CO-450

# CARTOGRAPHIC GENERALIZATION OF SOCIAL NETWORK

*POMBO R.M., SLUTER C.R.*
*Universidade Federal do Paraná, CURITIBA, BRAZIL*

**ABSTRACT**
The network term is strongly used in many fields of knowledge with different meanings and applications. In social sciences, network can be represented by nodes and lines. These nodes are the actors of the network and their relations are represented by lines. The arrangement of the network can be made by graphs without spatial reference. However when it comes with geographic positions of the actors, the network is highly improved because it may be shown in a database map with its additional information. The main scope of the study is to represent those networks in small areas like 15 inches computers screen to give more interaction between the user and the map. Although this interaction facilitates the user analysis, it creates communication problems like symbols overlap. To minimize this issue this research proposes the use of cartographic generalization. The generalization operators applied in this work are: aggregation, displacement, rotation and smoothing. Considering the communicability, the results show that generalized maps are more effectives than scale reduced ones.

## INTRODUCTION

In this paper we describe a map generalization approach for multiple representations of thematic maps visualized on a 15 inches computer screen. These thematic maps represent social network characteristics. Several social problems can be better understood from network analysis. In the Social Sciences, those networks are conceived as a set of interlinked nodes (network actors) that represent individuals, groups of people, or institutions, and they are analyzed as directional or non-directional graphs, named sociograms by sociologists (Figure 1). The actors' relations are represented by lines in network graphs (DELAZARI, SLUTER e KAUCHAKJE,2007).

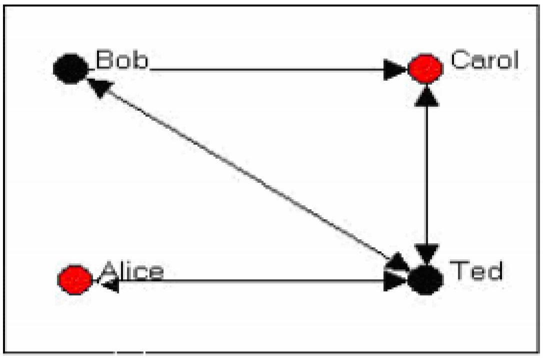



*Figure 1 – An example of a sociogram*

The analysis of social networks uses mathematical models specially based on graphs. In order to develop social network analysis the socialogists use softwares that represent just an arrangement of nodes linked with each other or not, without spatial references. The cartographic visualization applied to social networks can enhance the socialogist knowledge through an exploration of the geographic characteristics of the network (Matheus and Silva, 2006).

Although such graphs do not represent the spatial location of the actors, and consequently of the actors' connections as well, it is possible to define and depict the actors' geographic positions on a map by their addresses. Consequently, map design and generalization theories can be applied to social network representations and analysis to allow social scientists to achieve better results from data exploration. The social networks defined in this research project are related to different geographic regions: namely a Brazilian city, its state, and the whole country. We need to show on a computer screen, therefore, thematic maps of regions of different sizes; consequently, the map design demands multiple scale solutions. In this paper we describe the generalization solutions for representing the social network in the city of Curitiba, capital of Parana State, Brazil.

Marchis (2008) proposed a map design to represent social networks in large paper formats. In this research we represented the networks on virtual environment and they can be totally viewed in a 15 inches computer screens. The spatial referenced network deepens the knowledge of the sociologists because they can learn more about the geographic aspects of different regions and the correlation of the characteristics of these regions and the network. For example, it is possible to analyze the correlation between socioeconomics and cultural data and their influence on the social network actors. Therefore, the main objective of this work is to enhance the analysis capabilities of the socialists through the representation of geographic characteristics and structural aspects of social networks on a 15 inches computer screen, using cartographic generalization theories in order to keep the communication level of the maps.

**METHODOLOGY**

The methodology of this research project is mainly based on five generalization operations: classification, aggregation, rotation, smoothing and displacement. The first methodological step was to define what social networks would be analyzed by the maps' users, e.g., social scientists, and consequently to study the characteristics of the geographic region where those networks are located. Further, we developed some steps of a map design in order to decide the base maps and scales for each thematic map. Using GIS software, we defined the geographic location of every actor in the largest scale map by using their addresses. The first map generalization task was to classify the actors' attributes and their relationships. Based on the results of the attributes' classification, we proposed some criteria for aggregation and displacement operators. As the map scales were reduced, the generalization problems were detected and the criteria were applied in order to achieve suitable cartographic solutions. The maps were generated in UTM projection at 1:250.000 scale for the representation of Curitiba city, at 1:3.500.000 for Paraná State, and 1:50.000.000 with Polyconic projection for Brazil.

In the classification step we made decisions based on the following criteria: 1) that the attributes of the actors must allow the map user to know about their organization type and, 2) the number of links of each actor and the aspects of these relations must be known from the thematic map use. In order to accomplish the classification task in the map design we firstly classified the organizations by their types, that is, if they any kind of partnership with the govern or not. The result was two classes: governmental institutions and non-governmental organizations. Nevertheless there are significant differences among the non-governmental institutions, so another classification was defined for these organizations, and the resulted classes are: religious, business, philanthropic, public service, trade-unionist, others.

The information about social actors were learned from internet sites, and then they were organized and stored in computer databases as shapefile format to generate the thematic maps. The GIS database organization was based on the thematic data classifications, which are the results of the conceptual generalization.

The moment to apply the graphic generalization is defined when the reduction of map scale make possible a wrong interpretation of the map by the user. McMaster and Shea (1992) call this moment in their conceptual model as cartometric evaluation, which have three aspects: geometric conditions, global and special measures and control of the transformations. The geometric conditions include geometric situations created by the scale reduction like: congestion, coalescence, conflict, complication, inconsistence and imperceptibility. Each one of these situation needs at least to apply one operator of graphic generalization. The cartographic representation at different scales of the social networks defined in this research had mainly caused congestion and imperceptibility.

We used global and spatial measures in order to quantify and determine a geometric condition to which a generalization operator should be applied. These measures are the starting point for knowing about the geometric conditions. McMaster and Shea (1992) propose the following measures: density, distribution, length, sinuosity, shape and distance.

In this research the most frequently used graphic operators were aggregation (Figure 2), displacement (Figure 3), smoothing (Figure 4) and rotation (Figure 5) and they solved problems of coalescence, congestion and imperceptibility. Figure 2 shows that the aggregation was used when one-dimensional symbols of same class were overlapped. The result of this operation was the creation of a new symbol which differs through visual variable size. The proportion of the size variation was determined in relation to the quantity of actors represented by the symbol. When there is coalescence between two different symbols, the displacement operator is applied (Figure 3). These operators were applied under the condition that the change in position of the social actors cannot modify their orientation and relative position to the other actors.

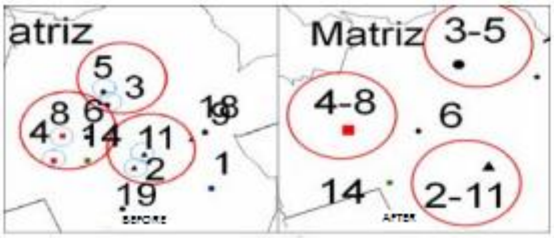



*Figure 2 - Aggregation*

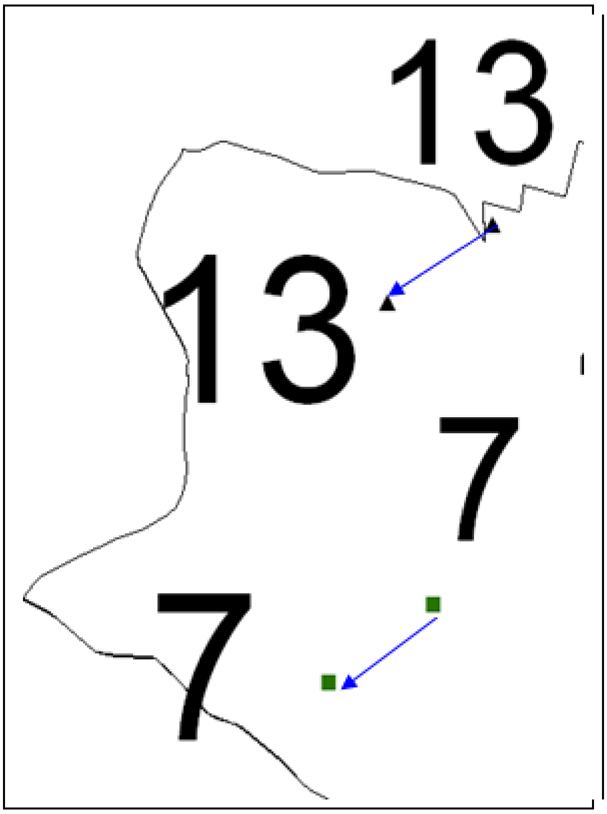



*Figure 3 - Displacement*

The same criteria were applied to linear symbols but here was used also the rotation operator (Figure 4). When only one actor of a network relation was dislocated, it was applied the rotation. The smoothing is used to remove the excessive details of the lines that represent the districts and city boundaries (figure 5). This is an usual situation when the boundaries are defined by rivers and streams.

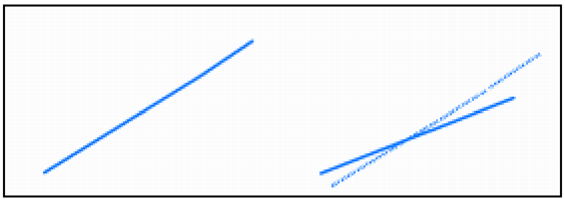


*Figure 4 - Rotation*

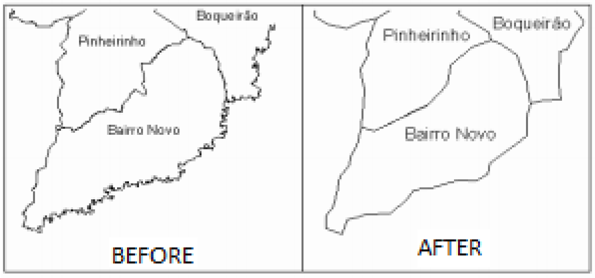
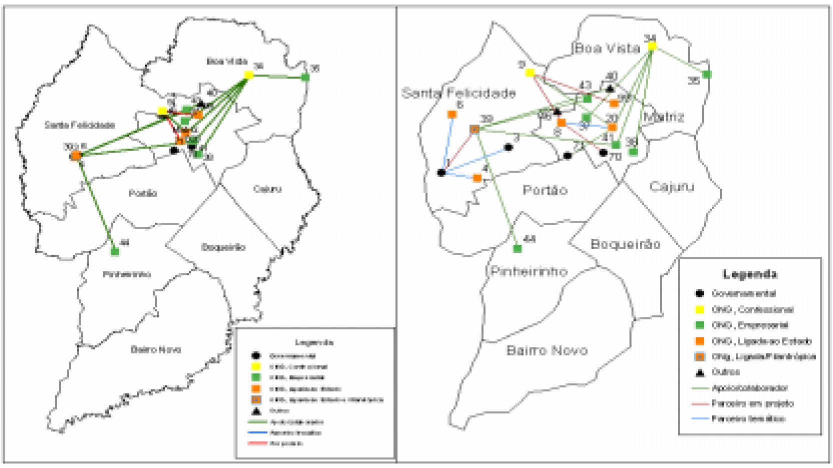



*Figure 5 - Smoothing*

**RESULTS**

The results obtained with the generalized maps are considered very efficient, since it is possible to visualize the main social network characteristics either in medium scale or small scale maps. The visualization of the generalized maps showed us that the downtown region is the most assisted area by social network actors because it is the region where the most influential actors are located. As a consequence, the map generalization of each thematic variable occurred mostly in the central part of the city. The displacement operator was used more frequently than the aggregation operator because most of the overlapping symbols occurred between actors of different thematic classes. Due to the large quantity of thematic symbols in the city's central region and to the application of a displacement operator, several point symbols were located all over the central part of the city. However, their relative position and orientation were preserved as a generalization condition.

In this section there are two maps that illustrate the thematic representation of the social assistance network in Curitiba before (figure 6a) and after (figure 6b) the cartographic generalization. On the map showed in the figure 6a it is difficult to recognize the social actors and their relationships in the regions called Matriz and Santa Felicidade. The network can be better viewed on the map illustrated in figure 6b, in which it is evident all the actors' connections.




(a) (b)

*Figure 6 – Result of generalization of the network thematic representation*

The results for the state and country's map are illustrated in the figures 7 and 8. It is evident the difficulty to depict the actors inside the city, which explains why all of them were aggregated and then just the relationships with another cities or states can be analyzed. There is no possibility of metric comparison because the only intention was to keep the relative orientation between the actors. When the map users compared both maps, that is, the original and the generalized map, they mentioned that it is also possible to understand the actors' relationship from the generalized map. Therefore, we can conclude that the use of the rotation operator was efficient.

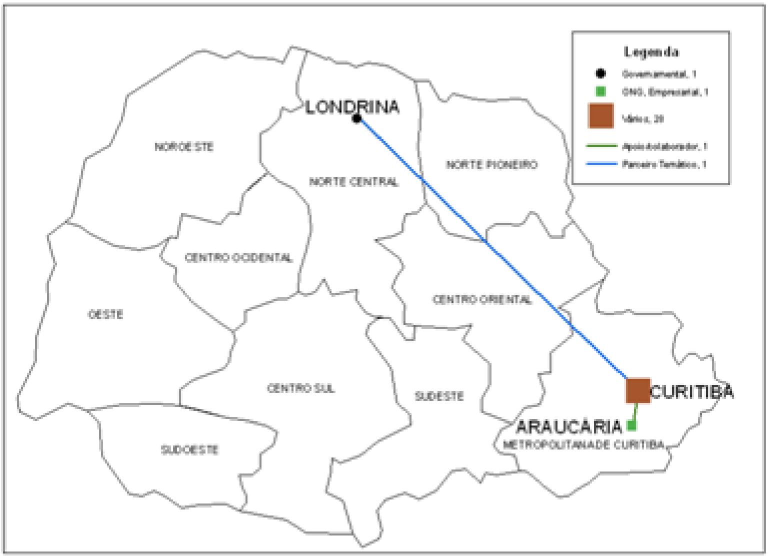



*Figure 7 – Result of generalization of the network in Parana*

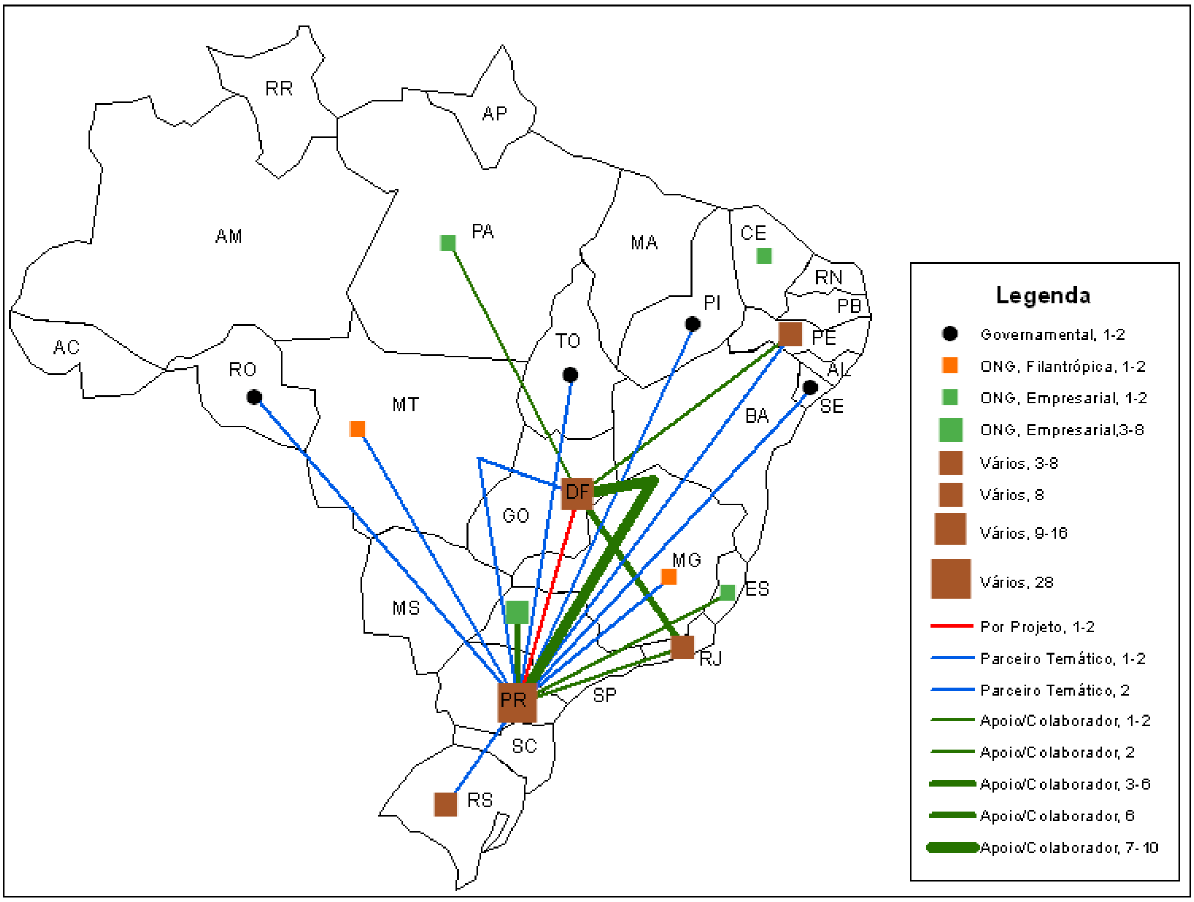



*Figure 8 – Result of generalization of the network in Brazil*

**FINAL CONSIDERATIONS**

The cartographic representation on a computer screen demanded a scale reduction and, as a consequence, it is necessary to handle some graphic problems like coalescence. At first it was tried to use the same classification made by Marchis (2008). However, the set of information was transformed due to graphic generalization needs. Therefore, the old classification was not suitable anymore because the aggregation was applied and this operator changes the actors' characteristics and the geometry of the network.

In this research the most used operators were aggregation, smoothing, classification and especially displacement. New symbols were created by applying the aggregation operator. The operation was defined by the union of two or more one-dimensional symbols. The smoothing operator standardized the regions limits. Finally, the displacement operator was applied to avoid congestions, imperceptibility and coalescence of symbols of different classes. The rotation operator was used for linear symbols when one or both actors had a position changed. The use of those operators showed that the level of communication of the generalized and non-generalized maps were similar. Therefore, the main purpose of this research was achieved.

The application of cartographic generalization in this research was intended to make evident the main characteristic of social networks: the links. However, the map failed to represent some spatial behavior of phenomena like social actors concentrations in some areas because these actors had to be moved to illustrate all their relations. In the cases of Parana's and Brazil's map just the relationships can be analyzed.

It is recommended for future studies to develop some algorithms to apply this operators in digital cartographic generalizations methods.

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