Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 186 (2017) 470 – 474

Procedia Engineering

www.elsevier.com/locate/procedia

XVIII International Conference on Water Distribution Systems Analysis, WDSA2016

Water age clustering for water distribution systems

Elad Salomons[a], Avi Ostfeld[b,*]

[a]*OptiWater, 6 Amikam Israel St., Haifa, Israel*

[b,] * *Faculty of Civil and Environmental Engineering, The Technion – Israel Institute of Technology, Haifa, Israel*

Abstract

This work presents an algorithm for water distribution systems water age clustering. The objective is to cluster a distribution system into water age sub-zones whose water age variability is minimized within each cluster. The algorithm stages are: (1) water age computation for each system node, (2) kick-off at a number of clusters equal to the number of nodes (i.e., each node initially acts as a cluster), (3) search for the two connected (by link) clusters which have the smallest absolute water age difference, and combine them into a single cluster; characterize their water age value as the weighted arithmetic mean of the two clusters, and (4) repeat step 3 until all nodes are lumped into a single cluster (i.e., the entire water distribution system). The algorithm thus spans all possible clusters starting from the total number of system nodes and up to a one cluster which holds the entire system layout. The model, through a clustering numbering trade-off, is demonstrated on a mid-size water distribution system.

Peer-review under responsibility of the organizing committee of the XVIII International Conference on Water Distribution Systems

Keywords: Water distribution system; water age; clustering

1. Introduction

Simplification methodologies for complex water distribution systems are essential for better understanding a water system behaviour. Such methodologies have been developed previously, proving a substantial improvement for water distribution systems management and operation. A water distribution system can be viewed as a graph consisting of nodes and links. Those characterize the consumers and pipes and other network elements such as pipe junctions,

* Corresponding author. Tel.: +972-50-7726139; fax: +972-4-8228898.
E-mail address: ostfeld@tx.technion.ac.il

Peer-review under responsibility of the organizing committee of the XVIII International Conference on Water Distribution Systems
doi:10.1016/j.proeng.2017.03.256

valves, sources, tanks, pumps, and reservoirs. Graph theory aids in dividing the network into clusters based on user's preferences, thus enhancing the network operator in achieving an improved network operation strategy. One of the methods building on graph theory towards controlling and gaining insights to a system operation is it's clustering into sub-regions entitled district metering areas (DMA's). Those techniques vary with network size and objectives, and are continuously evolving into practical techniques. This study is on clustering a water distribution system according to water age, as water age is a major factor in water quality deterioration of water distribution systems and can be viewed as a surrogate to water quality.

2. Methodology

As an initial technical step, all end-points of the network without demand are eliminated since their water age value will always be zero. After this technical step is done the methodology is built from two stages. In the first stage the basic clusters database for any cluster number is built. The methodology for the first stage of water age clustering is described in Figure 1. In the second stage the clusters are reorganized for a specific number of clusters according to the user requirements. The second stage is described in Figure 2. In the first stage the following steps are taken:

1. A water age simulation is made for a sufficient duration to ensure that stable water age results are obtained without influence of the initial conditions. The water average water age for each node in the network is calculated for a 24 hours' period of stable water age results. At this stage each node is considered to be a separate cluster: $cClusters = nNodes$, where $nClusters$ is the number of clusters and $cNodes$ is the number of nodes in the network. The connections between the clusters are recorded according to the links in the network.
2. The two connected clusters with the most similar values of water age are found and merged into one cluster. The water age value of the new cluster is calculated according to the water age values of the nodes which are included in it. The clusters counter is now reduced by one: $nClusters = nClusters - 1$ and the changes in the clusters connections and structure are recorded in the database.
3. Step 2 is repeated until $nClusters = 1$.
4. At this stage the clusters database contains the structure of the clusters for every clusters number from $nNodes$, where each node is a cluster, to 1 where all nodes are considered as one cluster.

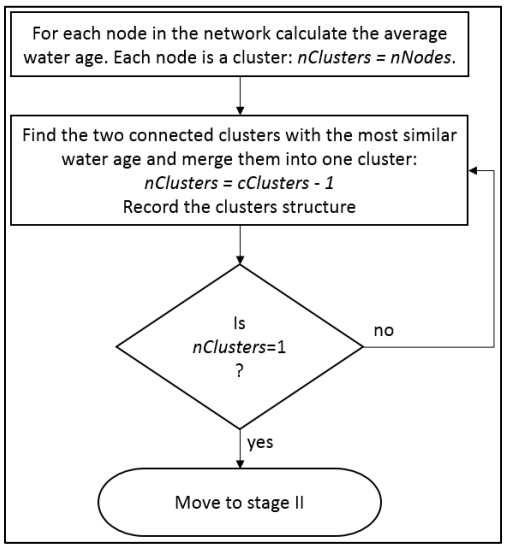

Figure 1: clustering first stage

Once the first stage is completed and the clusters database is built we move to the second stage. As an input to this