A WebGIS-based decision support system for leakage control and water quality monitoring in the water supply system of Paramythia city in Greece

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Introduction

Globally, water leakage in drinking water distribution systems is a significant issue for many cities and a major concern for water utilities (Panitsidis et al., 2018). Non-Revenue Water (NRW), being the water volume not bringing revenues to the water utility (including water losses), threatens the financial viability of water utilities and the sustainable management of the natural water resources (Karamage et al., 2016). The average daily volume of NRW is estimated to 346 million m^3, and its annual cost and value are 39 billion USD (Liemberger & Wyatt, 2019). As a result of the growing water demand and the effects of climate change, the preservation of water supply is already under stress, making the issue more urgent. Mediterranean countries are particularly vulnerable to water shortage. In some circumstances, in these countries NRW levels exceed 50% of water volumes entering the distribution system (Tsitsifli et al., 2017).

This work describes the development of a smart green decision support system (DSS) for leakage control and water quality monitoring in the water supply system of Paramythia city in Greece. The overall aim is to design and develop an effective tool (serving also as an early warning system) in the framework of a decision support process for leakage detection and optimal management of water supply system parameters in an automated manner.

Materials and methods

The first steps towards the final goal, as presented in this paper, are the development of the back-end solution of the decision support system (DSS) and its validation through simulation scenarios. The DSS architecture (Figure 1) is comprised of four main subsystems: *language system*, *presentation system*, *knowledge system*, and *problem-processing system*. The development process of the DSS is decoupled into the front-end subsystem and the modelling framework in the back-end. Four subsystems comprise the proposed back-end architecture solution of the DSS, implemented to improve the decision-making usability: **a)** DSS Logic; **b)** Data Access Layer; **c)** Security/Authorizations Layer; and **d)** API Gateway. *DSS logic* includes all the tasks related to the basic workflow for managing the parameters of the water supply network, such as calculations of evaluation indicators and deviations, leak detection, what-if scenarios, etc. Specifically, data (i.e., water flow, pressure, temperature, pH, turbidity, residual chlorine, conductivity, and nitrates) from the IoT subsystem (comprising 3 local telemetry stations) is integrated with data retrieved from the water distribution network hydraulic simulation model, and from the virtual sensors' subsystem concerning water qualitative parameters. The data is compared and known performance indicators (such as the IWA ones) are calculated. Their values are used to calculate deviations between the current operational conditions and the normal ones (e.g., leakage free). When deviations exceed the threshold values set, which are based on historical data, various scenarios are set in place, feeding the hydraulic simulation model, subsequently providing their results (parameters' values) to the system. Indicators are then estimated and compared to the thresholds. Finally, the leakage is detected, and its wider area can be determined. To locate the exact location of the water leakage, the water utility should use leakage detection tools, such as correlators, acoustic devices, etc. *Data Access Layer* includes all the required communication functions with the database and *Security / Authorization Layer* secures identity and access management process. Finally, all the required interactions with third-party systems (IoT subsystem, hydraulic simulation model and virtual sensors subsystem) are implemented in the *API Gateway*.

Results and concluding remarks

The implementation of this effort is based on System Development Life Cycle (SDLC) principles (Blanchard & Fabrycky, 2006). The back-end is currently under development using ASP Net language (C#) and MySQL as relational database management system, while for the front-end, HTML, CSS, JavaScript and PHP language are exploited.

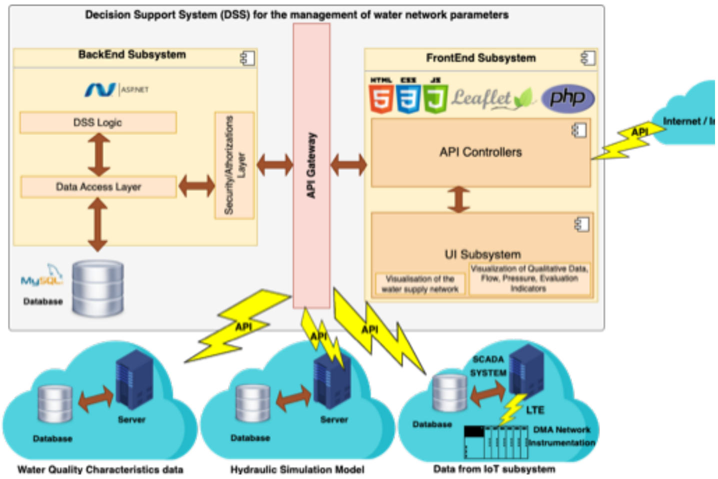

Figure 1. DSS architecture

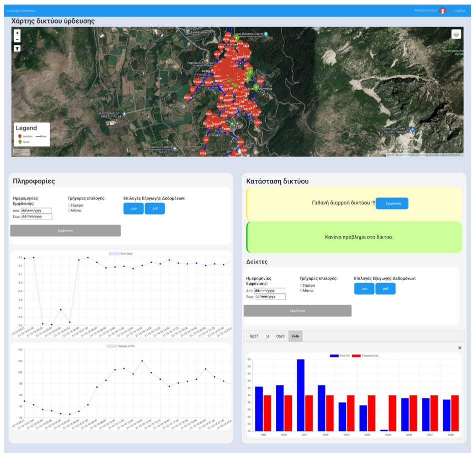

Figure 2. DSS front-end screen

A prototype application integrating the DSS structural components with an open-source Web-based Geographical Information Systems (Web GIS) tool and other open-source components and libraries is being built. It provides a visualization of the water distribution network using an interactive map where relevant information is displayed, such as, statistical values of water quantitative & qualitative parameters and real-time alarm events in case of leakage detection or exceedance of water quality parameters' thresholds (Figure 2). The ability to examine different scenarios based on the conditions in real-time enables the decision-makers and operators to respond to promptly and efficiently to potential threats to the water supply system. The prototype application is currently being built and will be operational in the next 10 months. The prototype is custom-made for the water distribution network of Paramythia.

Acknowledgments: This work is co-financed by EEA Grants 2014 – 2021 and Greek Public Investments Program.

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