

Detection of Complex Junctions in OSM Data for Automotive Navigation Applications



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Introduction



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Right-top: By Sergei Rubliov, Public Domain (from http://de.wikipedia.org/w/index.php?title=Datei:MKAD-Yaroslavka_interchange.JPG)

Right-bottom: By Stahlkocher, GFDL- <http://www.gnu.org/copyleft/fdl.html>

(from: http://upload.wikimedia.org/wikipedia/commons/6/6d/Autobahnkreuz_Breitscheid_Ratingen.jpg)

Introduction

- Complex junctions occur at:
 - Motorways
 - National roads
 - Highway exits
- Intersection of at least two roads at different grades by connecting road elements
- Importance:
 - Relative frequent: About 8000 complex junctions within Germany (estimate based on OSM data)
 - Complex junctions support various features in state of the art navigation systems

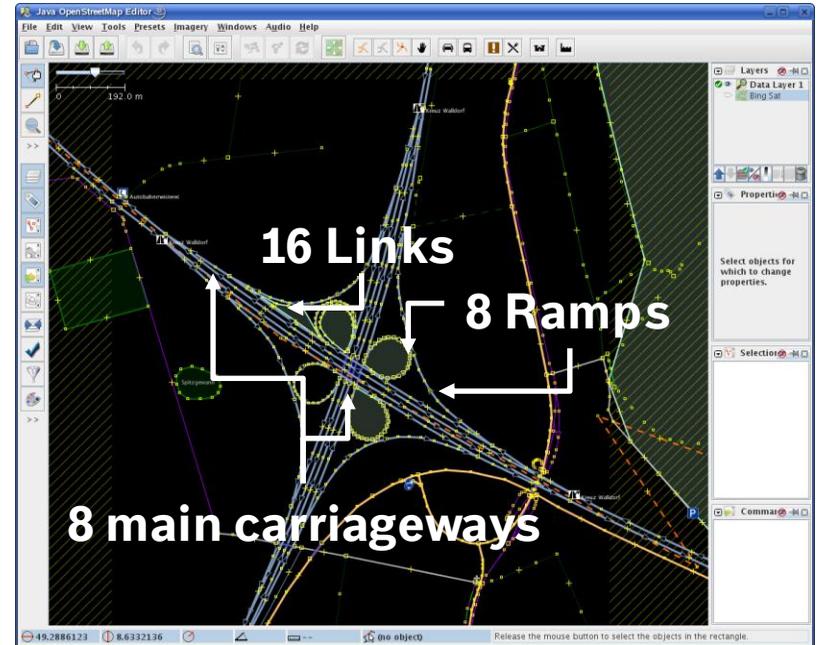
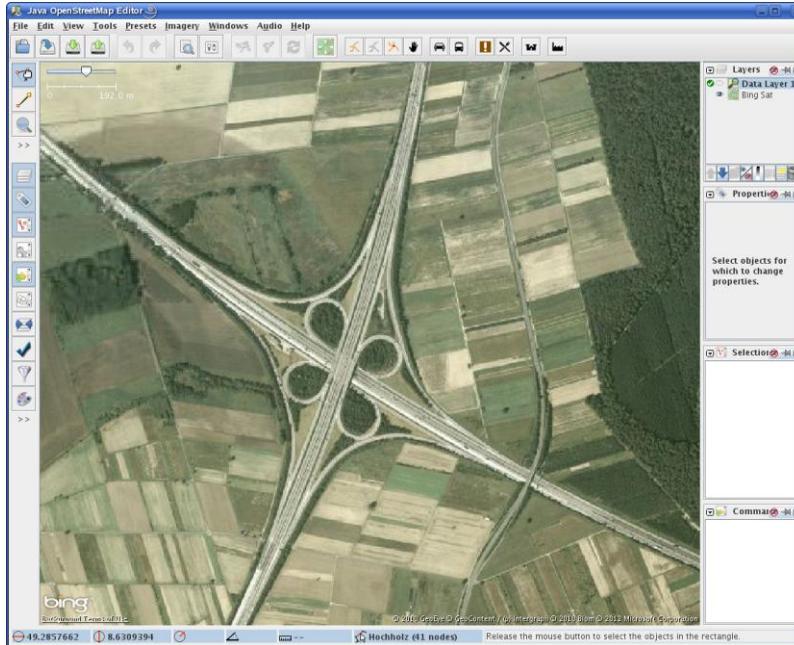


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Center: By Alex Needham, Public domain (from http://commons.wikimedia.org/wiki/File:Viaduct_in_Puxi,_Shanghai.jpg)

Bottom: By Softeis, CC-BY-SA-3.0 (from: http://commons.wikimedia.org/wiki/File:Autobahn_anschluss1.jpg)

Components of complex junctions



- Complex junctions consist of:
 - Main carriageway
 - Links (link ramps to main carriageways)
 - Ramps (connection btw. different roads)
- Example complex junction consists of 32 individual ways

Generalization of road network



Most detailed level

Coarsest level

- Generalization of road network for better performance in route calculation
- Road network is stored several times but at various levels of details by omitting entire roads on higher levels
- Omission is controlled by the highway attribution of a road element, which is linked to its importance in the entire road network
- Most detailed level contains the entire road network
- Coarsest level only comprises high/freeways and some important interconnecting roads
- Calculations close to the start and end positions are performed on the most detailed level, while the long distances are computed on the coarser levels.

Feature: Collapsing of complex junctions

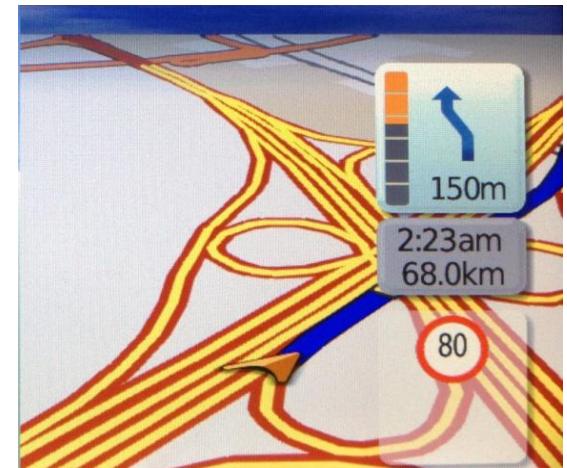
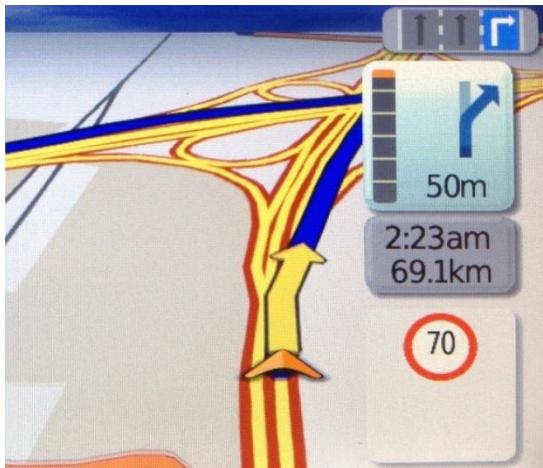
- Additional improvements in generalized road network: Reduce number of ways by simplifying the geometry objects (interest in topology!)
- Collapse complex junctions at coarser scales to single node where roads logically intersect:
 - Reduce significantly the number of elements (nodes and ways) of the complex junction
 - Better route calculation performance
 - Less data volume (online and offline)
 - Improved map display (optic and drawing performance)



Feature: Abstract maneuvers

ROUTENLISTE	
↶ 1:43am	B37
⬆️ 200 m	A656
⬆️ 1.8 km	AK HEIDELBERG
⬆️ 15.8 km	A5
⬆️ 47.1 km	A6
⬆️ 2:17am	AS HEILBRONN/NECKARSULM

- In reality:
 - Three different maneuvers
 - 1 bear right, 1 drive right, 1 drive left
- Abstract:
 - Only one maneuver
 - Possibility to indicate direction (e.g. left)



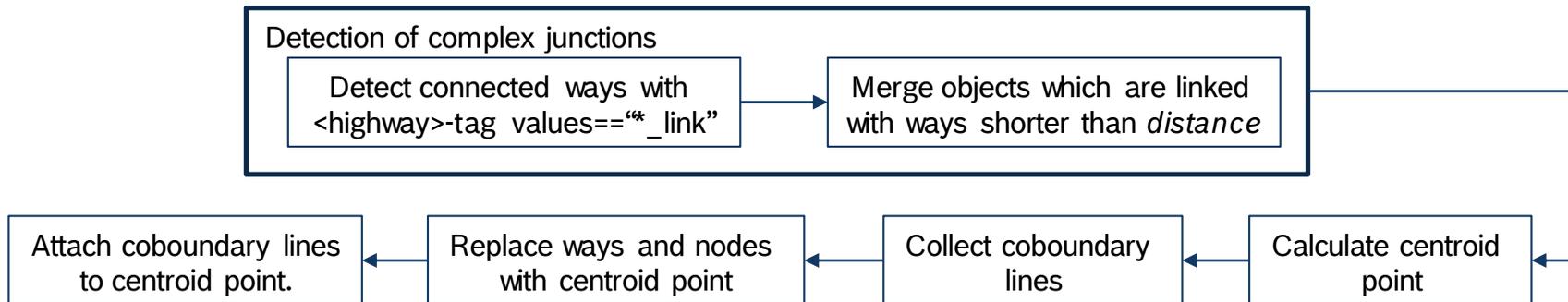
Complex junctions in OSM

- Complex junctions are not part of the OSM model, i.e. there is no indication which ways belong to a complex junction ☹️
- There is a feature proposal drafted in 2008, but no activity since then (http://wiki.openstreetmap.org/wiki/Proposed_features/Junction)
- The <highway> tag describes the importance of a way for the road grid;
- Complex junctions comprise ways with <highway> tag values:
 - motorway, motorway_link
 - trunk, trunk_link
 - primary, primary_link
 - secondary, secondary_link



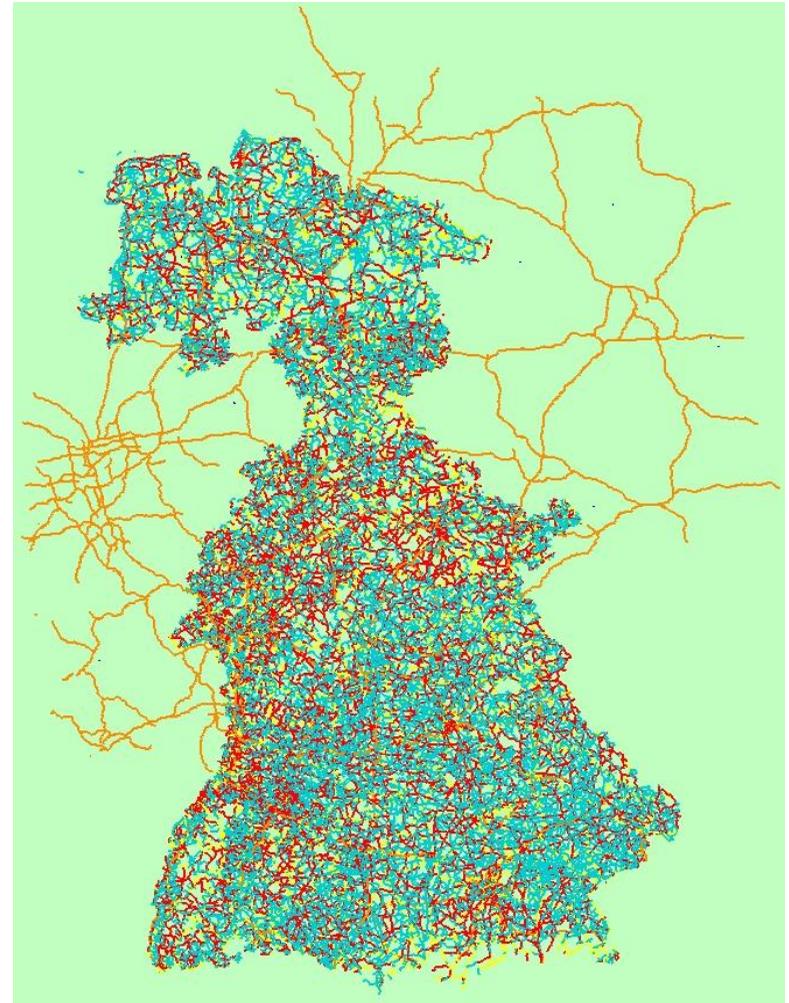
Automatic detection of complex junctions

- Automatic algorithm for detection of complex junctions based on:
 - <highway> tag values
 - line tracking
- Single parameter – *distance*; Controls the distance which two neighboring complex junctions at least must have so that they are detected as separate intersections:
 - *Distance* chosen too small: 2 neighboring complex junctions tend to be detected as a single one (omission error)
 - *Distance* chosen too large: single complex junction tend to be detected as several complex junctions (commission error)
- Principal steps in algorithm:



Results: Test data set

- OSM data from December 2011
- Processed 6 federal states of Germany:
 - Baden Württemberg
 - Bayern
 - Bremen
 - Hessen
 - Niedersachsen
 - Thüringen
- 4311 detected complex junctions



Results: Generalized road network

Complex junctions not collapsed



Complex junctions collapsed



Most detailed level



Coarsest level

- ➔ At most detailed level, complex junctions remain in full detail
- ➔ At coarser levels, complex junctions are collapsed to single node

Results: Comparison of data quantities

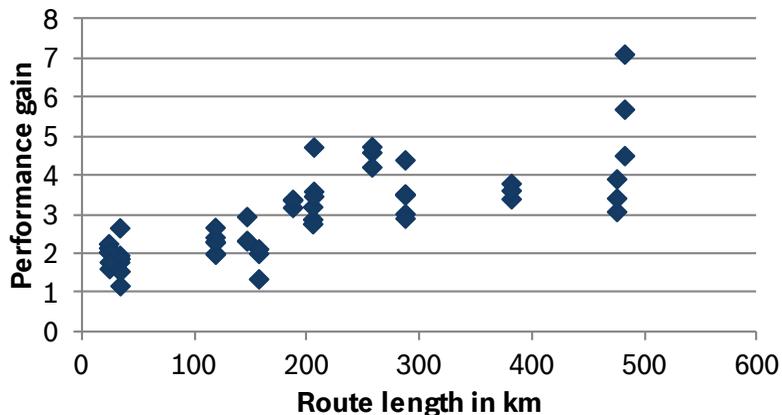
	Coarsest-1 level		Coarsest level	
	No complex junctions	Complex junctions	No complex junctions	Complex junctions
Number of ways	81003	24910	19646	3087
Number of nodes	56731	15159	16432	1851
Number of clusters	398	119	30	5
Number of neighbor clusters	2182	522	138	12

- Road network is partitioned into clusters
- Cluster generated according to criteria relevant for navigation purposes (e.g. based on the highway attribution of the road elements)
- “Number of neighbor clusters” is the total number of neighbor relationships in between all clusters
- On the “coarsest -1” level, data reduced to about less than 1/3
- On coarsest level, data reduced to about less than 1/6

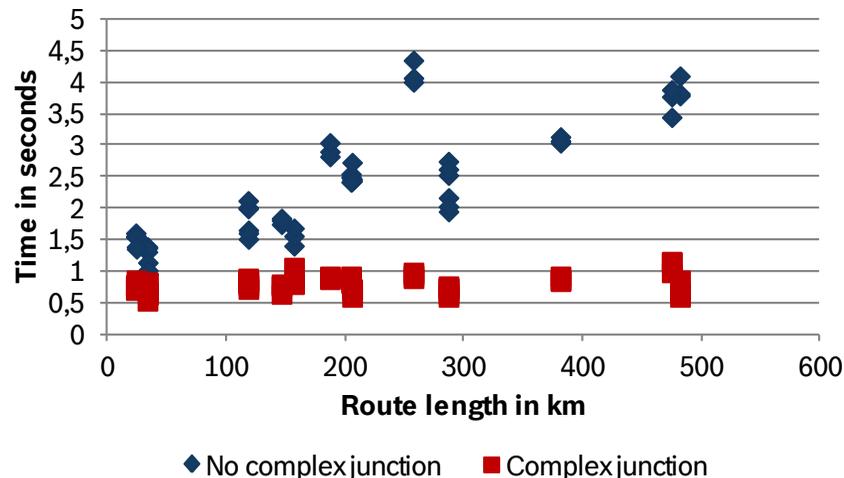


Results: Route calculation time comparison

Performance gain

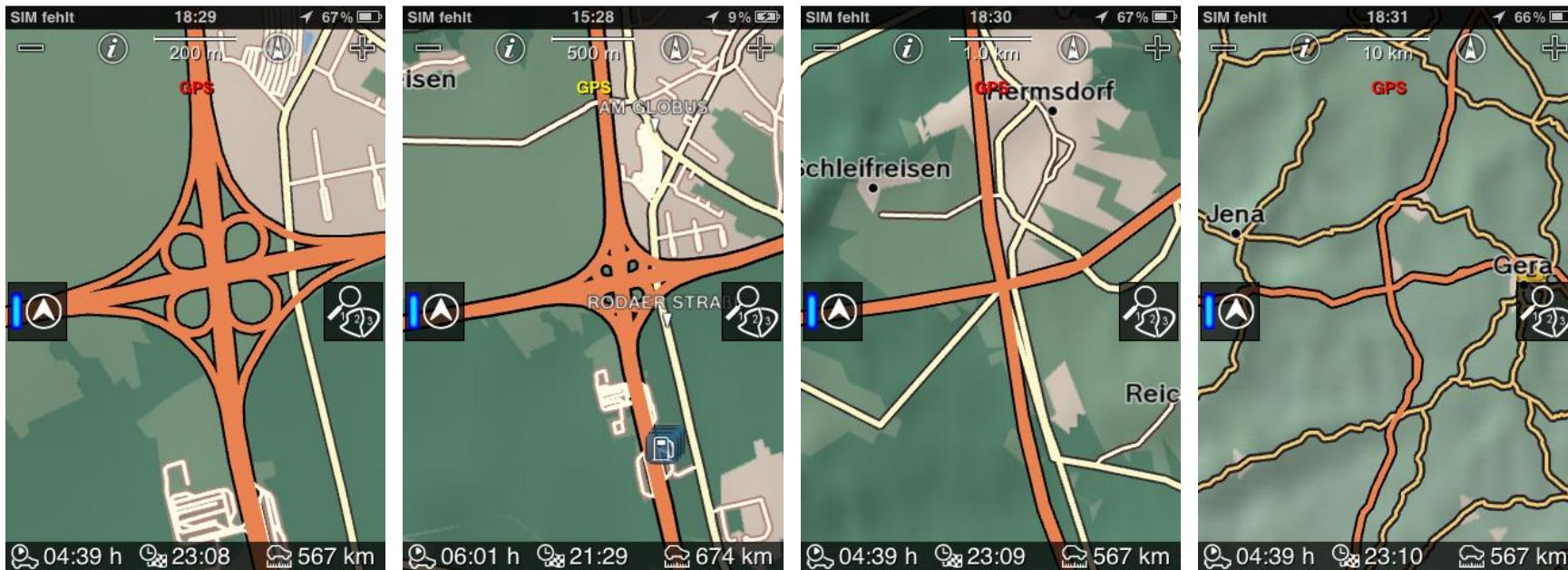


Absolute calculation time



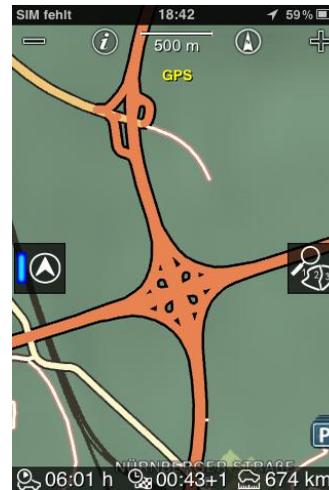
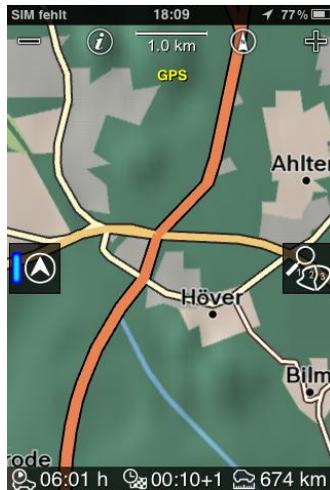
- Calculated 17 different routes from 30 km – 480 km length (each 3 times) on standard PC (not on target HW) with and without complex junctions
- Relationship between route calculation times relevant, not absolute values as such
- Left: The longer the route length, the better the performance of the complex junctions
- Right:
 - With complex junctions: route calculation almost independent to route length
 - Without complex junctions: Linear dependency (or worse) between calculation time and route length

Results: Improved map display



- ➔ Fine scale: Display complex junction in full detail
- ➔ Coarser scale:
 - Collapse complex junction to single node where roads logically intersect
 - Improvements in visual appearance and drawing performance (less nodes and ways to visualize)

Results: Problems with automatic detection



- ➔ Left: Imprecise calculation of centroid point causes not realistic bend in the display of the road in higher levels
- ➔ Right:
 - Separate complex junctions, which are close to each other, are detected as single complex junction (dependent on the setting of the distance parameter)
 - In combination with centroid calculation problem this results in bad map display
- ➔ Problems are only related to the map display, but not to the routing functionality
- ➔ Conclusion: Better to include information about complex junctions directly in OSM data

Proposal for OSM Model

- Based on existing proposal we suggest some adaptations (original: http://wiki.openstreetmap.org/wiki/Proposed_features/Junction)
- Complex junctions modeled as relation in the following way:

Key	Value	Description
type	Junction	
junction	various	type of junction (e.g. complex junction);
grade_separated	yes /no	grade separated yes/no
name	A name	Name of complex junction, if applicable
exit-ref	A reference	If there's one unique number for the whole intersection (Exit-Nr. 10 -> k="ref" v="10"). If different exit numbers exist for one intersection (e.g. "Hannover-Ost" is Exit 48, if on A2, but is Exit 57, if on A7), then they must be tagged on the first exiting ramps.

Way or Node	Role	Recurrence	Description
		1...n	Ways and nodes comprising the complex junction
	center_point	1	Marks the position, where the intersection is to be drawn cartographically, if simplified to one point. Usually this is the location of the bridge, where the main intersecting roads cross each other, or the crossing point of the main intersecting roads, if not grade-separated
	location_hint	0...1	Hint for renderer for locating junction number or junction name in map



- Complex junctions are important for several features in navigation systems (e.g. map display, abstract maneuvers, performance)
- Complex junctions are not modeled in OSM so far
- In principal, detection algorithms can detect complex junctions automatically; but error prone
- Hence, complex junctions should be modeled in OSM directly
- Provided proposal for modeling complex junctions in OSM via relation for discussion



- In case of positive feedback, we document the proposal for the complex junction relation in the OSM wiki

- Planned improvements for detection algorithm:
 - Eliminate distance parameter
 - Calculation of centroid-point for complex junctions

- Detection of complex roads (e.g. highways):
 - Improved map display
 - Better system performance

Thank you for your attention!

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