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Label Propagation Algorithm Based Methodology for Water Supply Network Sectorization

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Abstract. The increasing pressure over water resources has raised the need to establish procedures to efficiently manage water supply networks (WSN). An example of such procedures is the sectorization of networks either by installing valves (closed) or by sectioning pipes. This work presents a WSN sectorization method based on a combination of operational criteria with a so called *label propagation* algorithm. The method has proven to be appropriate to sectorize WSN dependent of a trunk where the number of sectors is *a priori* unknown.

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1. Introduction

The global concern on the pressure over fresh water resources has raised the need to redefine or to put forward new strategies for urban water supply management. One of such strategies is sectorization, which entails the subdivision of WSN by closing some pipelines and installing flow meters in a single line (pipe) of each subsector. Over the last decade, several computer based methods have been put in place in order to automatically sectorize WSN [3, 5]. Essentially, these studies have used graph techniques along with mathematical optimization tools to treat the sectorization problem as a graph partitioning problem with a predefined number of sectors. Although there are many large WSN where this type of approach is unfeasible given that the number of sectors is initially unknown, only few studies have tackled this problem [1, 4]. Graph clustering has been a very relevant field of investigation in recent years. Clustering of networks where the number of sectors is *a priori* unknown fall within the field of communities' detection, which has been broadly studied by the social network scientists [2].

1.1. Community detection through label propagation algorithm

A WSN can be considered a union of subgraphs (areas with high edges density) given that their layouts respond to urban needs. Any urban block (e.g. neighborhood or conglomeration of industrial facilities) counts on a subnetwork of minor diameter pipes connected to other areas or to a trunk by means of few larger diameter pipes. The *label propagation* algorithm is an approach based on networks structure. It does not require initial information on the number and size of sectors. The algorithm works labeling each node individually, and at each iteration each node adopts the label that most of its neighbors currently have. In this iterative process, densely connected groups of nodes form a consensus on a unique label to form communities [7].

2. The proposed methodology

The objective of this methodology is to define sectorization layouts in WSN where the number of sectors is not initially prefixed and has to be explored based on the network community structure and operational criteria. The steps of the methodology are the following: (1) Network transformation into a weighted graph; (2) WSN trunk pipes segregation based on a factor and pipes weights; (3) Communities detection in the reduced graph through *label propagation* algorithm; (4) Entrance definition to each sector based on an energy assessment. Figure 1 illustrates the whole process.

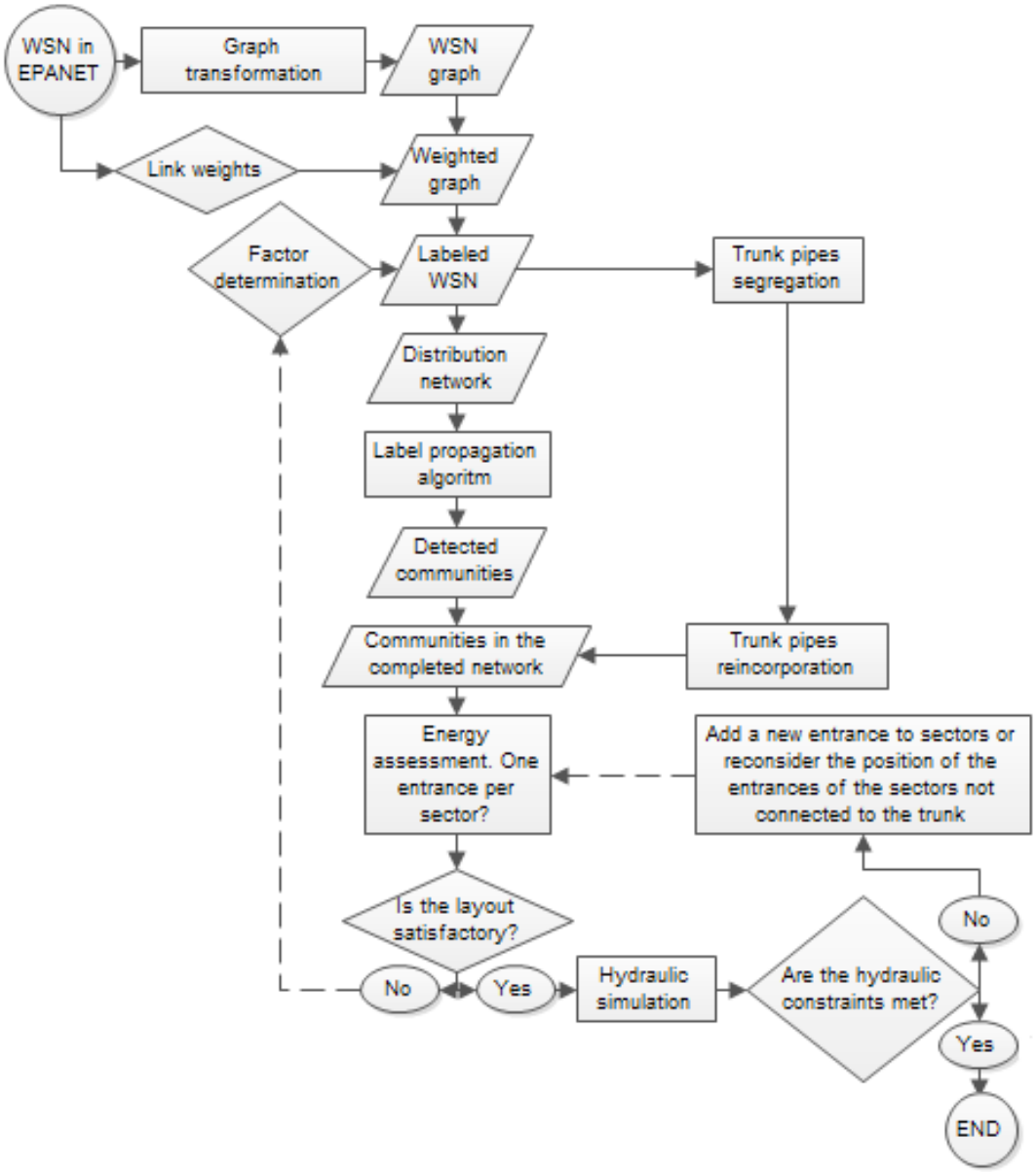

Figure 1: Flowchart of the process.

3. Example of implementation

To exemplify the method described above the well know WSN from "The Battle of Water Networks II" [6] is sectorized. For this example the network was subdivided in seven large sectors and a series of very small sectors. In Figure 2, the original network and the communities detected are presented.

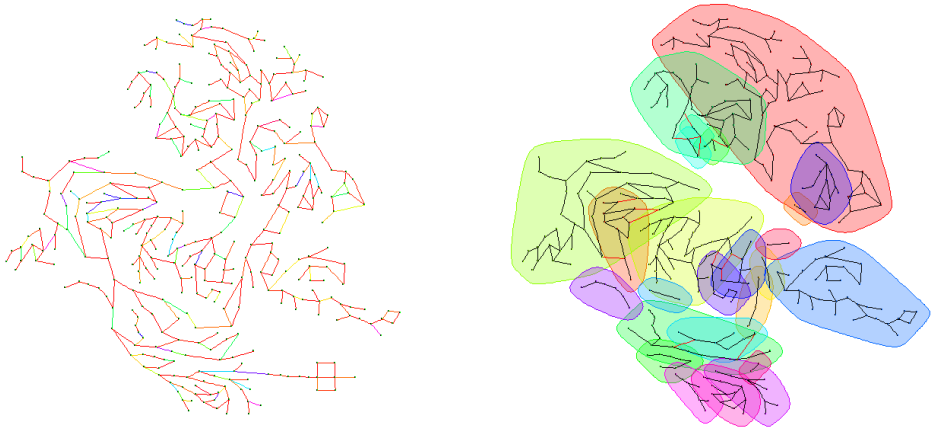

Figure 2: Original network (left). Communities detected in the network (right).

4. Conclusions

Through the methodology presented above, it is possible to obtain sectorization layouts in WSN where the number of sectors is *a priori* unknown. Specifically, the *label propagation* algorithm allows the detection of subgraphs in the network corresponding to blocks connected by few pipes that are naturally found in WSN. This methodology allows water operator to center efforts in the areas of WSN where leakages are more frequent, making water losses management more efficient.

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