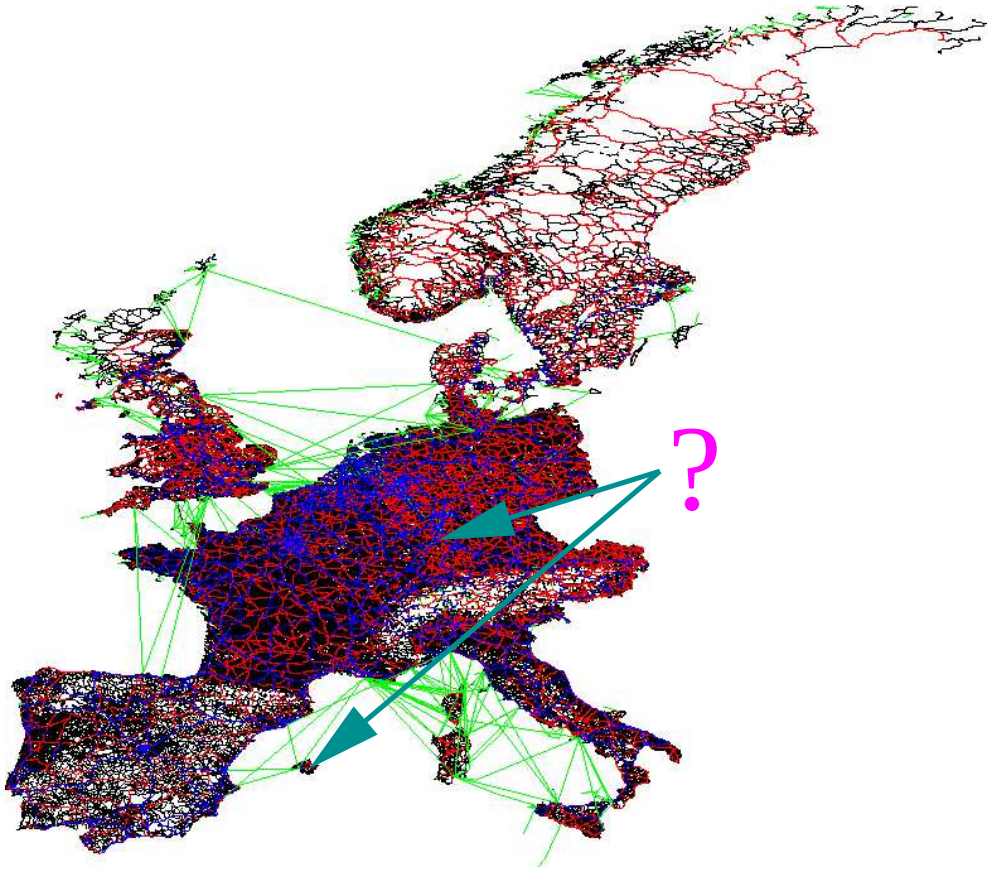
From each node:

Search a local area

Query

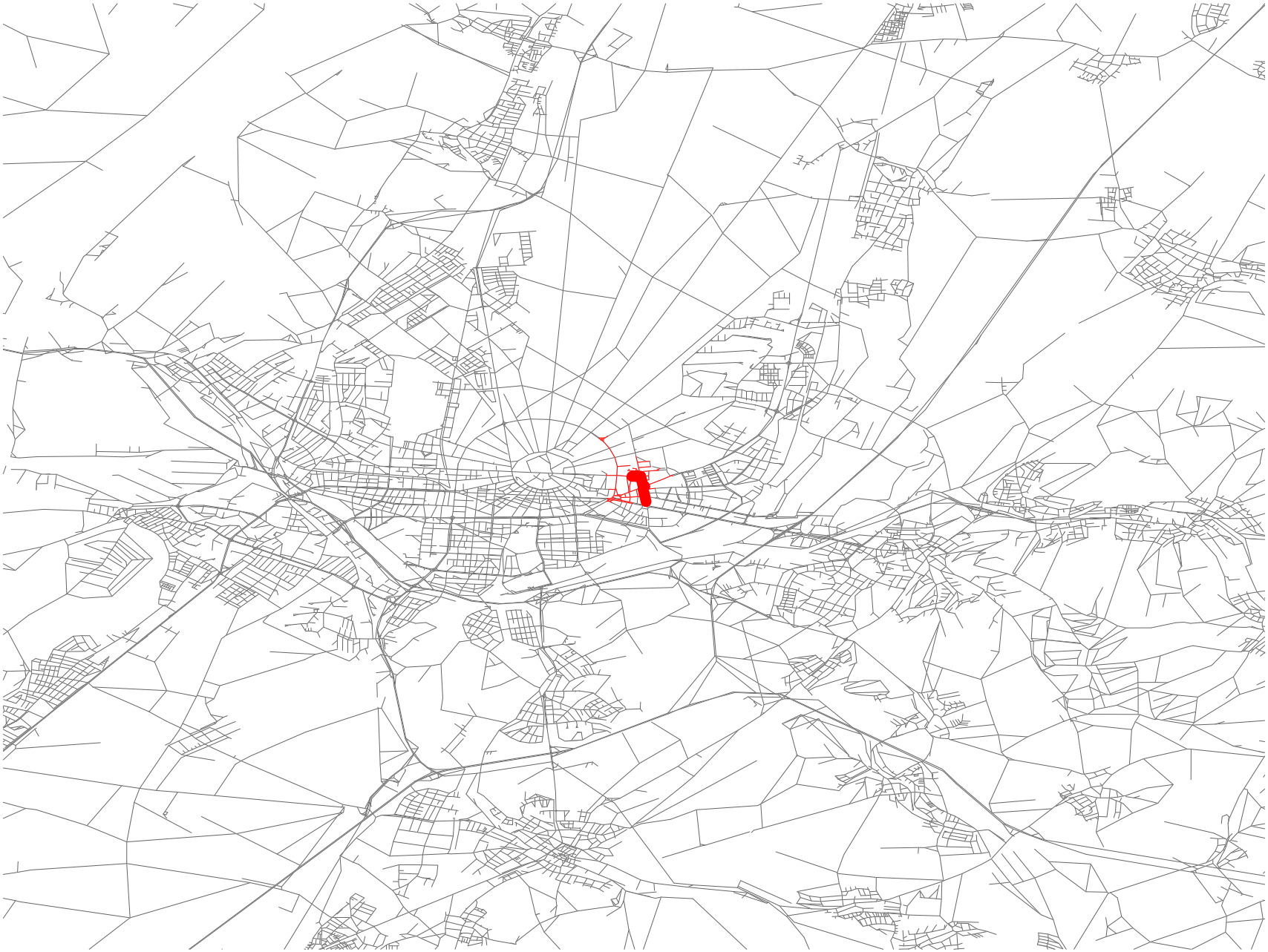
Example: from Karlsruhe, Am Fasanengarten 5

to Palma de Mallorca

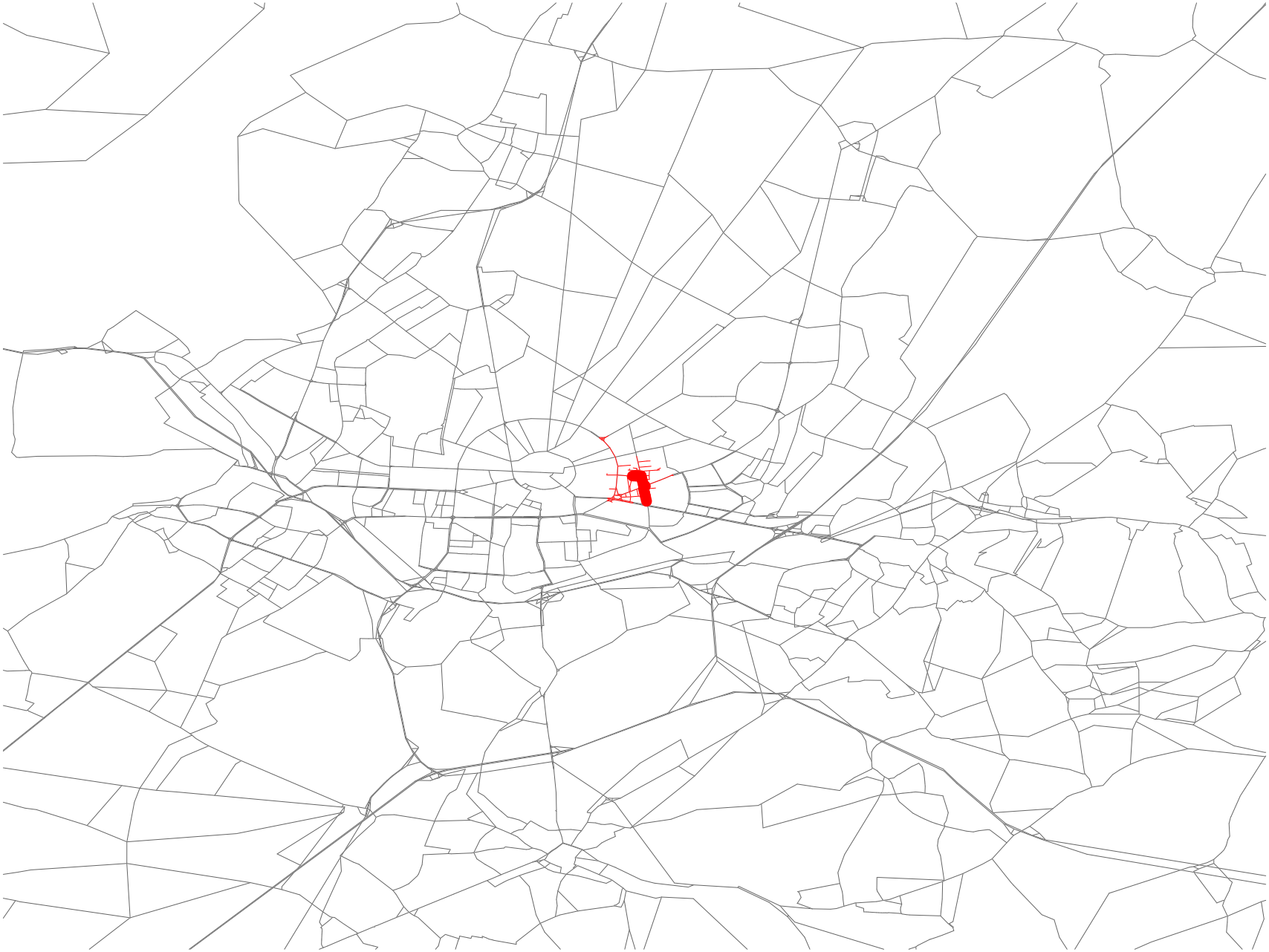


Level 0

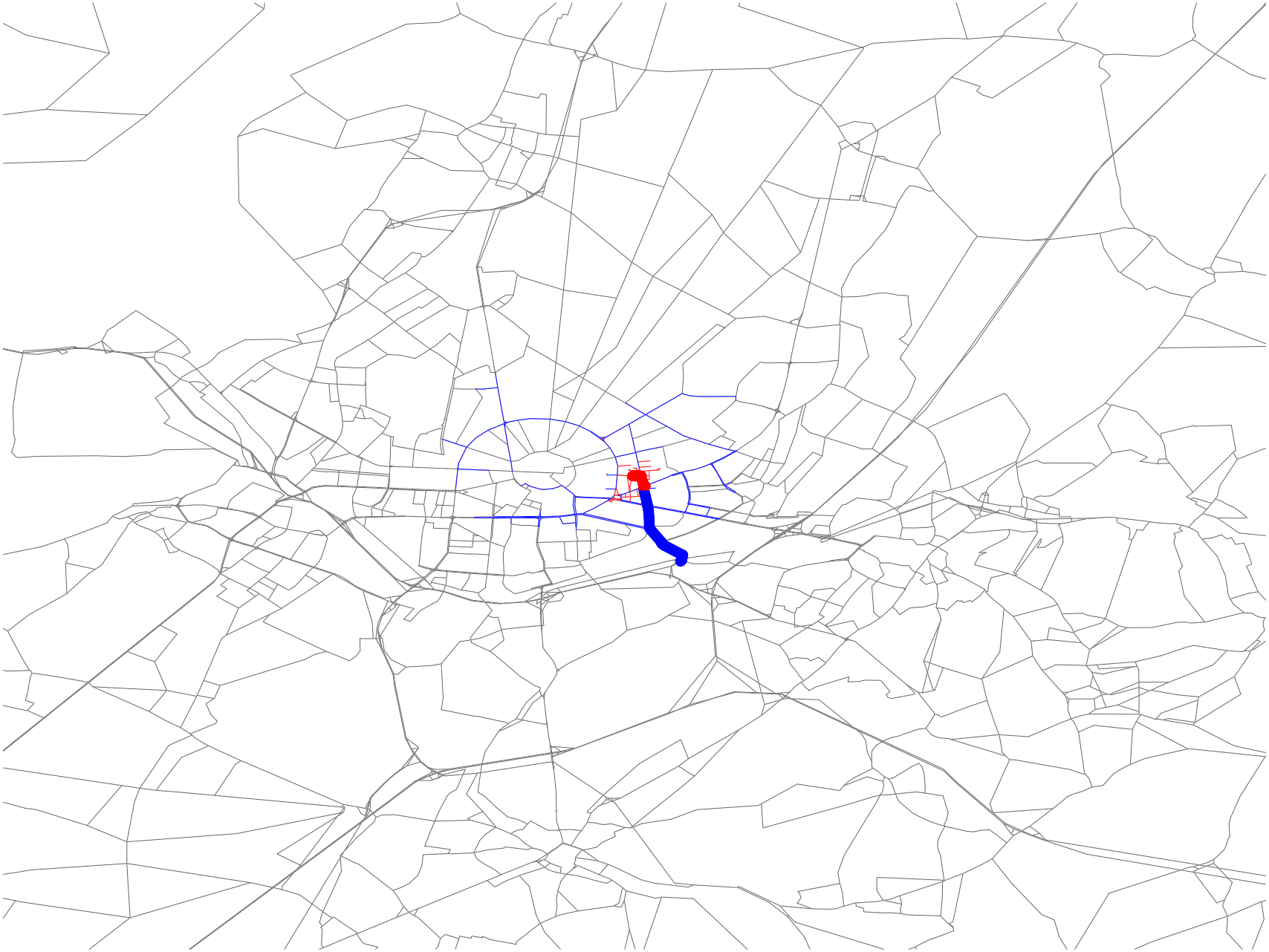
Level 0 search space



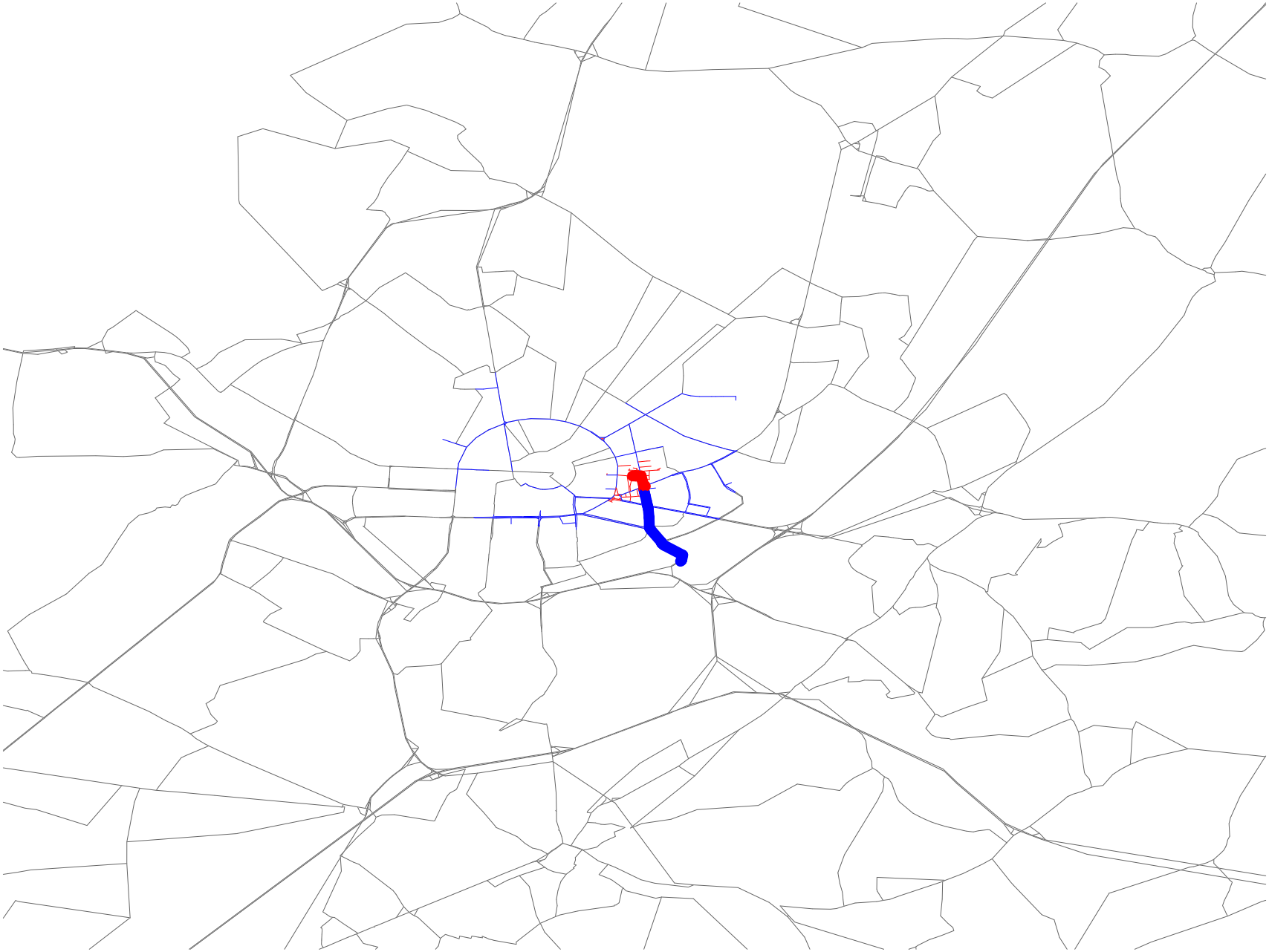
Level 1



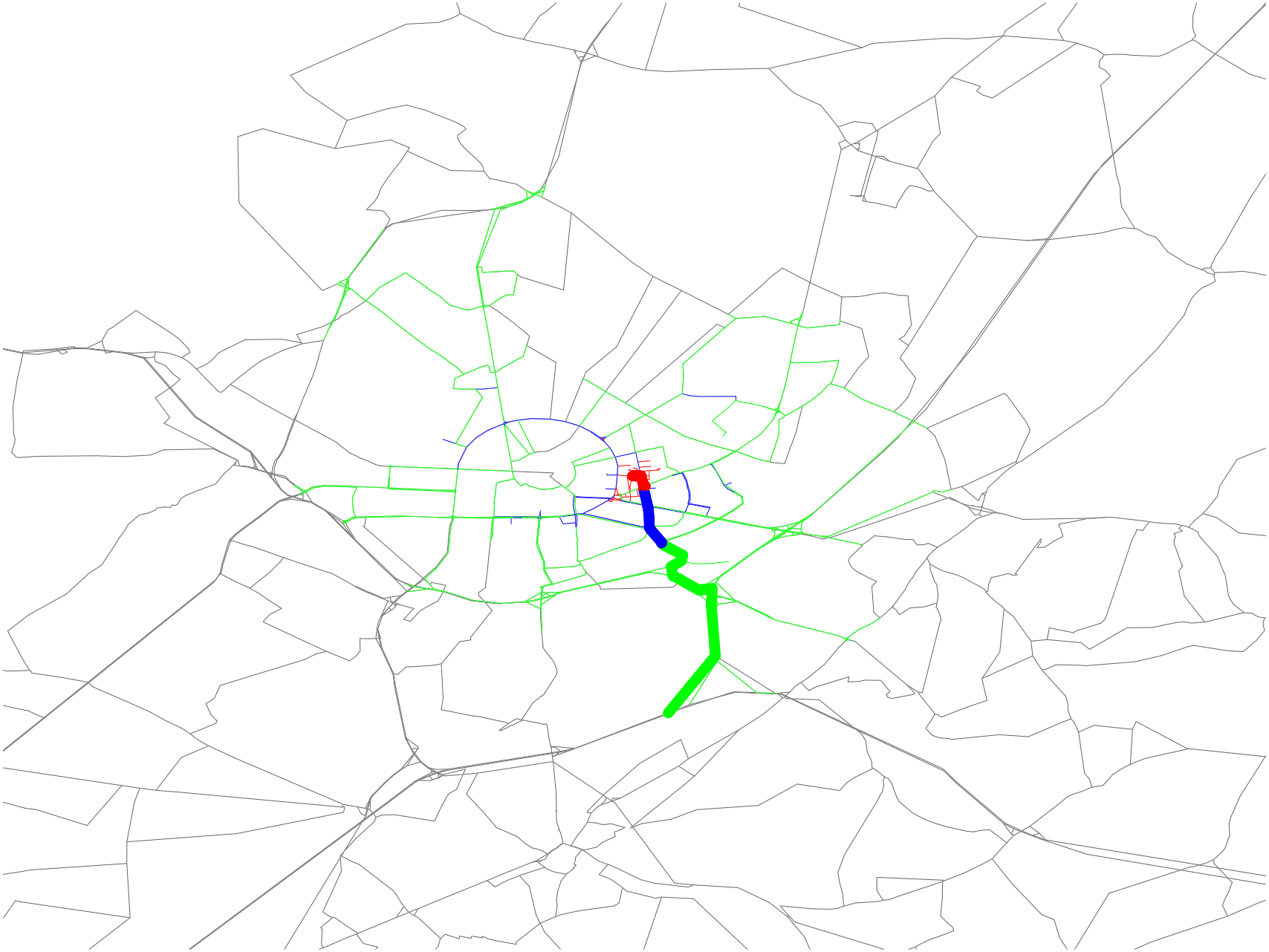
Level 1 search space



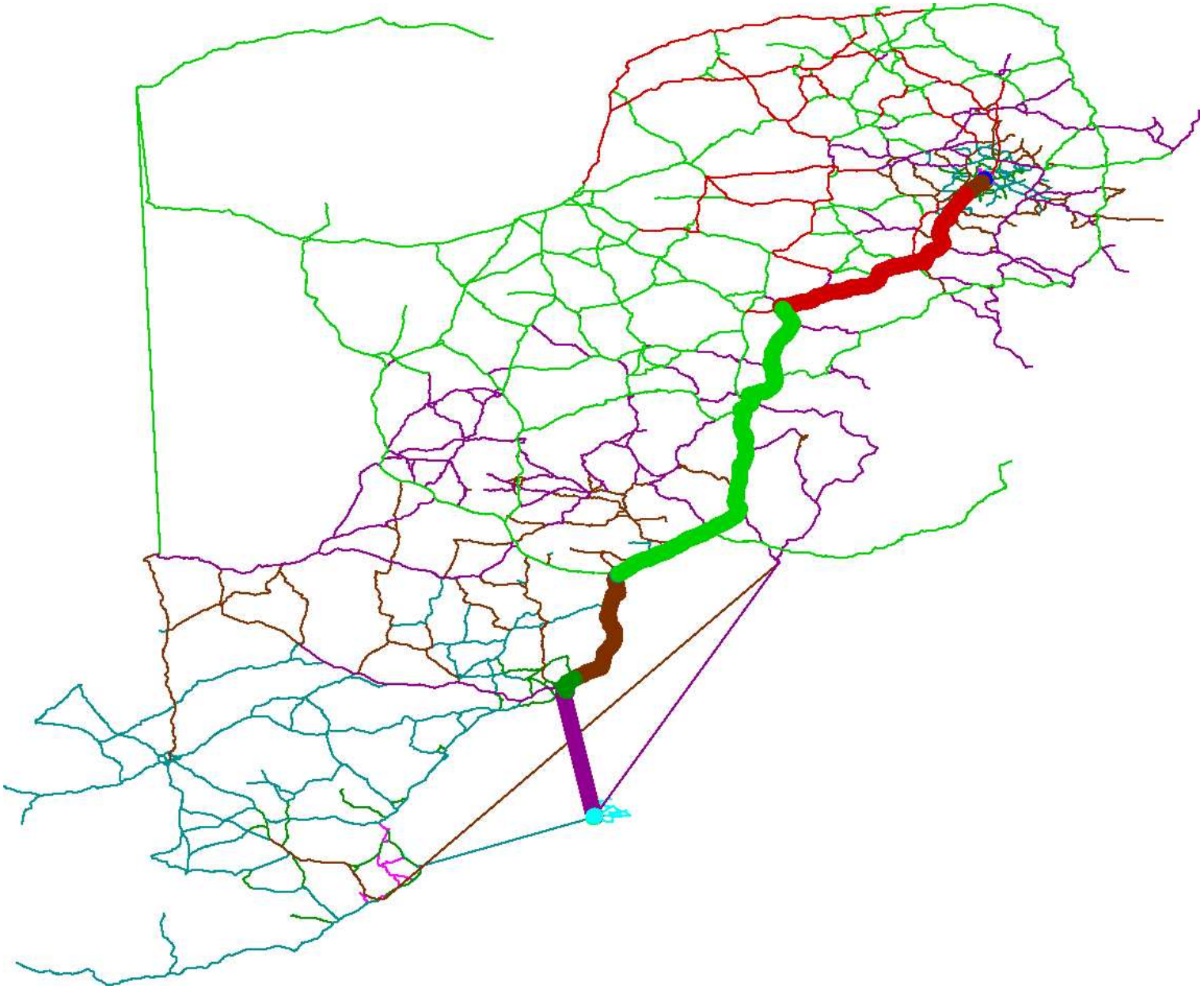
Level 2



Level 2 search space

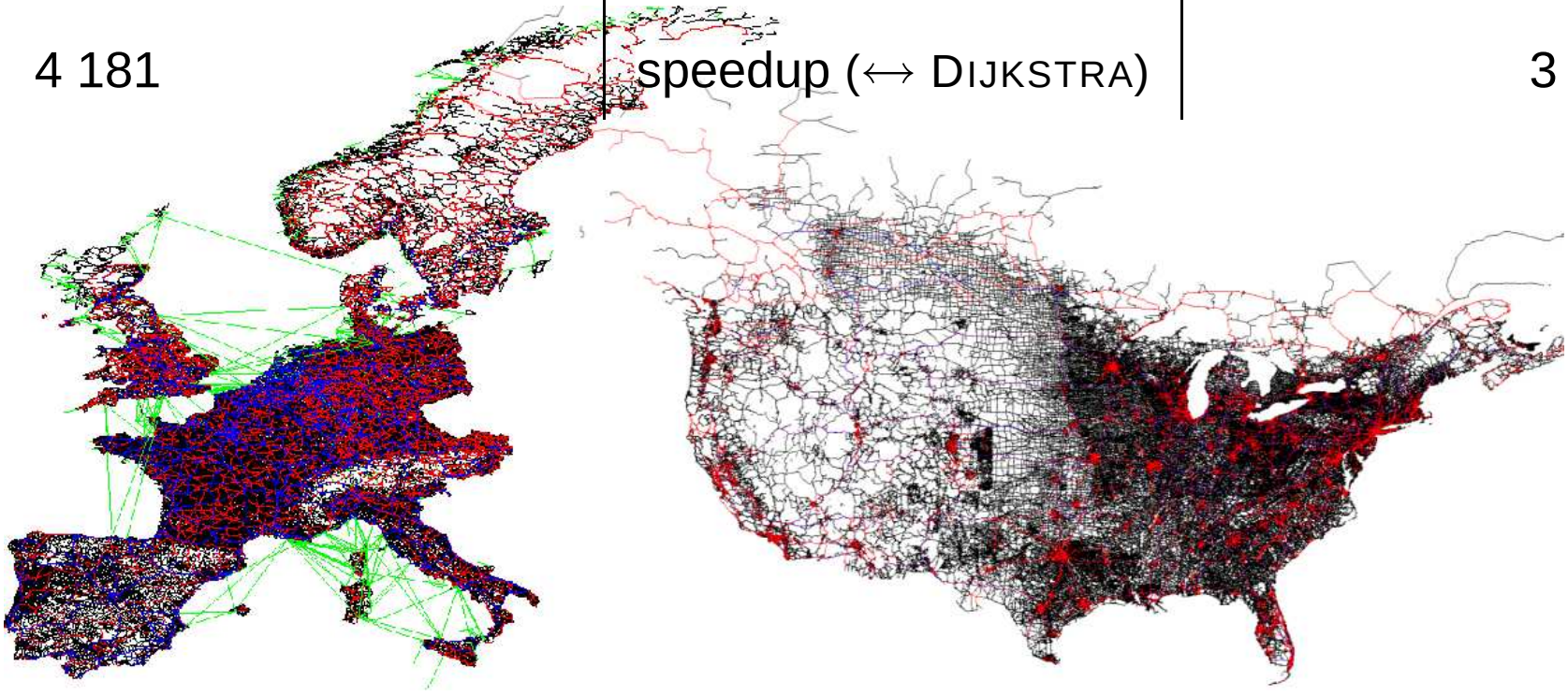


Level 10 search space



Experiments

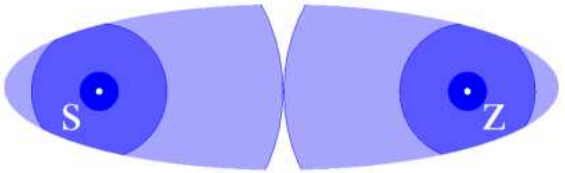
W. Europe (PTV)		USA/CAN (PTV)
18 029 721	#nodes	18 741 705
42 199 587	#directed edges	47 244 849
19	construction [min]	30
2.45	search time [ms]	3.37
4 181	speedup ($\leftrightarrow$ DIJKSTRA)	3 316



Summary

- exact routes in large street networks — e.g. $\approx$ 22 mill. roads
  - $\rightsquigarrow$ quality advantage, advertisement argument
- fast search — $\approx$ 3 ms on x86
  - $\rightsquigarrow$ cheap, energy efficient processors in mobile devices
  - $\rightsquigarrow$ low server load
  - $\rightsquigarrow$ lots of room for additional functionality
- fast preprocessing — $\approx$ 30 min
- low space consumption — $\ll$ data base
- no manual postprocessing of data
  - $\rightsquigarrow$ less dependence on data sources
- organic enhancement of existing commercial solutions

Future Work



- combination with goal directed approaches
- fast, local updates on the highway network

  (e.g. for traffi c jams)

- Implementation for mobile devices

  (flash access . . .)

- Flexible objective functions
- . . .

Industrial Cooperations

- We help transforming technology into products: consulting . . .
- Joint projects for further features

. . .