GeoGraphLab: a tool for exploring structural characteristics of transportation network

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1 INTRODUCTION

Transportation systems hold in their structure a complexity inherent to the arrangement of the various components (nodes and edges) that composing them. In order to get information that will be useful for users (travelers, network operator or land developer), it is necessary to understand how a transportation network reacts to different stimuli.

There are several problems related to the analysis of a transportation system: firstly combinatorial problems arise as mathematical indicators based on all shortest paths on the network, secondly data storage and mining problems and finally problems to visualize these data.

This paper introduces new methods for network exploration aiming at solving these problems. To answer to these different issues, this paper proposes software architecture dedicated to the structural exploration of a transportation network.

2 CONTEXT AND ISSUES

A transportation network is a geographical object with a spatial dimension (nodes location), a metric dimension (nodes and edges attributes) and a topological dimension (the relationships between these nodes through edges).

In this context, this paper presents a tool to explore the structural properties of transportation network. The exploration is here defined as the set of methods which allows assessing the structural organization of transportation network in order to highlight properties and to understand a phenomenon based on the network. The tool lies on an efficient model which answers to issues related both to combinatorial networks (important data volume) and to their visualization.

To realize a structural study of a network, some indicators have to be computed (Chapelon, 1997; Gleyze, 2005). Most of the latter are called relational and need a collection of paths on the network as inputs. Our study focuses on Origin-Destination (OD) space where origin and destination nodes are connected by their shortest path (SP).

3 SOFTWARE ARCHITECTURE

3.1. Model

Our model aims to help the understanding of structural properties of a network. It lies on the map principle which allows translating the network's behavior when users apply different indicators on it. A map can be decomposed in four main properties (fig 1) which are the different parameters in our exploration system (Mermet, 2009):

- **Space** is constituted of a set of OD relations on the network. Where:

  $OD_k = (n_i, n_j)$, $n_i \neq n_j$

  OD-Space = $\{OD_1, OD_2, \ldots, OD_k\}$, $k=n^2$ if graph is directed $k=n^2/2$ else

  It is the set of definition for measure calculus.

- **Measure** is a mathematical property which synthesizes information collected on OD relations.
- **View** is a graphical representation of the network which permits the variation of levels of details by nodes aggregation (Gleyze, 2003, Gleyze, 2009).
- **Legend** allows better assessing results displayed by operating variation on the number of boxes (classification) and colors (symbolization).

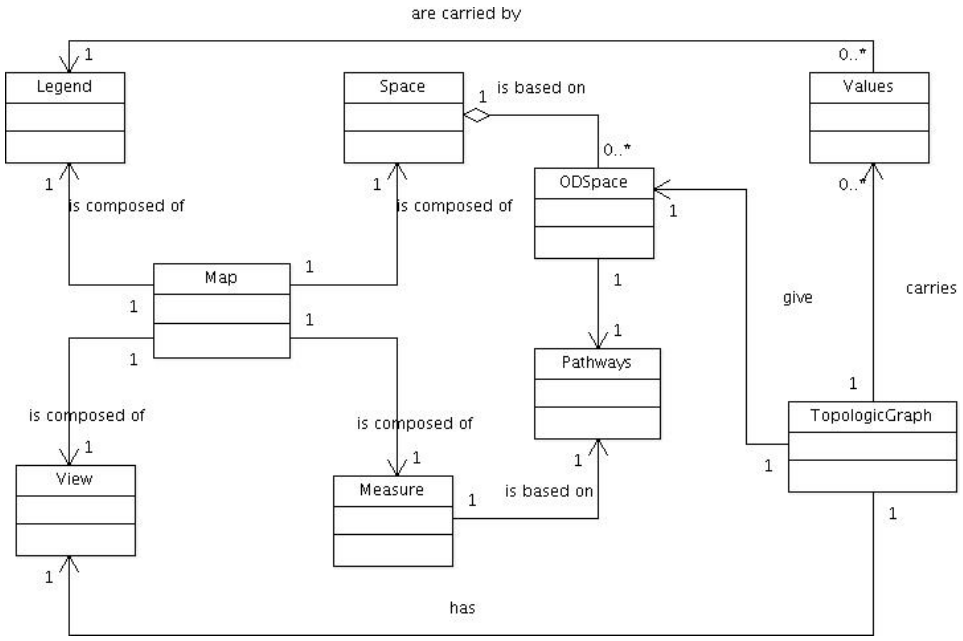

Figure 1: simplified UML diagram for the exploration kernel

3.2. Tools for exploration

Based on these four properties, dynamic exploration methods and tools have been developed and gathered in a system for exploring the structural properties of transportation network, called GeoGraphLab. GeoGraphLab (fig 2) is a tool built on the top of the conceptual model. It is a multiplateform tool as it is written in Java and use common LGPL libraries like JGrapht[1] that provides us mathematical graph-theory objects and some algorithms or GeoTools[2] for spatial analysis.

GeoGraphLab contains the following functionality:

- A tool for managing OD Space: it can apply selections from the whole OD space in order to reduce the workspace,
- A library of indicators (betweenness or proximity centrality, average or maximum distance, proximal or distal radius, etc.) whose calculi are based on the OD space defined above,
- A tool to set dynamic legend that allows users to choose colors in a palette, or to set the segmentation of classes of values,

1 JGraphT: http://jgrapht.sourceforge.net/

2 GeoTools: http://www.geotools.org/

- A tool for nodes or edges aggregation in an area (values are conserved on these aggregations by average or median),
- A layer manager which stores maps in the system and keeps an historical linear track of the exploration,
- A command line which operates on parameters of the layers component inspired by another graph exploration tool: GUESS (Adar, 2006),
- A workflow method allows visualization as tree for the exploration and the history storage (Fig 2).

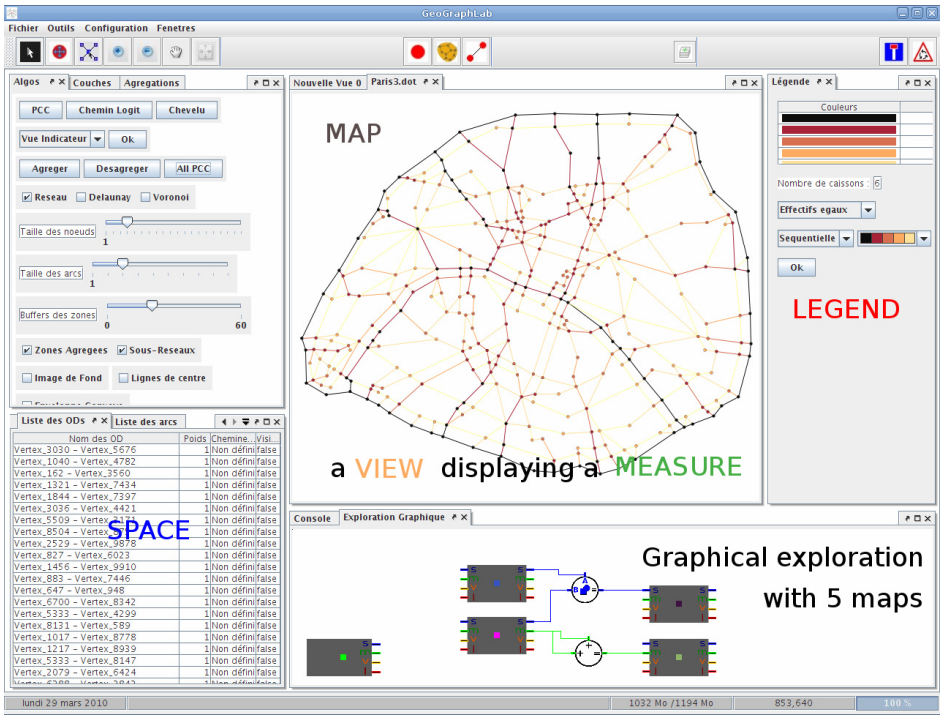

Figure 2: interface of the GeoGraphLab tool

4 CONCLUSIONS AND FUTURE WORK

This paper has presented a new program called GeoGraphLab for exploring structural properties of a transportation network. GeoGraphLab is developed upon a conceptual model based on four parameters of a network analysis map that are an Origin-Destination space, a measure, a view and a legend.

A modification in parent map will result on creation of a new map with different parameters. Each map is stored in a history stack. Once these maps stored, it is possible to view them separately with all parameters conserved. Thereafter, it is possible to cross the map parameters between them to obtain new maps. There is tow ways for this operation. Either user can use the command line for crossing measure values with basic mathematical operations or either it is possible to use a tree exploration graphical interface to realize sequences. These methods allows to users to have logic in their

exploration and to follow their thinking. It also stores the exploration sequence as a tree by using a graphical interface where maps are symbolized with blocks in a graphical language.

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