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# SMARTER WATER NETWORK OPERATION MANAGEMENT

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**Abstract** *Water utilities cannot operate on the basis of a regular business aiming at just increasing sales to increase revenue. They rather have to discourage demand for the sake of environmental and resource sustainability. But, how to discourage demand without affecting the financial viability of utilities, while keeping a high standard service? It is one of the main challenges of the twenty first century utility management. Succeeding in this challenge requires adding a higher level of intelligence into our water systems that help us identify problems that could allow for robust mitigation, and give us the information necessary to decide better, to act quickly and to operate efficiently. Achieving this in praxis requires efficient numerical techniques and advanced soft computing algorithms due to the complexity of Water Distribution Systems. Design and refurbishment tasks need the support of multi-objective evolutionary algorithms able to deal with conflicting objectives, nonlinearities, mixed variables and the evaluation of different working conditions during the decision-making process. Monitoring of service quality, especially in real-time, will benefit from efficient techniques of time series data treatment. Operation may be integrated into appropriate data structures, which may rely, in turn, on other types of optimization techniques. These and other use cases are proposed in this paper to illustrate how utilities can use soft computing for smarter water network operation management.*

## 1. INTRODUCTION

Running a profitable water utility in the 21st century is a major management task [1]. Water resources can be scarce or strongly affected by climate changes and demand increase with higher rates of population. Existing supply systems are also getting into stress for the increasing amount of people moving into urban areas. Aging infrastructures and social limitations for increasing service prices complete the scenario to realize that the traditional operation and management tools are not enough to face the posed challenges. Many specialists coincide on using data-driven technologies and creating a so called smart water network as a better approach for operating and managing distribution systems [2]. Nevertheless, these ideas are finding a strong wall at the front of a very traditional industry like the water industry. Adoption of data-driven technologies is not a technical challenge but rather a management challenge within utilities. While the technology has been developed to enable smart water networks, there remains a challenge to convince water utilities [3]. Being inundated by data can be intimidating for a utility but the only way to gain efficiency starts on understanding where, when, and why we use water [4].

Specifically regarding metering infrastructure, water utilities are late to the game of smart technologies compared to electric utilities. Only 23% of utilities surveyed believe they have the organizational infrastructure to manage and use advanced metering service (AMS) data. Only 45% of utilities that have adopted AMS are currently using some form of data analytics platform [5]. High cost of smart water meters slows adoption by utilities [6]. It is then logic that utilities use the return on investment (ROI) as an argument against data driven technologies. They cannot have a satisfactory ROI if data is just collected without turning it into valuable information creating a positive impact in their business.

The social impact of water supply cannot be taking out of the picture when rethinking the way utilities should be managed today. No matter the technical solution for dealing with water scarcity, engaging customers is a necessary step. The study presented in [5] informed that utilities in drier regions with scarce rainfall (less than 825 mm of rainfall per year) tend to maximize conservation and engage customers. These “dry” utilities showed 13 percent greater interest in conservation and 7 percent greater interest in implementing a customer portal than “wet” utilities [5].

## 2. SMART WATER NETWORKS

The smart grid for water represents a significant shift from a data-poor, hardware-centric, asset-driven nineteenth-century model to a data-rich, information-centric environment that is 100 percent accurate and contextualized in space and time [1]. For utilities with current analytics capabilities, leak detection is by far the most utilized function. Other functionalities like meter health/right-sizing, pressure management, asset management, and preventative maintenance are desired by utility executives but are still not easy to find in the existing commercial analytics platforms [5].

A layered view of data technologies has been established for the smart water networks [7,8]. As a base, it is taken the physical layer of the network and on top of it other 4 layers specifically related to data technologies has been added. First comes a sensing and control

layer followed by information collection and communication. Next comes a data management and display layer with data fusion and analysis at its top. Despite the idea is illustrative, it could be misunderstood with what a smart water network should be. Water systems are more than the sum of their engineered parts. They can be described as socio-technical systems, or socio-ecological systems, as they involve highly complex interactions between human, technological and environmental components [9]. In this paper, the authors have preferred to avoid the layer description and instead a group of interacting elements are proposed. These interacting elements are totally abstracted from the technology to be used behind them. This way each utility, small or big, has more freedom to decide the way they implement these elements based on what they can afford. Making smarter the operation and management of water networks will involve the following elements or a consequence/combination of them:

- Social engagement through great billing and customer services automation: Making customers aware of their consumption, their costs, how their water use compares to others and some indicators of the distribution system can help to control excessive demands mainly in zones with water scarcity. Well stablished mobile technologies can be used for customer services automation.
- Operation cost efficiency: Saving energy with optimization-based operation decisions. Wisely reinvesting on network infrastructure and preventive maintenance. Modelling-based pressure management with measurement integration.
- Reduction of non-revenue water: Non-revenue water is an indicator that summarizes several aspects of how the water network is operating. It should be strongly integrated to automatic water balance based on metering data as well as integrated with leak detection processes.
- Adequate metering infrastructure: It is more than just placing right-sized water meters in the network or automating data transmission. It is an enhanced integration between accurate metering data and the rest of processes in the utility.
- Sustainable water supply and quality resilience: Here resilience is understood as the ability to reduce the magnitude and/or duration of disruptive events. Utilities should anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event.

Using these elements as guideline and the technology available, a rigorous business case for evaluating the ROI of smart water networks should be constructed around three critical decision points:

- why a change should be done,
- where that change will have the biggest impacts, and
- what are the benefits of those changes.

There is no a one-size-fit-all solution because each utility is a different world. Nevertheless sharing the experience among utilities with similar size will definitively help to have a clearer view of the alternatives. Independently of the characteristics of the utility and its budget, these authors has selected in the next section four basic tools that will certainly support utilities on making smarter its operation and management.

## 3. STARTING KIT FOR SMARTER WATER NETWORK

Even without installing sensors with advanced data transmission technologies, the management of a water supply system could be made smarter. At least, manually, the utility is collecting certain amount of data that properly shared can improve operation efficiency and social engagement. As starting point 4 elements are proposed for taking advantage of collected data either if the collection is automatic or not.

- Customer Portal: Web-based portal with mobile integration where users are informed about their consumption, costs and any service related issue. It can also be used by users for sending requests to the utility.
- Automatic Water Balance: Water balance generation based on available data from the network and the use of network models and data analytics.
- Online Water Distribution System Analysis: online here refers to the integration between models and data that has been taking from the network.
- Extensible optimization framework: A framework that can be used in combination with hydraulic simulators for solving different decision support tasks.

The previous points have been taken as a base for the implementation of Xirka[i], an online portal for smarter operation of water networks. As part of it, a new toolkit for water distribution system analysis (WDSAT) has been developed with a significant degree of compatibility with the EPANET toolkit. Despite Xirka has been developed specially for online distributed application, it is possible to create offline applications using its WDSAT and other components for data analysis. These offline applications can be eventually connected to the online system if required. The idea is to have a flexible way to extend functionalities or to adapt existing ones to the requirement of each utility. Scientific or application interests for using or extending these tools can be directly communicated to the authors of this paper.

## 4. CONCLUSIONS

For most of the utilities, today it is not clear at all if they are going to have a satisfactory ROI from using data-driven technologies. Water utilities typically operate and invest in a risk-averse fashion, prioritizing proven technologies that reduce operational and regulatory non-compliance risk. Water utility stakeholders welcome this, but it has the unintended

[i] https://xirka.de

consequence of limiting investment in technologies that can benefit consumers and communities alike [5].

For those who have already made the step into "smarter technologies", the fully exploitation of the data collected is still a pending topic. Consequently, the return on their investment will be affected as they cannot profit from all the potential of the technologies installed.

Doing nothing arguing a limited budget is not an option. A good start can be done with the data traditionally collected by the utility. It makes less sense to invest money for receiving more data under limited budget conditions when the already available data is not efficiently used for a positive impact in the business.

Being conservative and hiding behind the argument that water networks have been operated for many years without significant data technologies change is also not an option. Our changing climate, aging utility infrastructure, and water shortages are continuing to alter customers' expectations. In this environment, analytics that enable a data-driven organization will become more than a "nice to have." They will be required [5].

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