Dynamic cartographic network visualisation methods for limited viewports

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Abstract. The presentation of networks on maps helps users to explore, analyse and interpret relations between objects concerning a certain set of facts. Cartographic visualisation must consider several different types of networks with varying complexity. Typical scopes of application are schematic metro maps, street networks or power supply grids.

Visualisation of more or less complex network maps on computer screens often becomes a demanding issue, because small screens especially on mobile devices only offer a rather limited viewport. Although screen size and resolution have increased during the last years, it is still a problem for the user to recognize all details and keep a good overview of the whole network at the same time. Furthermore, mobile devices offering location based services usually require specially designed solutions.

A first approach to a potential solution is to use a part of the viewport frame to show graphical objects, which represent the currently invisible objects or the invisible network parts. Here we keep cartographic concepts in mind, which visualise off-screen objects in the viewport frame using basically the same concepts as for on-screen objects.

Keywords: network visualisation, off-screen objects, limited viewports, animation

1. Introduction

Nowadays map presentations on computer screens are often realized by means of web based mapping solutions as shown in *Figure 1*. They allow interactivity like panning and zooming or selecting and filtering the information shown on the map. Here, zooming helps to get detailed information of a certain part of the map. On the other hand, showing only subsections of

the network makes it hard to get an overview of the whole set of facts and may lead to misinterpretations.

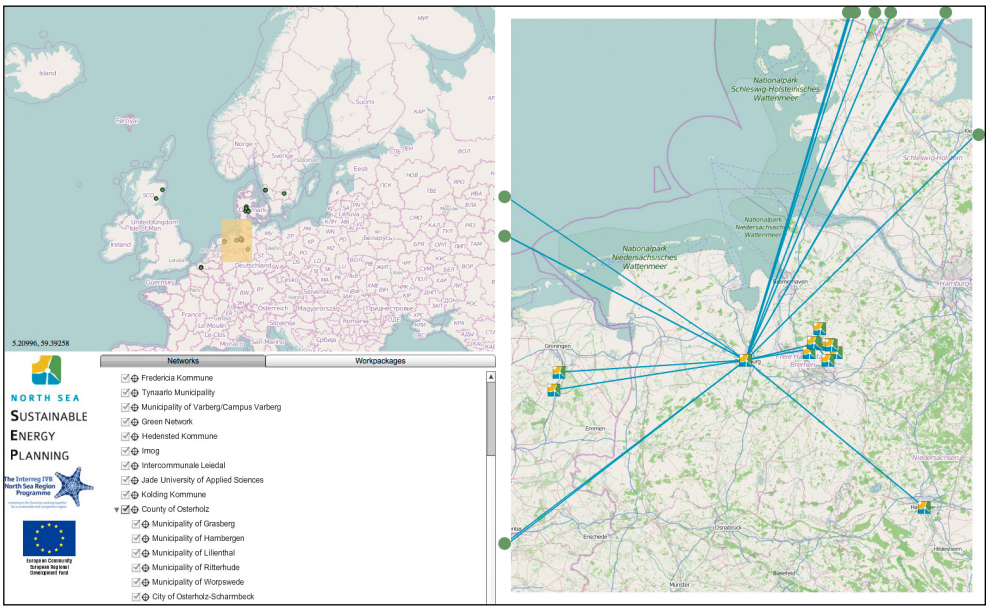

Figure 1. Web mapping application, visualising the relations of the member organisations of a research network using the "fringe". An additional overview map helps with the orientation (Gollenstede & Weisensee 2014).

Mobile devices, especially smartphones like in *Figure 2*, only offer an even smaller viewport. Thus, the task is to find an appropriate compromise between mobility and the ability to show as much information as needed or even possible.

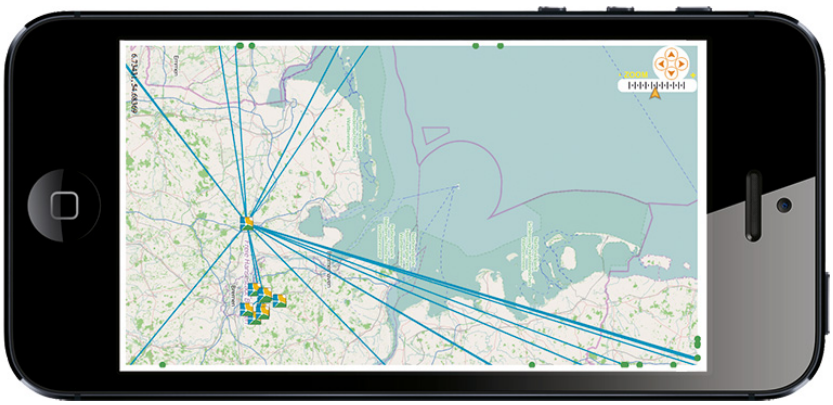

Figure 2. Mobile application visualising the network shown in *Figure 1* (Gollenstede & Weisensee 2014).

2. Visualisation of Off-Screen Objects

For proper interpretation of the network or its subjects it is often necessary to get information about qualities or quantities, which can be found outside of the current viewport.

A first approach to a solution is to use a part of the viewport frame border to show graphical objects, which represent the actually invisible objects or the invisible network parts - herein called the "fringe" cf. *Figures 1, 2 and 5*. In the simplest case the fringe can be used to show where the next objects of the network are located and so it can lead the user to pan into the right direction. The fringe can also be used to give information about the number of objects or quantities outside the viewport. Therefore, graphical objects of the fringe can vary in size or colour or both. In the end all the traditional methods of cartography to visualise different kinds of quantities can be used here.

Different techniques for the visualisation of off-screen objects have already been introduced. A typical solution is to use space at the screen border, similar to the "fringe", to display information about the objects outside the actual viewport.

Baudisch & Rosenholtz (2003) proposed a technique indicating off-screen objects by using a visual effect named "halo" shown in *Figure 3*. Based on this work Gustafson et. al. (2008) introduced a technique called "wedge". They developed an algorithm for a clutter-free screen border displaying multiple off-screen objects. At the same time also usability aspects on mobile devices have been taken into account.

Figure 3. Baudisch & Rosenholtz (2003) are using a visual effect called "halo" to inform the user about the position and the distance off-screen objects.

Hanewinkel & Specht (2010) concentrated on aspects of high quality cartographic output. Here, the indicator has been named "orbit" and is used in desktop and web based applications as in *Figure 4*.

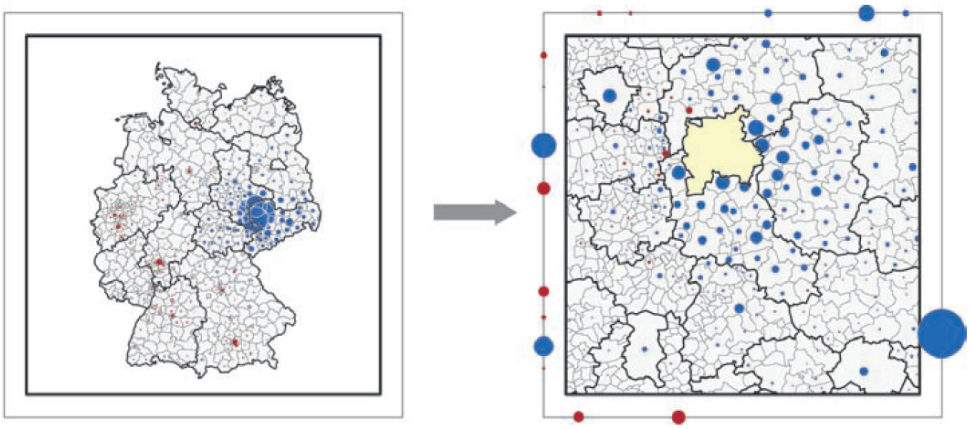

Figure 4. A sophisticated approach for the cartographic visualisation of complex commuter relationships between German municipalities by Hanewinkel & Specht (2010) using the "orbit".

3. Animation

User interactions like panning and zooming require a constant updating of the fringe. The fringe objects constantly move and may change as well size as colour. Depending on the complexity of the network data a large amount of calculations need to be executed on the mobile client to animate the dynamic fringe.

In addition to the fringe other types of animation can be used to support the user and to give an easy access to the network, e. g. showing animations of the edges, which are interconnecting the nodes of the network.

If objects related to the network vary in time and place, a "live" animation of the network elements and the fringe is required. Representations like moving buses on a schematic public transportation map require a continuous update and animation of almost all elements on the screen. Then, the fringe can additionally contain information about the expected arrival of the next bus, as illustrated in *Figure 5*, or the stations still to go for the passengers.

Figure 5. Sketch of a mobile application visualising a schematic public transportation network. The fringe displays the expected arrival of the next buses to come for two selected routes. The background shows parts of the off-screen network. (Gollenstede 2014; map: http://www.vwg.de, accessed April 01 2015)

4. Further aspects

Another possibility to avoid overcrowded small screens and to ease the interpretation of networks is the simultaneous use of different levels of generalisation on the map screen. Then, the degree of generalisation should be small in the centre of the viewport and increase to the border of the viewport.

Alternatively, Wolff (2013) mentions different deformation methods of the map centre e. g. the fisheye view, which can help to dissolve overcrowded areas. Similar approaches are well known from printed city maps of the German publishing house Falk (Lichtner 1981).

When geometric networks have to be visualised, graph drawing and cartography are combined (Wolff 2013). In this case certain visualisation tasks,

like generalisation of the network, can be solved with algorithms of graph theory.

Finally, if additional screen space is available, a medium sized conventional overview map as shown in *Figure 1* can be supportive.

5. Current Work

Current work in progress at Jade University of Applied Sciences integrates existing algorithms, e. g. in the field of graph theory, in the first step. The main emphasis lies on increasing the quality of the cartographic visualisation of networks on mobile devices.

Here, different basic approaches based on generic use cases are currently implemented and will be optimised for a proper cartographic presentation on mobile terminals. For these devices, especially the limited viewports are taken into account.

In an initial attempt cartographic variables have been analysed systematically in order to improve the functionality of the fringe as well as enhancing the comprehensibility.

elements	attribute-types	static/ dynamic	...	network objects	fringe objects
nodes	qualities	static			
		changing			
	quantities	static			
		changing			3 8 9
edges	qualities	static			
		changing			...
	quantities	static			...
					...
					...
...	...	...			...
objects moving on edges	qualities	...			...
	quantities	...			...
	time				2 5 7
...	...	...			...

Figure 6. Excerpt of the draft of a table showing several network objects with selected attributes and their cartographic representation in the "fringe" (Gollenstede 2015).

6. Conclusion and Outlook

Presenting complex networks on limited viewports is a technical and visual challenge especially when focussing on the quality of the cartographic representation. But keeping cartographic rules in mind will surely increase the usability of the system and it will help to communicate spatio-temporal information of off-screen objects, since the user can fall back upon well-known visualisation methods of classic cartography.

As a second step the development and test of more sophisticated methods of visualisation and animation of networks on mobile devices will be tackled.

Furthermore, the project analyses, whether the algorithms used are suitable on mobile devices with regard to the still limited performance compared to desktop applications.

Finally empirical test beds are planned to evaluate how users deal with those different ways of presentation.

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