Accurate High-Performance Route Planning

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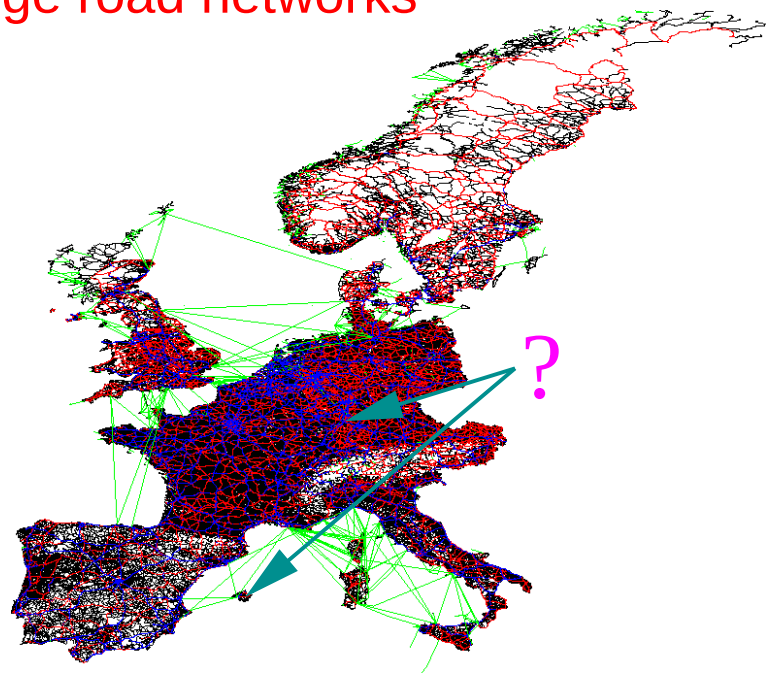
Route Planning

Goals:

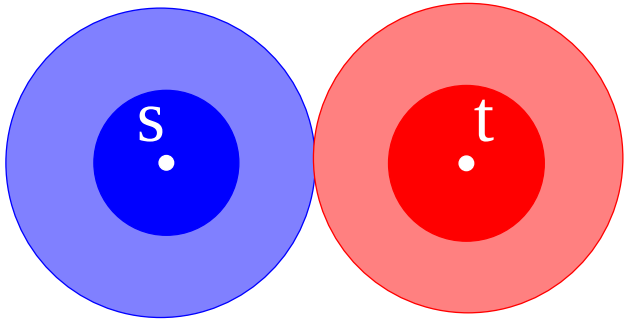
- exact shortest (i.e. fastest) paths in large road networks
- fast queries
- fast preprocessing
- low space consumption



Applications:

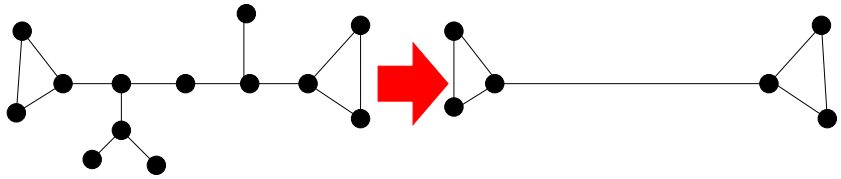
- route planning systems in the internet
- car navigation systems
- . . .

Our Approach: Highway Hierarchies[1]

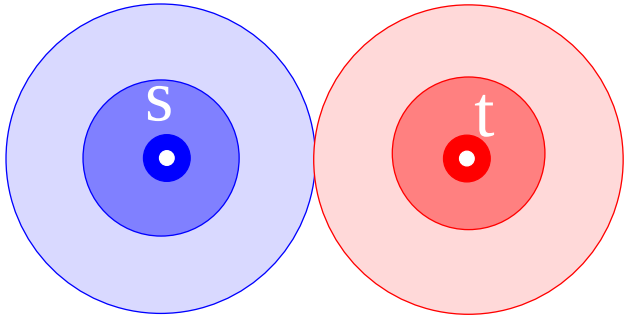


- complete search within a local area
- search in a (thinner) highway network

  = minimal graph that preserves all shortest paths



- contract network, e.g.,
- iterate $\rightsquigarrow$ highway hierarchy



[1] presented at ESA 2005

Local Area

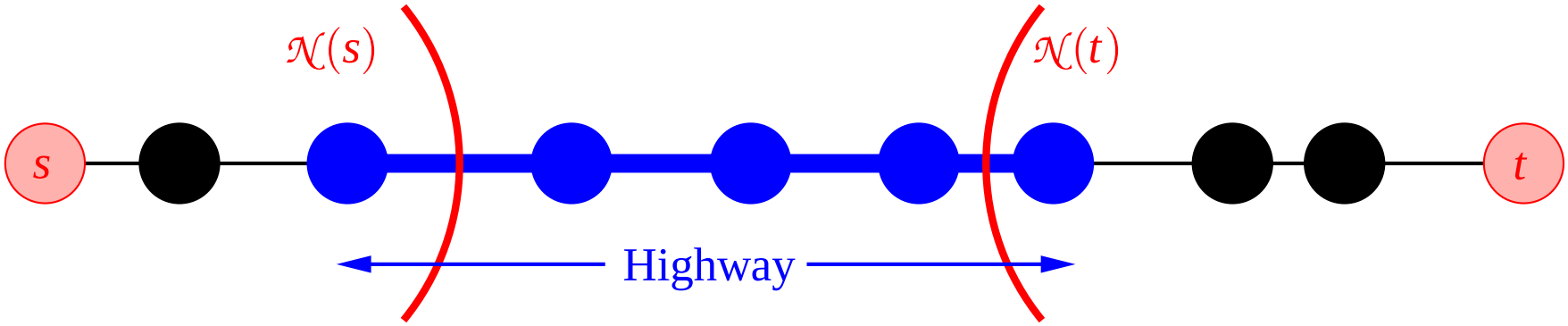
- choose neighbourhood radius $r(s)$

  (by a heuristic)

- define neighbourhood of s

$$\mathcal{N}(s) := \{v \in V \mid d(s,v) \leq r(s)\}$$

Highway Network



Edge (u,v) belongs to highway network *iff* there are nodes s and t s.t.

- (u,v) is on the "*canonical*" shortest path from s to t

and

- (u,v) is not entirely within $\mathcal{N}(s)$ or $\mathcal{N}(t)$

Improvements[2]

- support of directed graphs
- more general and more effective contraction
- simpler query algorithm
- faster preprocessing, faster queries, less memory usage
- per-instance worst case performance guarantees

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[2] to be presented at ESA 2006

Neighbourhood Radii

small changes do not significantly affect the performance

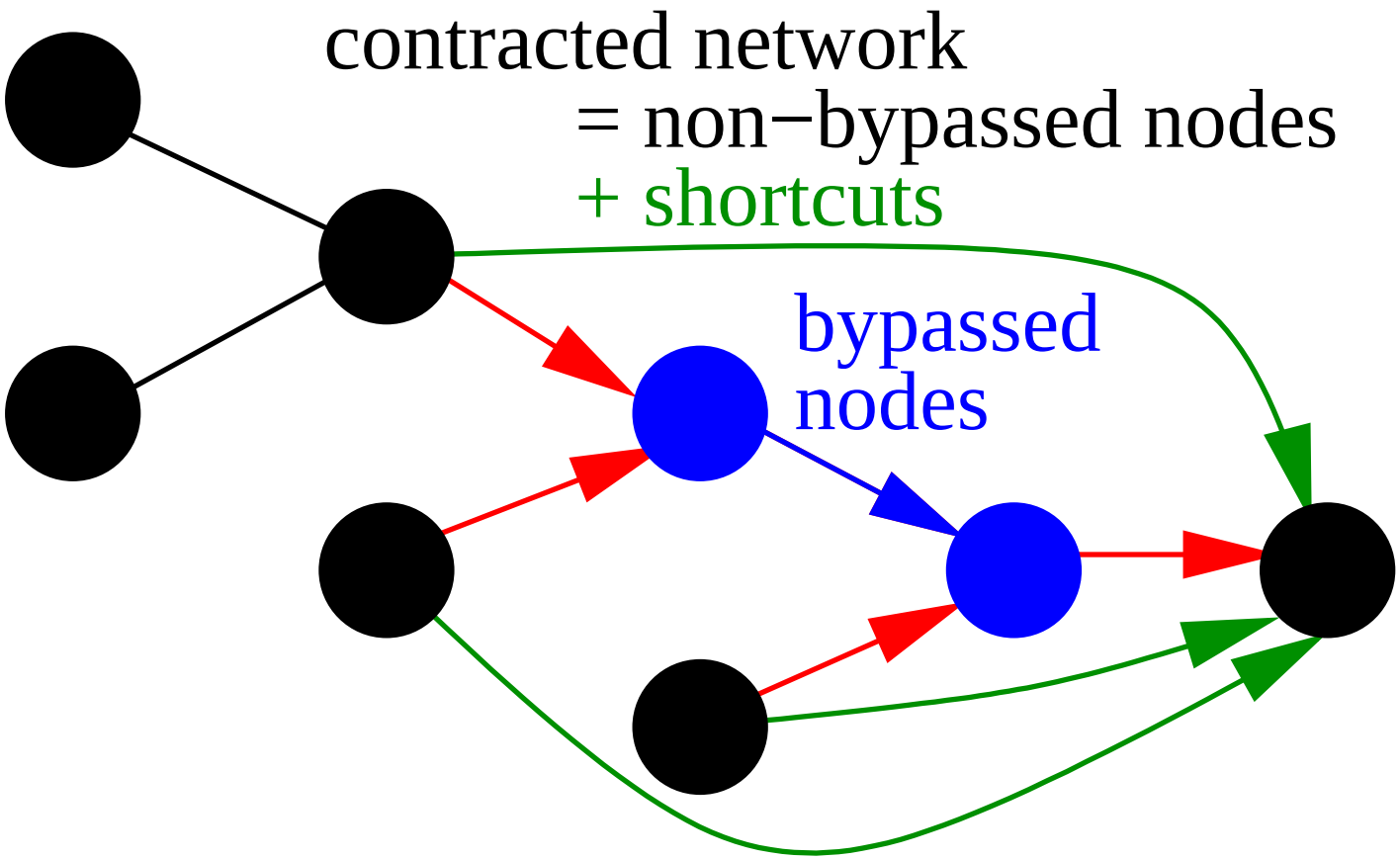
$\rightsquigarrow$ lossy compression can be applied

(e.g. a simple linear mapping)

first experiments indicate: only 8 bits are sufficient

(in case of more sophisticated mappings, even less?)

Contraction



Contraction

Which nodes should be bypassed?

Use some heuristic taking into account

- the number of shortcuts that would be created and
- the degree of the node.

Optimisation: Distance Table

Construction:

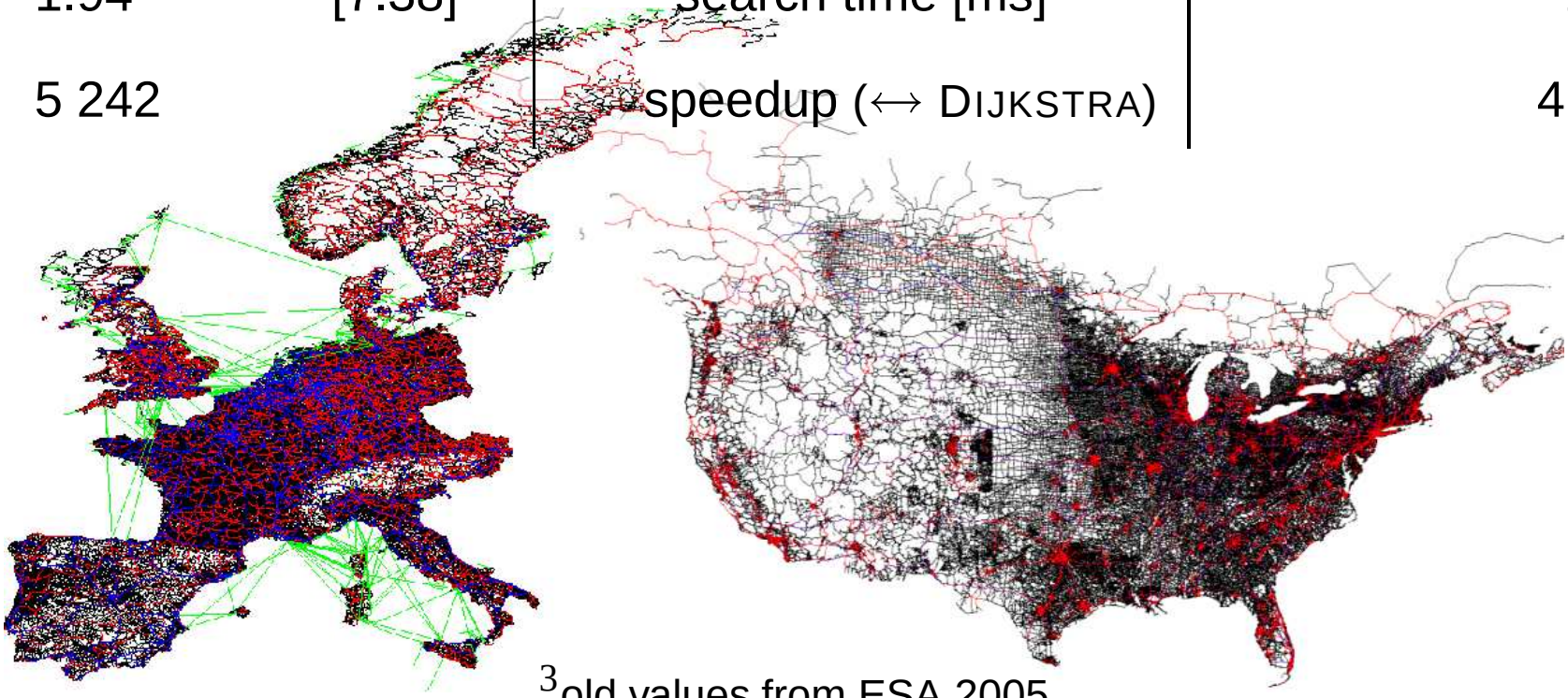
- Construct fewer levels. — e.g. 4 instead of 9
- Compute an all-pairs distance table for the topmost level L. — 8 776 $\times$ 8 776 entries

Query:

- Abort the search when all entrance points in the core of level L have been encountered. — $\approx$ 70 for each direction
- Use the distance table to bridge the gap. — $\approx$ 70 $\times$ 70 entries

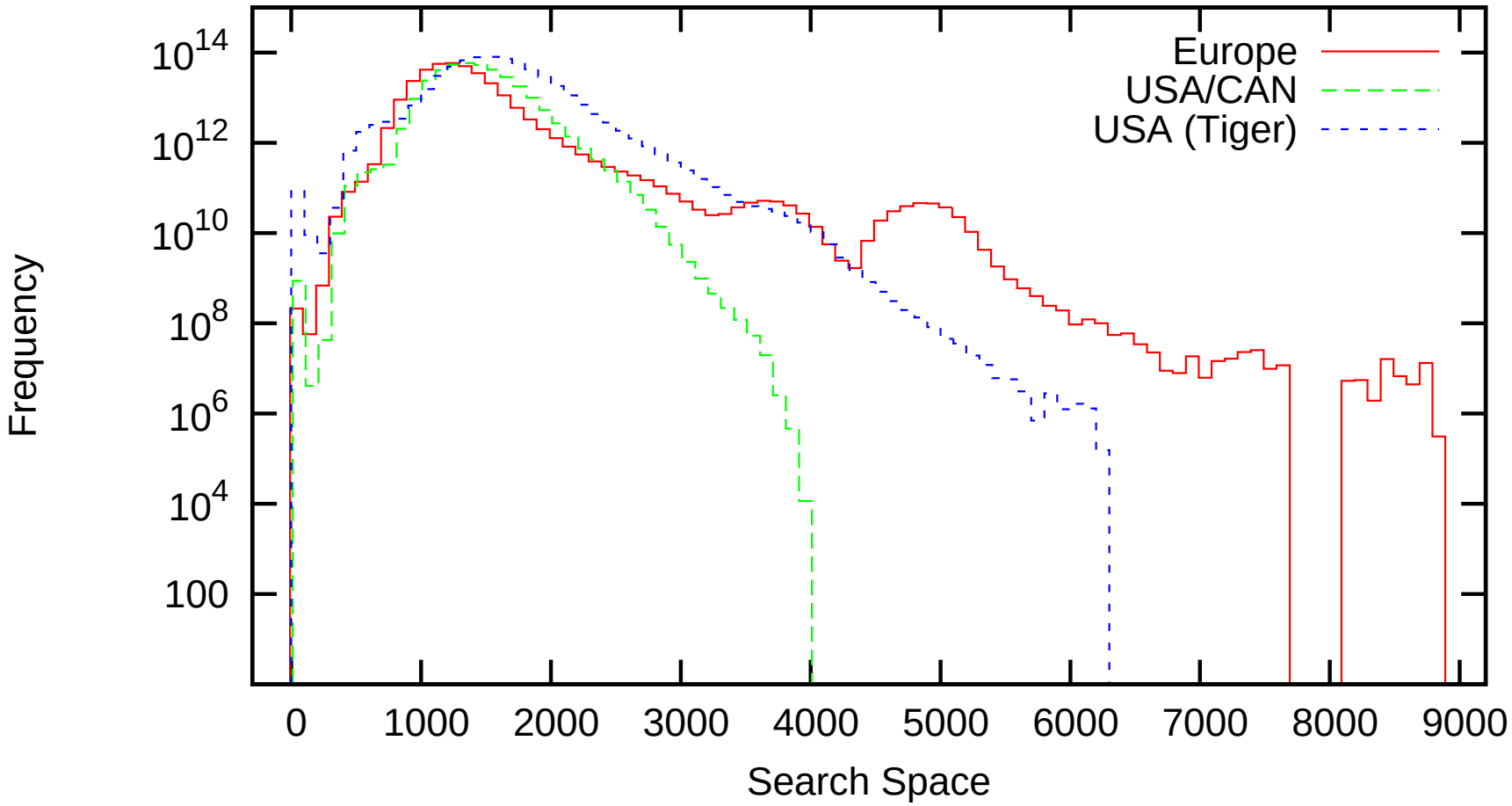
Experiments

W. Europe (PTV)			USA/CAN (PTV)
18 029 721		#nodes	18 741 705
42 199 587		#directed edges	47 244 849
21	[161][3]	construction [min]	30
1.94	[7.38][3]	search time [ms]	2.49
5 242		speedup ($\leftrightarrow$ DIJKSTRA)	4 021



[3] old values from ESA 2005

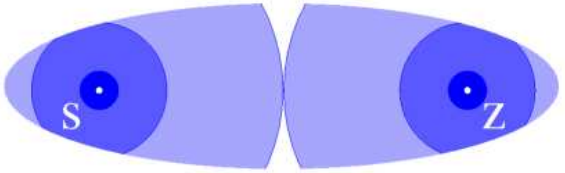
Worst Case Costs



Worst Case for Europe: 8 806 settled nodes (< 0.05% of all nodes)

Future Work

- combination with goal directed approaches



- fast, local updates on the highway network

  (e.g. for traffic jams)

- Implementation for mobile devices

  (flash access . . .)

- Flexible objective functions

- . . .