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Water distribution network model building, case study: Milano, Italy

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Abstract

Most developments for Water Distribution Network (WDN) modeling purposes refer to optimization approaches for design, rehabilitation or operation. However, most case studies presented in the literature are rather small and represent only a small portion or simplification of a network. The city of Milano with a population of around 1.3 million inhabitants is an example of a WDN where many phenomena occur simultaneously and where the utility, Metropolitana Milanese S.p.A, (MM), needs to deal with many factors for its daily operation. Under the framework of the EU-FP7 ICeWater project, a new model for the WDN of the city of Milano has been developed with UNESCO-IHE, during the last 2.5 years. This article presents the process of model building, the challenges for the calibration process, open issues and tasks to be developed in the near future.

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Keywords: Water Distribution Neworks, ICeWater project, Milano, Setup, Calibration.

1. Introduction

Many examples of benchmark case studies for optimization in Water Distribution Networks (WDN) have been developed in the last 50 years. The first networks to be used for such purposes were *New York* (Shake and Lai, 1967), *TwoLoops* (Alperovits and Shamir, 1977), *TwoReservoirsA* (Gessler, 1985), *Anytown* (Walski et al., 1987) and *Hanoi* (Fujiwara and Khang, 1990). Later on, other WDN have appeared as benchmarks for the understanding of problems in different locations such as, *ThreeTanks*, (van Zyl et al., 2004), *Apulian* (Giustolisi et al., 2009),

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Balerma (Reca and Martınez, 2006), and with time these networks have grown in size and number of elements as *LargeNetwork* (Kang and Lansley, 2012), *One-Reservoir*, *DoubleReservoir*, *ThreeReservoir*s, *FiveReservoirs* (Zheng and Zecchin, 2014, although *FiveReservoirs* is a modification of *LargeNetwork*). Such networks models are useful to serve as a proof of concept for optimization purposes, although these lack the complexities of real systems and deal with a simple problem in water supply at a time.

Nomenclature

AMR	Automated Meter Readings
CMR	Consorcio Milanese Recherche
DB	Database
DSS	Decision Support System
EU- FP7	European Union, Seventh Framework Programme
EPANET	US Environmental Protection Agency, pressurized pipe network simulation software
GGA	Global Gradient Algorithm
ICeWater	ICT Solutions for efficient Water Resources Management
ICT	Information Communication Technologies
MM	Metropolitana Milanese S.p.A.
MOO	Multi-Objective Optimization
PMZ	Pressure Management Zone
SCADA	Supervisory Control and Data Acquisition
VSP	Variable Speed Pumps
WDN	Water Distribution Network
WSS	Water Supply System
WTN	Water Transmission Network

In the case of *Richmond* and *RichmondSkeletonized* (van Zyl et al., 2004), *Exnet* (Farmani et al., 2004), Battle of the water sensors network 1 (*BWSN1*) (Ostfeld et al., 2008), *Parete* and *Villarica* (Di Nardo and Di Natale, 2010) and *C-Town* (Ostfeld et al., 2012), these WDN correspond to approximations of real networks with a larger number of elements increasing the computational runtimes. Other known cases of networks used in the literature for modeling and optimization purposes are *Barcelona*, Spain (Cembrano et al., 1988); *City T*, China (Shihu et al., 2010); *Goiania*, Brazil (Carrijo et al., 2004); *Haifa-A*, Israel (Salomons et al., 2007); *Madrid*, Spain (Gomez et al., 2014) and *Valencia*, Spain (Martinez et al., 2007).

Several algorithms are available for simulation of real systems (Todini and Rossman, 2013), being the most common used in the literature Global Gradient Algorithm GGA) (Todini and Pilati, 1988) as implemented in EPANET 2.0 (Rossman, 2000). With the investment of utilities in Geographical Information Systems (GIS), for the management and visualization of their WDN, the number of elements in a network increases and operational rules become more complex (Savic and Banyard, 2011). However, in most of the cases, WDN simulation deals with a simplification of the real systems or with a limited number of pipes, pumps and sources.

One example of a WDN which contains many assets (e.g. pipes, pumps, tanks, valves, connections) is the system of Milano, currently operated by Metropolitana Milanese S.p.A (MM). The system provides water for around 1.3 million inhabitants and 0.7 million commuters. Currently, it is operated as a single Pressure Management Zone (PMZ), limiting the amount of energy that can be saved in a daily basis. For this reason, in 2012, MM agreed to participate in the EU-FP7 ICeWater project[†], "*ICT Solutions for efficient Water Resources Management*". ICeWater combines sophisticated ICT solution to provide real time data from the field. Thanks to

[†] http://www.icewater-project.eu/