Generation of synthetic water distribution networks

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Introduction

A lot of research has been done in the field of optimisation of water distribution networks (WDN) over the past thirty years. One criticism on the current state of the art is that the metaheuristics developed in this field are not adequately tested in terms of robustness and performance. The applied benchmark networks are useful to demonstrate the developed methods, but cannot be used to base scientifically correct conclusions on. In order to make generalisations and perform sensitivity analyses, the developed methods should be tested extensively on a wide range of test networks. Preferably, these networks should have a high resemblance to realistic networks.

Unfortunately, the number of available, realistic instances on which algorithms can be tested is limited to only a handful. This is due to (1) the time consuming process of data collection, data conversion, data digitalisation, calibration and validation and (2) confidentiality reasons : water distribution companies are not eager to share their data and the dissemination, even for research ends, is prohibited.

This need for realistic test networks caused us to develop a tool to algorithmically generate (synthetic) water distribution networks.

Our method

The developed water distribution network generation tool has the following properties :

- The development of synthetic WDN's is done algorithmically, in order to be able to generate an extensive library of diverse problem instances.
- The tool is able to generate realistic WDN's of arbitrary size and characteristics, corresponding to the networks of different sizes and characteristics found in real life. This is reflected in adjustment of parameter settings.
- The database of generated networks is freely available online.
- The generated networks are available in EPANET format, since this is the most frequently used hydraulic solver.

The generation method is divided into five phases :

1. Generate random points.
2. Generate a minimum spanning tree.
3. Add water reservoirs, tanks and pumps.
4. Generate loops.
5. Assign load patterns.

In Figure 1, a generated synthetic water distribution network is shown.

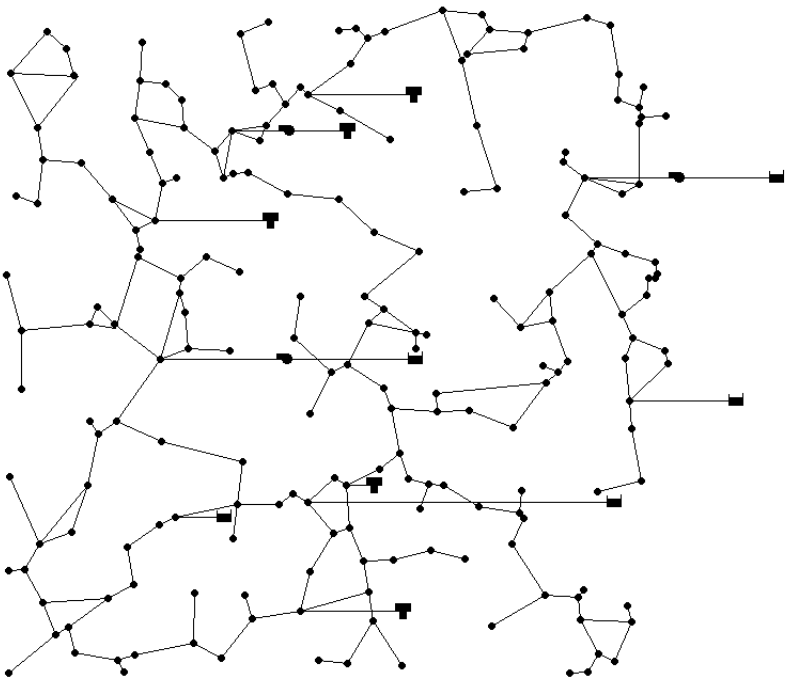

FIGURE 1 – Generated water distribution network : 200 demand nodes, 5 water tanks, 5 reservoirs and 3 pumps

Network analysis

Since WDN can be seen as finite, connected planar graphs, graph theory principles are used to analyse and compare both realistic and generated water distribution networks.