Advanced Traffic Light Information in OpenStreetMap for Traffic Simulations

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Abstract In this paper, we show the development process of a new proposed feature for OpenStreetMap (OSM) traffic light tags. We introduce the needs for such kind of information in OSM and define requirements for our simulation needs. After comparing different traffic light tagging ideas and matching them to our requirements we come to the conclusion to extend the current classic way of tagging with OSM relations, which define turn restrictions and traffic light information. As a proof of concept a plugin for the popular OSM editor JOSM is shown as well as a conversion implementation of a complex intersection from OSM to SUMO is presented.

1 Introduction

The use of OpenStreetMap (OSM) [2] data in traffic simulation environments is very common nowadays [1, 4, 6]. No other traffic network data sources offer such high quality data in urban areas for free without difficult licensing restrictions. Nevertheless, there are still some areas in OpenStreetMap, which could be improved to make traffic simulations out of OpenStreetMap data even better.

Traffic lights and lane information are OSM features which are still underrepresented even in areas, which already have been mapped in great detail. Reasons for

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this are mostly ease of use or need for this specialized information. Even simple information such as the number of lanes of a road are still used sparsely.

In this paper, we show how we extended the current OpenStreetMap traffic signal model with more detailed traffic signal data, how to convert this new information to a valid SUMO simulation scenario and how to use the traffic signal information in our Vehicle-2-X Simulation environment.

2 Extending the OSM Format

Traffic Lights in OpenStreetMap are usually modeled using only one node per intersection, regardless of the number of actual traffic lights, number of lanes at that intersection or intersection geometry (see Figs. 1, 2).

Today, there exists no concept in OpenStreetMap, which can be used to represent detailed traffic light information. There are proposed features that try to model more advanced signals information at intersections with focus on optimized information for navigation systems, but these cannot be used to include signal information nor are they optimized for simulation purposes.

To enhance the traffic light model in OSM, we collected different requirements that a new solution might address and added a weighting from one to ten (ten being most important) to each requirement (in parentheses):

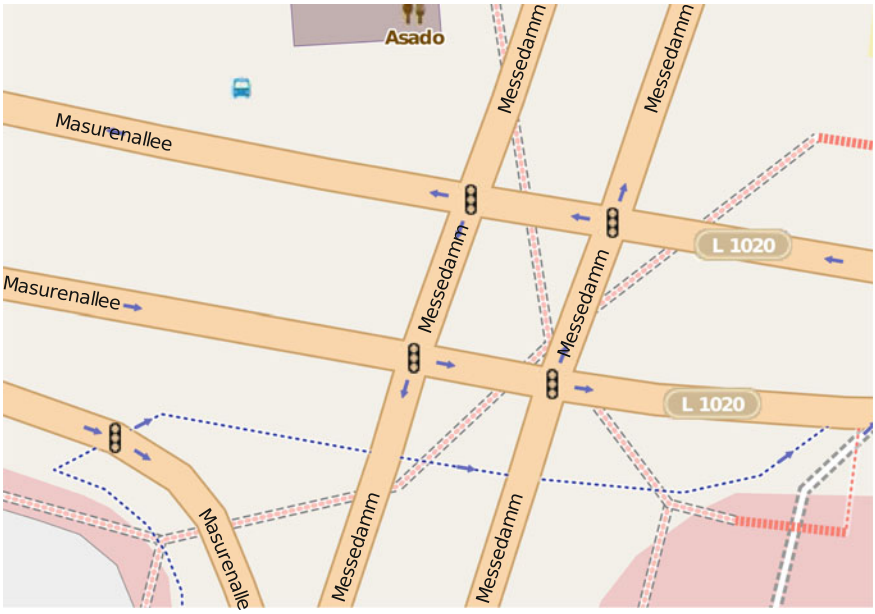

Fig. 1 Complex traffic light controlled intersection

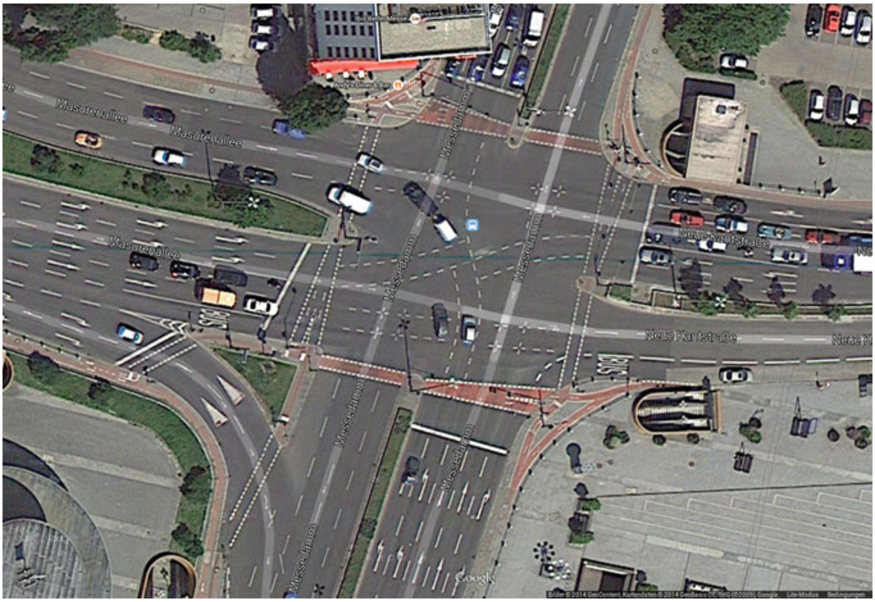

Fig. 2 Satellite view of complex intersection

1. All possible (physical) assignments between lanes and traffic lights can be captured (10)
2. There are no adjustments needed for simple one-lane intersections (8)
3. Signal phases and timing information can be defined per traffic light head (5)
4. Map visualization is possible (2)
5. Mapping of intersections can be done efficient with existing tools (7)
6. Technical evaluation of intersections, lanes and traffic lights is possible (i.e. no undefined states, unique interpretation possibilities) (7)
7. Downwards compatibility, i.e. intersection geometry information remains untouched, existing tools should still work with the extended attributes (10)

To find a suitable solution, we analyzed different traffic light (TL) tagging ideas (Table 1).

By comparing each requirement with the various traffic light modeling methods, we came to the following requirements matrix (see Table 2).

One can see that the alternative tagging methods do not do better than the classic tagging method at least with regard to the defined requirements. Therefore we came to the conclusion to introduce an extension of the current relation-model by adding a *traffic signal* relation, which enables lane precise traffic signal modeling (right, left, straight or combinations of all directions). This offers a high flexibility but also keeps the classic tagging system.

By using the common concept of referencing already existing attributes (lanes) and extending them with new options (from, via, to) existing information can easily

Table 1 Comparison of traffic light tagging ideas

Tagging type	Pros	Cons
Classic TL tagging		
	• Simple geometry	• Phases and timing not possible
		• No lane-specific TL-Tagging
Lane TL tagging		
	• Traffic light tags per lane	• Complex geometry
	• Turn restrictions per lane	• High mapping costs
		• Uses huge amount of data
Star TL tagging		
	• Logic modeling of lanes	• Visual representation != logic representation
	• TL and turn restrictions per lane	
	• Downwards compatible	
	• Medium mapping costs	
Area TL tagging		
	• Individual lanes	• Incompatible with current routing engines
		• Improper usage of areas to model intersection-connections

Table 2 Requirements table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Load	10	8	5	2	7	7	10
Classic	0	10	0	7	10	10	10
Line	10	10	0	10	0	5	10
Star	10	10	0	3	5	5	10
Area	0	10	0	3	5	0	0

Table 3 Fields of the new traffic_signal relation

Attribute	Description
type	Type description of the relation (traffic_signals)
ref:lanes:from	Mapping of input lanes
ref:lanes:via	Mapping of via lanes
ref:lanes:to	Mapping of outgoing lanes
phases	Description of the traffic signal phases
timing	Description of traffic signal timings

be reused. Phase and timing information is described in a similar way to SUMOs way of representing traffic signal information (|-separated values for phases and timings). Table 3 shows the extensions made to the relation.

We also show the usage of our easy-to-use plugin for the popular Java OpenStreetMap editor (JOSM), which supports the user in creating new or updating existing traffic light information in his/her area (see Fig. 8).

3 Conversion of OSM Files

To convert standard OSM data to our simulator specific formats, we already use a tool called VSimRTI scenario-convert to import OSM data and export to different formats, e.g. SUMO *.nod.xml, *.edg.xml and *.tll.xml files. We extended this tool to make use of the additional traffic light information and export the relevant files to a SUMO and VSimRTI compatible format.

In this paper, we show the conversion process from the raw OSM file to the SUMO traffic network. Some OSM features can be translated direct to the corresponding parts in the SUMO files (see Fig. 9), while in other parts a more complex transition is needed (e.g. intersection lane modeling)

A screenshot of the conversion can be seen in Fig. 7. In this example, the intersection in Fig. 2 was extended with the advanced traffic signal information, which was gathered by measuring the traffic signal phases. Then, the OSM file was parsed using VSimRTI scenario-convert and SUMO netconvert created the SUMO files (Figs. 3, 4, 5, 6).

The SUMO tool netconvert offers also an osm conversion feature to import OpenStreetMap files directly and write SUMO compatible files, including traffic light guessing and intersection joining. Unfortunately, this method did not work due to the intersection complexity. With further effort on modeling the intersections, better results are expected.

4 Simulation

We use the generated traffic network and traffic light programs in our V2X simulations using the Vehicle-2-X Simulation Runtime Infrastructure (VSimRTI) [5].

VSimRTI is developed by Fraunhofer FOKUS is a framework for simulation of Vehicle-2-X scenarios by coupling different simulators (e.g., traffic simulator, network simulator, application simulator…). The framework is based on the High Level Architecture [3] which offers mechanisms to connect and synchronize different simulators using a common runtime infrastructure.

SUMO is mainly used as traffic simulator in VSimRTI, whereas communication and applications for vehicles are simulated on other simulators. Information about traffic lights is simulated in SUMO, but can be altered from an application running on a vehicle.

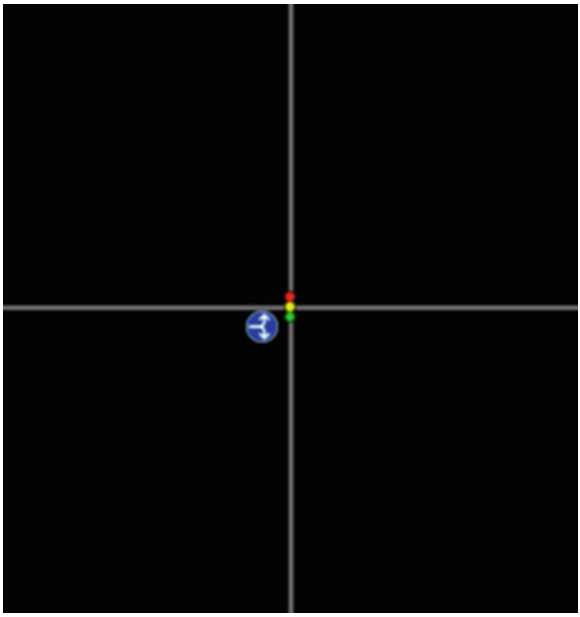

Fig. 3 The classic traffic light tagging as it is used currently, contains one traffic light tag per intersection. Turn restrictions usually belong to whole ways

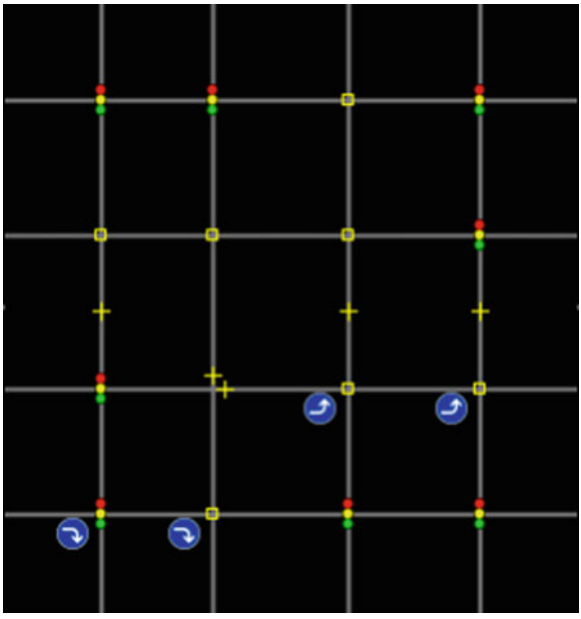

Fig. 4 The lane traffic light tagging uses a visual way of traffic light tagging. Each lane is modeled individually, traffic lights and turn restrictions are applied directly to the lanes

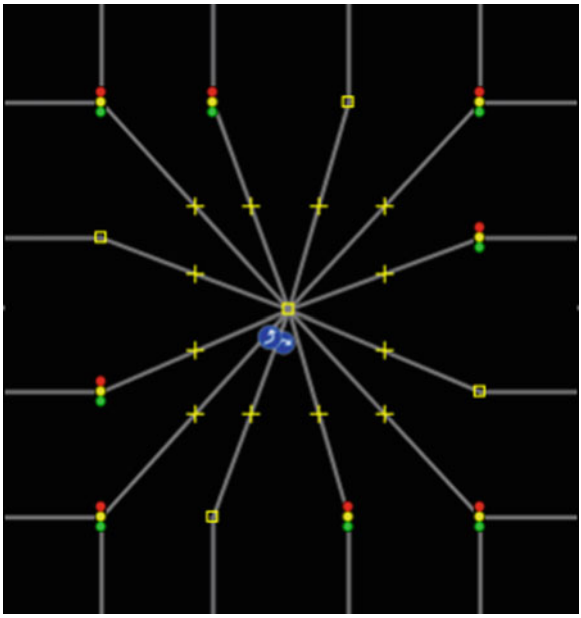

Fig. 5 Star traffic light tagging is an abstract way to model lanes logical. The intersection node as used in the classic traffic light tagging stays the same, but roads are splitted into individual lanes

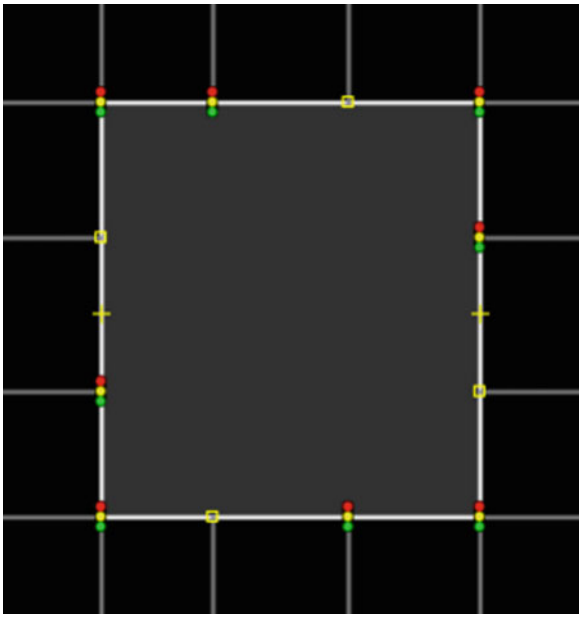

Fig. 6 The area traffic light tagging models the whole intersection as one OSM-area, where each lane connects to the intersection

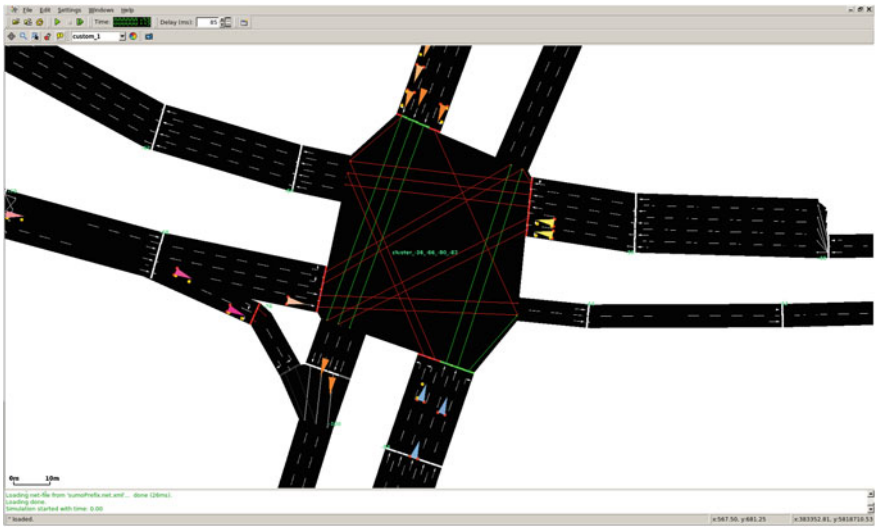

Fig. 7 SUMO traffic simulation with junction connections shown

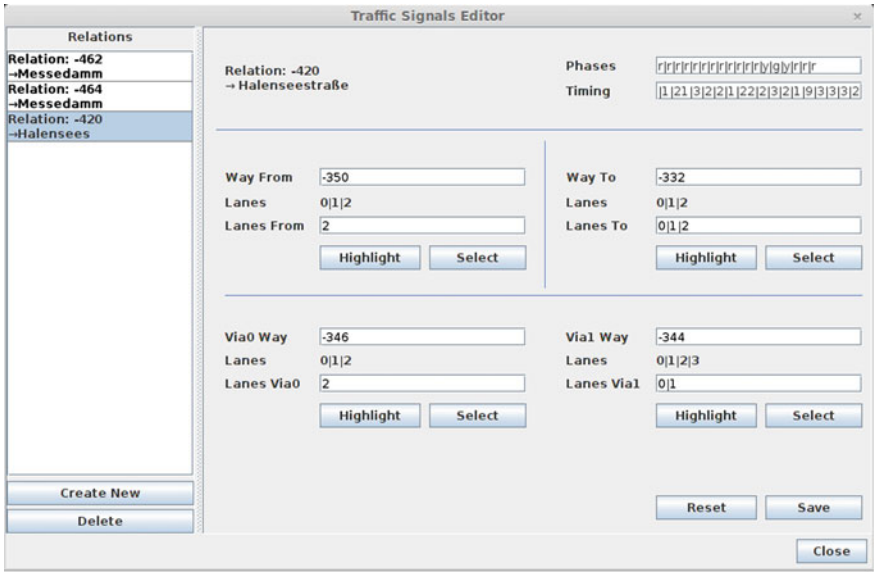

Fig. 8 JOSM traffic signal editor plugin

```
<relation id='-36'>
    <member type='way' ref='-16' role='to'/>
    <member type='node' ref='-4' role='signal'/>
    <member type='way' ref='-14' role='from'/>

    <tag k='ref:lanes:from' v='1|2'/>
    <tag k='ref:lanes:to' v='3|4'/>
    <tag k='phases' v='g|y|r|r'/>
    <tag k='timing' v='31|4|31|4'/>
    <tag k='type' v='traffic_signals'/>
</relation>
```

```
<tlLogic id="0" type="static">
    <phase duration="31"  state="gr"/>
    <phase duration="4.0" state="yr"/>
    <phase duration="31"  state="rg"/>
    <phase duration="4.0" state="ry"/>
</tlLogic>

<connection from="7_-8" to="6_-4"
    fromLane="0" toLane="0"
    tl="0" linkIndex="0"/>

<connection from="7_-8" to="6_-4"
    fromLane="1" toLane="1"
    tl="0" linkIndex="0"/>
```

Fig. 9 OSM traffic signal extension and corresponding tags and values in SUMO

5 Conclusion

The presented extension of the classic traffic light definition in OpenStreetMap offers a lot of advantages for traffic simulations. By adding relations with information of phases, timing and turn restrictions, even complex intersections can be modeled comparatively easy using only OpenStreetMap. Furthermore, this information can also be used easily in traffic simulation tools such as SUMO. Lane based turn restrictions or even lane numbering alone being one crucial information for routing engines, this feature can also help to spread OpenStreetMap data even more.

6 Outlook

Although the presented methods allow for tagging complex intersections and advanced traffic light definitions, the proposed features currently only include static traffic light information. Further traffic signaling mechanisms, e.g. induction loops or camera controlled traffic lights, public transportation prioritized traffic lights or green wave settings or daily/weekday setups are not handled by the presented feature. Adding these or offer possibilities to include some kind of online requests for the current status might add some valuable information to next generation routing applications.

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References

1. Behrisch M, Bieker L, Erdmann J, Krajzewicz D (2011) Sumo-simulation of urban mobility-an overview. In: SIMUL 2011, The Third international conference on advances in system simulation, pp 55–60
2. Mordechai H, Patrick W (2008) Openstreetmap: user-generated street maps. Pervasive Computing, IEEE 7(4):12–18

3. Institute of Electrical and Electronics Engineers (2000) IEEE standard for modeling and simulation (M&S) high level architecture (HLA)–framework and rules. IEEE Standard 1516.1. IEEE, New York
4. Rieck D, Schünemann B, Radusch I, Meinel C (2010) Efficient traffic simulator coupling in a distributed v2x simulation environment. In: Proceedings of the 3rd international ICST conference on simulation tools and techniques, p 72
5. Schünemann B (2011) V2x simulation runtime infrastructure vsimrti: An assessment tool to design smart traffic management systems. Comput Netw 55:3189–3198
6. Zilske M, Neumann A, Nagel K (2011) Openstreetmap for traffic simulation. In: Proceedings of the 1st European State of the Map–OpenStreetMap conference, number 11-10, pp 126–134

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