A Progressive Transmission Scheme for Vector Maps in Low-Bandwidth Environments Based on Device Rendering

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Abstract. The Internet has created an interesting environment for geospatial data sharing, so that users may transfer, visualize, manipulate and interact the data sets. This environment not only provides new opportunities to geospatial data usage, but also introduces new problems that should be addressed in order to provide an efficient and effective use of these datasets. One of such problems is related to the use of these spatial datasets in a low-bandwidth environment, such as those involving mobile computing. This paper presents a progressive transmission method for vector maps on the Web. The proposed method anticipates the map rasterization process to be performed at the server side, so that the amount of information transmitted may be reduced. We combine scale-dependent transmission techniques with simplification and progressive ones, in order to maximize the overall performance of a Web GIS environment.

1 Introduction

Visualization plays an important role in geographical phenomena understanding and analysis. For a long time, maps have been used for representing spatial data, aiming to clarify and understand their relationships.

Currently, the Internet is becoming the main vehicle for publishing geographical information, which enables data interchange, analysis and geographical data visualization [1], [2]. The rapid evolution on Web technology has lead to an improvement of the geographical information utilization and availability [3], [4], [5], [6], [7].

The Internet has created an interesting environment for geospatial data sharing, in which data providers make their databases available through the Web, and users may transfer, visualize, manipulate and interact with them [8]. This environment introduces new problems that must be addressed to make possible an efficient and effective use of these datasets. One of such problems is related to the availability of huge geospatial data amount in repositories with limited connection bandwidth [9].

Even though the access to large network bandwidths is becoming more popular, there are situations where the transmission is a critical factor, as in wireless networks.
These requirements have lead to a set of techniques devoted to the minimization of bandwidth requirements and better utilization of available resources, so that it may enable the publication of vector geospatial data in low bandwidth environments.

There are some classes of techniques employed to address the problem of efficient transmission of huge amount of geographical data, which include multiresolution, generalization and progressive transmission.

This paper presents a scheme based on the combination of generalization, content adaptation and progressive transmission techniques to make more efficient the map transmission process in a client-server environment. Our approach aims both to minimize the impacts in data consistency and to improve the application usability through a better user response time. Furthermore, we seek to deal with large vector maps transmission and visualization over the Internet.

The remainder of this paper is organized as follows: section 2 discusses related work on vector map transmission. Section 3 focuses on architectural issues. Section 4 presents our proposed progressive transmission scheme. Section 5 highlights the results obtained from the tests performed. Finally, section 6 concludes the paper and highlights further work to be undertaken.

2 Related Work

Several methods have been proposed to transmit spatial data in its vector format using a progressive process [1], [8], [10], [11], [12], [13]. Such methods are based on the idea that a typical user consumes the map information gradually from low levels of detail to more detailed scales. Based on this evidence, we can generate the map and transmit it gradually.

In the progressive transmission, the map server divides the map into a low resolution version and a set of incremental versions, that when incorporated to a certain map version will generate a more detailed map version. The client is responsible for receiving a map detail increment at some level $n$ and for integrating it into the current map version which generates a map version at level $n+1$.

Other approaches to this problem explore device restrictions like visualization resolution. This can determine the level of detail that can be visualized in a specific device. In general, the device can represent less detail information than the amount that is sent by the map server. The level of detail that cannot be visualized increases the transmission cost and does not improve the quality of the map visualized by the client. Thus the elimination of such information reduces response time at the client side without compromising map quality [14].

Bertolotto and Engenhofer [15] have proposed an on-the-fly mapping generation for the Internet using a progressive transmission scheme. Their work creates multiple dataset representations corresponding to different levels of detail, which are sequentially transmitted and added to the map visualized on the client.

Harrie et al. [16] address the visualization of geographical data for mobile users. Methods to adapt data stored in the database to small-scale areas of the map in real time are described, using generalization procedures through a XSLT transformation.