Selective progressive transmission of vector data

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1. Introduction

Delivering raw geospatial data to mobile devices is an interesting and challenging computational and user-interface problem. Geospatial data can be rendered in real-time on the mobile device using appropriate visualisation software running on the mobile device operating system. Currently the majority of approaches in delivering geospatial data to mobile devices provide pre-rendered maps (tiles, images). While tile-based approaches have evolved into a defacto standard we feel there are a number of advantages in delivering geospatial data in raw vector formats (XML, GML, Shapefile, etc) to mobile devices including: *User personalisation:* User can choose which geographical features are displayed, change map themes, set visualisation preferences, etc. *Timeliness:* The user is always provided with the most up-to-date and recent versions of the spatial data. A number of contraints imposed by the mobile device environment provide major challenges including: screen resolution, available network bandwidth, and usability issues arising from providing map visualisation on small screens (Raper et al.; 2007). In this extended abstract we describe an implementation of a selective progressive transmission scheme for vector data. We use OpenStreetMap (OSM) as the case-study vector dataset. OSM data has a number of attractive features which make it a useful case study, these including: in many areas, OSM data often changes very quickly; OSM attempts to map a very wide range of geographical features; and is freely and openly available. In our implementation a user requests an area of OSM data they wish to view on their mobile device. This OSM data is downloaded immediately on the server where it is generalised. This OSM data package is then progressively transmitted beginning with a low level of detail version of the dataset. In an iterative process additional spatial detail is transmitted to the mobile device until the full resolution dataset is delivered. Our paper provides a brief overview of the implementation of our progressive transmission scheme. We describe an example of selective progressive transmission for a sample OSM dataset.

2. Implementation and Discussion

In previous papers (Ying et al.; 2010b,a) we proposed a model for progressive transmission. This model has been implemented in the Android platform. Figure 1 provides a flowchart of the implementation of this model. The user selects an area from an OpenStreetMap (OSM) slippy map on their mobile device. The Android client application sends a request to our server system. The OSM-XML data corresponding to the area requested is downloaded immediately from OpenStreetMap.org using the OSM API. For improved performance the OSM-XML is processed using data streaming. A Java-based implementation was written for the OSM-XML processing and subsequent generalization of the spatial data. We use two generalization approaches. The well-known Douglas Peucker algorithm is used for polyline simplification. For polygons it is very important to preserve shape/contour attributes for rendering on the small screen of a mobile device (Setlur et al.; 2010). We employ a very well known method from the domain of computer vision which preserves the shape of a contour across levels of detail. The method by Latecki and Lakamper (2000) is a contour preserving approach to generalization of polygons. Some OSM polygons and polylines are greatly under-represented while others are very well represented with many hundreds of nodes (Mooney et al.; 2010). Consequently some of the features in the input dataset are more heavily generalized than others. Figure 2 outlines the data structure used to maintain the ordering of nodes from the geographic features which undergo generalization. For a given node n_i a number of characteristics are maintained in the data structure including: the nodes n_j and n_k which are connected to n_i in the polygon P or polyline L; the significance KS_i to the overall polygon which is calculated from the angle at n_i and length of this node's incoming and outgoing edges (from (Latecki and Lakamper; 2000)); the order or position where n_i was removed during the generalization process is used by the progressive transmission to progressively rebuild the polygon or polyline.

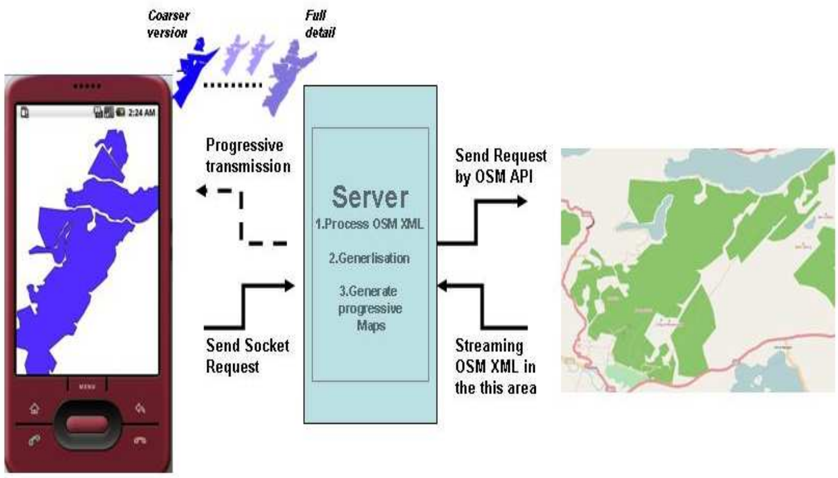

Figure 1: A schematic diagram illustrating the software implementation of our progressive transmission model

Figure 3 shows screenshots from the Android device of an example of progressive transmission (top row of images) and selective progressive transmission (bottom row of images) applied to a sample OSM dataset. The left-most column shows the progressive transmission process when only 20% of the original nodes are present in the input dataset. Subsequent columns show 40%, 60%, 80%, and finally the right-most column shows the full resolution (100%) dataset. Two polygons are coloured in blue. The large polygon is NP_a and the smaller polygon is NP_b. In the progressive transmission example nodes are added in the reverse to how they were removed during generalization. The most significant nodes are added to the transmitted dataset first. Only close to the end of the progressive transmission are the nodes with very low overall significance transmitted. The problem with this approach is that shapes with small area (relative to other shapes in the map) containing a large number of nodes are only provided with additional spatial detail close to the end of the progressive transmission. In a selective transmission scheme (bottom row of images in Figure 3) the area

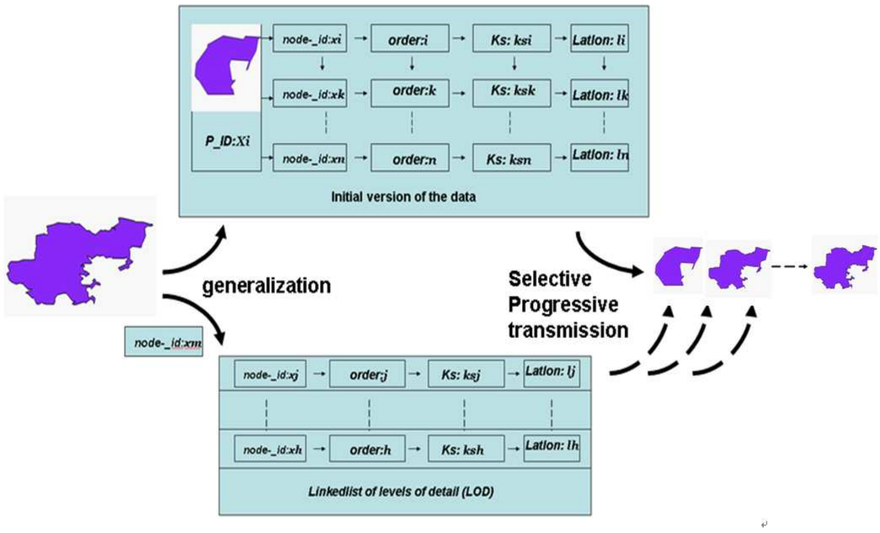

Figure 2: A schematic diagram of the indexed data structured used to maintain the ordering of nodes from the geographic features after generalization

of each polygon shape in the map is used as the selection criteria. Regardless of the significance of nodes the larger shapes in the map recieve additional spatial detail before smaller shapes. This could help reduce the cognitive load on users as the larger shapes are more visible on small screen displays (Burigat and Chittaro; 2008). A number of different selection criteria could be used to drive the selective progressive transmission process. These include: measures of circularity or rectangularity of the shapes, area ratio (normalised ratio of difference between area of the polygon and its convex hull), shape complexity based on convexity of shapes (Brinkhoff et al.; 1993), map clutter indicators (Harrie and Stigmar; 2010), etc.

3. Conclusions and Future Work

With the gradual move of cartography from paper maps to web and mobile maps the requirement for real-time cartography has come into play (Yang and Weibel; 2009). We have described the implementation of a model for selective progressive transmission of vector data over the Internet to mobile devices. In this phase of our research we have used the area of the polygon shapes in the map as a shape metric to guide the selective transmission after the generalisation of the data on the server side. Using different shape metrics will affect how the spatial data is transmitted to the client device. To quantify which shape metrics work best for delivery of raw spatial data, such as OpenStreetMap, to mobile devices we are carrying out extensive user trials. During these trials with the Android-based mobile device we are collecting large quantities of additional information including zooming and panning behaviour of users as the map display progressively becomes more detailed and click/point interaction from the user with the map display. The long-term goal of this research is to develop a robust model for the smooth and seamless delivery of large quantities of raw vector data (in our case OSM data) to mobile devices. Progressive transmission strategies will become more important going forward resulting from the increased requirement of spatial content and the ubiquitous nature of mobile devices. The commercial aspect of this research is summarised by Khurri and Luukkainen (2009) who comment that to continue innovation in mapping services and user-generated content for Location-based Services map vendors will only gain competitive advantage by providing “up-to-date maps as a primary precondi-

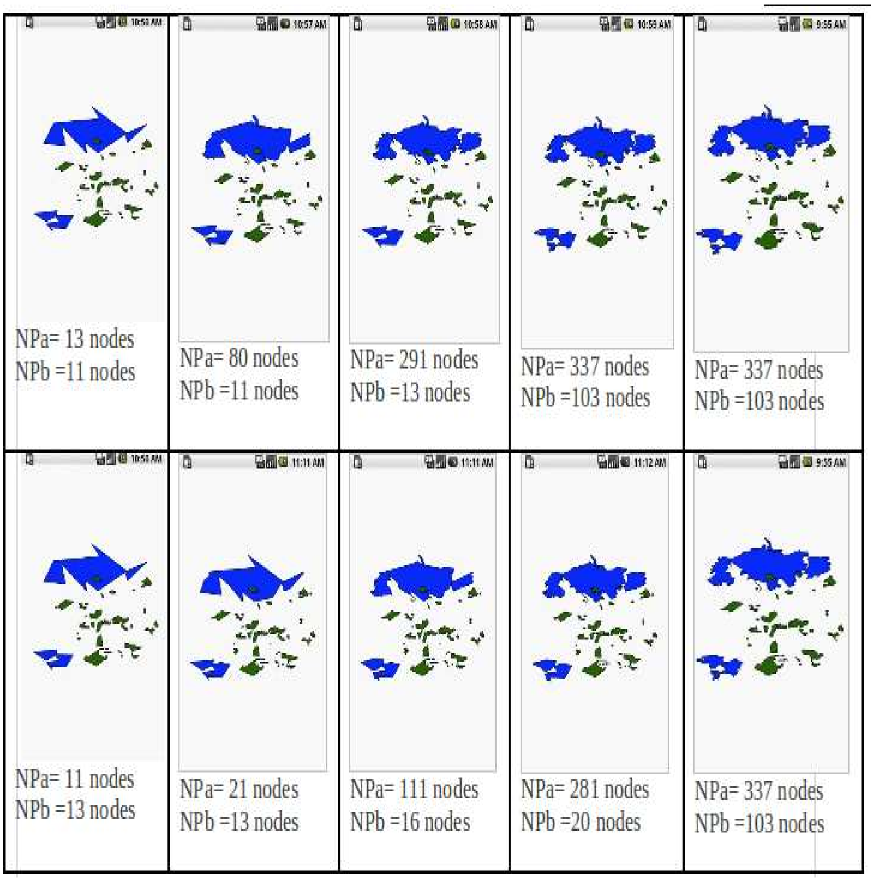

Figure 3: An example of progressive transmission (top row) and selective progressive transmission (bottom row). In the progressive transmission example detail (nodes) are added in revese to the order they were removed while in the selective case larger shapes recieve detail early in the transmission. NP_a is the large blue polygon while NP_b is the small blue polygon

tion for supplying accurate, timely and relevant content to LBS consumers".

Acknowledgements

Fangli Ying is funded by Irish Universities Association and China Scholarship Council. Research presented in this paper was funded by a Strategic Research Cluster grant (07/SRC/I1168) by Science Foundation Ireland under the National Development Plan. Peter Mooney is funded by the Irish Environmental Protection Agency STRIVE programme (grant 2008-FS-DM-14-S4).

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