Towards Extending Web Map Services for Mobile Applications

Mehmet Bozkurt\textsuperscript{2}, Roger Groth\textsuperscript{1}, Björn Hansson\textsuperscript{2}, Lars Harrie\textsuperscript{1},
Peter Ringberg\textsuperscript{1}, Hanna Stigmar\textsuperscript{1}, Karl Torpel\textsuperscript{2}
\textsuperscript{1}GIS Centre, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden
\textsuperscript{2}SonyEricsson Mobile Communications AB, Nya Vattentornet, SE-221 88 Lund, Sweden

Correspondence to:
lars.harrie@lantm.lth.se

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Abstract
This paper begins with describing a case study of using the standard Web Map Services (WMS; from Open Geospatial Consortium) for mobile applications. The WMS client was tested in Lund using cartographic data at a scale of 1:10 000. From a map generalisation perspective, two experiences were gained from this case study: the screen map often has too little/much information and the communication can break down due to too large file sizes. The main part of this paper is devoted to these two issues. Firstly, a usability study of the amount of map information is presented. The result from this study indicates that we should not only consider scale when determining generalisation level, but also information density. Secondly, the paper contains a short discussion about methods to restrict map file sizes using WMS.

1. Introduction
The development of mobile technology is fast. Modern mobile terminals have quite large screens and the distribution of data is fast. From a cartographic point of view, the technology is now good enough to create useful mobile map services. In this paper we describe an ongoing project of using the Open Geospatial Consortium (OGC, 2005) web map service (WMS) for mobile applications. The aim is to get experience of using WMS in mobile applications, evaluate limitations, and propose solutions to these limitations.

WMS consists of two mandatory types of requests: GetCapabilities and GetMap. By using the GetCapabilities request a client retrieves information about which data that a web map server can deliver, which spatial reference systems that are used, etc. By this information a GetMap request can be formulated. The response of this request is a map. WMS has been extensively used for desktop applications, but more seldom for mobile applications.

This paper starts with a description of a case study of using WMS in a mobile environment. The case study identified two topics of interest for the generalisation community: controlling the level of information in the map and controlling the file size of the map. These two topics are treated in Sections 3 and 4. The paper concludes with final remarks.
2. Case study of using WMS in a mobile environment
In the test a WMS server was set up (Section 2.1) and a WMS client was developed (Section 2.2). The purpose of this study is to obtain some experience of using WMS as a map query protocol in a mobile environment (Section 2.3).

2.1 WMS server
On the server side we used GeoServer (Refractions, 2005); GeoServer is a transactional Java (J2EE) implementation of Web Feature Service specification (WFS), with an integrated Web Map Service (WMS). GeoServer supports both raster images and vector graphics (SVG; scalable vector graphics).

2.2 WMS client for mobile applications
Bozkurt (2005) developed a WMS client application (Figure 1). The application runs on a mobile phone with a connected GPS receiver (using Bluetooth). The application is implemented as a Java MIDlet which retrieves a map (in SVG format) over HTTP. The application contains a menu where actions such as zooming and panning the map can be performed. From the menu the user also controls which of the available layers that should be visible. Switching between pan mode and cursor mode is yet another option available in the menu. Cursor mode is when the user moves a cross over the map with the arrow keys on the mobile phone instead of panning the map. This could for instance be used as a selection tool when touch screen support is unavailable on the mobile phone. It could also be used to retrieve map coordinates for a certain point on the screen.

The client is implemented as a multi-threaded application. The reason is that the application has to react in real-time to user events, position updates and occasionally connect to the Internet in the background. Since a multi-thread approach is used, the application is not unacceptably irresponsible or slow. One thread is used to fetch new map data whenever the user pans outside the map or moves too close to the edges of the map. Another thread, which is created when the application starts, is awakened each time an event is generated from the underlying native layer. The thread updates the position information and requests a repaint of the screen before it awaits a new update. The third thread in the application is the event handling thread provided by the platform.
Figure 1: The WMS client application.

2.3 Experienced gained from the case study
The WMS client was tested in Lund using cartographic data at a scale of 1:10 000. There are several experienced gained from this case study. Two of these are related to generalisation: the screen map often has a too little/much information and the communication can break down due to too large file sizes. To improve the usability of WMS for mobile applications two additional functionalities could be made:

1) controlling the amount of information in the map, and
2) controlling the file size of the map.

These two functionalities are the topic of the next two sections.
3. Controlling the amount of information in the map

The amount of map information can be stated as:

\[
\text{amount of map information} = f(\text{scale, level of detail in representation, amount of information in reality, map size})
\]

Since the amount of information in reality varies (e.g. between city centres and rural areas) the amount of map information varies in ordinary paper maps. A question is whether these variations are wanted for maps in mobile devices or if you always want the same amount of information to be presented. One could argue that you should use an appropriate scale of your map so that the information content is reasonable. But, it might be better to change the level of detail in representation using the same scale.

In this study we will test the hypothesis \( h_0 \):

The preferred level of detailed in representation is dependent on amount of information in reality.

This implies that the level of detail in map representation changes while you are moving from an area with much information (e.g. city centre) to an area with little information (e.g. rural area). To test this hypothesis we designed and performed a usability study (Sections 3.1-3.3). While designing the usability study it was important that the outcome of the study should give useful input to designing maps in real-time (Section 3.4); that is, measures on information content that rely on human understanding are not allowed.

3.1 Usability study

The basic idea of the usability test was to construct a number of paper maps (below denoted test maps) of different areas and then asking users about their preferences. Based of the users’ preferences of the test maps, the hypothesis \( h_0 \) was tested.

The map data used in the test covers the city of Lund and is originally made to be presented at a scale of 1:10 000. In the test, we used the map data layers: roads, buildings, and land use. The maps contain both areas where the amount of information in reality is large and where it is small.

The design of the test maps started with the identification of suitable map coverage locations. Fourteen locations were decided for the test maps (Figure 2). The test maps are of the same size 4x5.5 cm - the size of the screens of some commonly used mobile phones.
Figure 2: Location of the test areas. For the test maps the areas were mapped using the following scales: 1-7 scale 1:15 000, 8-11 scale 1:25 000, and 12-14 scale 1:35 000. The city is Lund, Sweden.

The test maps for each location were generalised. The aim was to create a set of maps, covering the same area and in the same *scale*, with different *level of detail in representation*. For the road data and the land use data generalisation of polygons and simplification of lines (using a Douglas-Peucker simplification) gave either hardly noticeable results or altered the objects too much (e.g. for large area objects such as land cover objects). Therefore, these layers are used in their original state in this test. The buildings in the maps were simplified by an algorithm developed by Hampe and Sester (2004). As an input to this algorithm a parameter is set; to state it simply, the algorithm then removes all features of the buildings less than this parameter value. For some maps the building were aggregated manually into blocks. For each of the fourteen locations the *test maps* were created according to Figure 3 (for some areas not all levels were created).
Figure 3: A set of maps of the same scale that covers the same area (area 5 in Figure 2). The maps differ in terms of level of detail in representation, LOD. The parameter value refers to the building simplification algorithm presented by Hampe and Sester (2004).
For each of the test maps the amount of map information was computed. The information amount was measured using the number of points. Since the original was filtered (using Douglas-Peucker with a low threshold value) all points can be regarded as object break points in all the LODs.

The usability study was performed with twelve test persons. Each test person was given one test map set at a time. She/he was then asked to choose which map (i.e., level of detail in representation) she/he would prefer to use on a mobile device (using it as a pedestrian navigation aid). The best map was given the grade 1, the second best map grade 2, etc.

3.2 Result of the usability test
At the time of writing, we have only evaluated the usability study on an aggregated level. That is, the result in this section is based on the total grade for all test persons. There has not been, so far, any work with trying to interpret the difference in preference between the test persons.

Table 1 describes which level of detail in representation that was preferred. For each test area, we identified the level of detail in representation with the total lowest grade. The results are grouped using the scale levels (cf. Figure 2). In Figure 4 the map preference is shown in relation to amount of map information (measured by the number of points).

Table 1: The figures in the table describe which level of detail in representation (LOD; cf. Figure 3) that is preferred for respective test area. In some cases two level of detail in representation received the same total sum.

<table>
<thead>
<tr>
<th>Map scale</th>
<th>LOD1</th>
<th>LOD2</th>
<th>LOD3</th>
<th>LOD4</th>
<th>LOD5</th>
<th>LOD6</th>
<th>LOD7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:15 000</td>
<td>1</td>
<td>1,2,3,6,7</td>
<td>4,5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1:25 000</td>
<td>9</td>
<td>8,9,10,11</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1:35 000</td>
<td>13</td>
<td>12,13,14</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Figure 4: The total grade for all test persons as a function of information content (measured by number of points in the map). The following representation were used for the areas: 1 - solid black, 2 – dashed black, 3 – point-dashed black, 4 – point black, 5 - solid red, 6 – dashed red, 7 – point-dashed red, 8 – point red, 9- solid blue, 10 – dashed blue, 11 – point-dashed blue, 12 – point blue, 13- solid green, 14 – dashed green.

3.3 Interpretation of the result

There are two major conclusions that can be drawn from Table 1. Firstly, for all the test areas the test persons preferred maps where the buildings where represented. This comment was also given explicitly by several test persons. However, most of the test persons stated that they would not bother if the buildings were simplified to a very large extent, as long as all the buildings were still presented in the map. This becomes apparent considering the test result for level of detail in representation 3. Here test persons noted that several minor buildings are removed. One could therefore argue that this level might have got a much better test result if the generalisation algorithm was functioning in a different way. Instead of removing buildings when being below the specified parameter value these buildings could be kept at their most generalised level.

The second conclusion is that there is no strong relationship between the scale and the level of detail in representation. It is only in two cases, area 4 and 5, that the level of detail in representation 3 was regarded as the best one and in these two cases the maps were in scale 1:15 000. As regard to Figure 2, the area 4 and 5 are the areas with the largest amount of information in reality. It should be noted that level 3 also for these maps did remove several of the minor buildings. Still, the test persons argued that this was the best level.
From Figure 4 one interesting observation can be made. The lines that are on the left hand-side (corresponding to areas with small amount of information) normally have the lowest total grade for its most, or second most, detailed representation. This in contrast to the lines to the right, where more generalised maps often are preferred.

It is not possible from this usability study to verify the hypothesis $h_0$. But, at least, we can conclude that the results indicate that the preferred level of detailed in representation is not independent on amount of information in reality.

### 3.3 Using the outcome of the usability test

The result from this study indicates that we should consider amount of information in reality while determining the level of detail in representation in mobile maps. To establish which generalisation methods to use (i.e. sought level of detail in representation) as a function of scale and amount of information in reality will require extensive usability testing. Furthermore, the measure of amount of map information must be possible to compute in real-time. In this study we used a very simple measure (total number of points with no weighting for different object classes), but more realistic measures should be developed.

### 4. Controlling the file size of the map

When requesting a map using the WMS protocol it is not possible to control the size of the returned file. There is no limitation when selecting the bounding box and there is no way for the client to determine whether the requested map will be too large or not. If the selected bounding box results in a map image that is too large in file size the application will not be able to receive the file, or it may be able to receive file but not able to process it. As for example in the case of an SVG file is received, the application runs out of memory when the file is parsed.

In this section we start by describing some technical limitations of handling large file sizes in a mobile environment. Then follows description of two methods for restricting the file sizes: bounding box strategy (at the client) and generalisation strategy (at the server).

#### 4.1 Technical limitations

There are a number of limitations of the amount of data that can be handled in a mobile environment. One limitation is the bandwidth (currently the efficient bandwidth is some tens of kbps); another limitation is the available RAM of the mobile client (some hundreds of kb); a third limitation is often set by the mobile phone operators. Furthermore, if we would like to transfer the map as an MMS (which is a sensible choice), we have to restrict to the limitations of a MMS message (currently 100 kb). To conclude, there are a number of limitations of the file size in the mobile technology and to guarantee a good communication we should use methods that guarantees that these size limitations are not exceeded.

These technical limitations are highly relevant for map applications. For example, an SVG-file that contains the LOD1 map in Figure 3 is in the range of or larger than 100 kb (the exact amount is of course dependent on type of spatial reference system used, if absolute or relative coordinates are used for the SVG geometries, etc.).

#### 4.2 Bounding box strategy (client)

In our WMS client (Bozkurt, 2005) the bounding box is set to a specified size and kept at this size for all consecutive requests. The initial bounding box was created manually and the application assumes that the file, unparsed, will fit in the available memory. The class which parses the XML-document for the received SVG file checks for the current memory usage. If the amount of available memory is below a certain limit, the class requests a garbage collection. If the available
memory still is below the limit the class skips the next element to parse. The result is that certain features are excluded in the final rendering of the image onto the display. There is no control of which of the elements that are to be excluded. Smarter algorithms could be incorporated where features within a certain radius around the current user position is always included and features further away from the user is not included, if the memory limit is about to be reached.

4.3 Generalisation strategy (server)
The second strategy would be to include functionality at the server side to control the file size. This is nothing we have implemented yet, but would like to test in the future.

In this scenario we would introduce a new parameter MaxFileSize as an optional parameter to WMS getMap request. By setting this value to a certain value, the client will be ensured not to receive a larger file than the amount specified. At the server side, generalisation methods must be implemented to select the most appropriate objects and level of details in representation to decrease the amount of data. Ideally, this generalisation would be based on usability studies similar to the one in Section 3.

This extended WMS approach should be compared to the more elaborate feature generalisation interface protocols that recently have been developed and implemented to control the response of map services (Sarjakoski et al., 2005; Burghardt et al., 2005). In our kind of proposed extended WMS, the client has control of the amount of data in the response, but no control at all of how the map is generalised. This is of course a weakness to the more powerful feature generalisation interface protocols. On the other hand, an extended WMS is an intuitive and easy approach which is likely to be more used (at least in a near future) than the more advanced feature generalisation interfaces.

5. Final remarks
In this paper we have presented a usability study concerning preferred level of detail in representation as well as a discussion about restricting file sizes in WMS getMap request. We think that both of these issues require future attention and also think that they are, partly, related to each other. Our hope is to get future funding study these issues further.

From a cartographic point of view it would also be interesting to test a stronger hypothesis than we did here. This hypothesis is: we prefer the same amount of map information on the screen of a mobile device (for a specific scale and map size). But to test this hypothesis we really need an appropriate measure of map information which is currently lacking.

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References


