Researchers determine how to digitalize, optimize and safeguard water management in smart cities

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Drought and massive water leaks in the subsoil of large cities, such as those recently reported in the Barcelona metropolitan area, make it more

necessary than ever to improve the management of water resources in urban environments. The implementation of smart, connected systems for water supply and purification infrastructures has clear benefits and will come with time. However, as the sector is currently wanting in digitalization, this transition must be agile and carefully monitored.

A new study has laid the foundations for how this process should be carried out. The brain behind it is Cristina Villar, a graduate of the Universitat Oberta de Catalunya (UOC) and an employee at one of Spain's top tech companies, where she designs digitalization and security solutions for multiple types of infrastructure.

Carried out as a final project for the University Master's Degree in Telecommunications Engineering, the study examines what needs to happen for this renewal to take place and describes the network architecture and specific type of hardware required to secure the water supply chain, which is key considering that climate change and population growth are making this resource increasingly scarcer.

Villar, who is listed as the study's first author, said, "In water treatment and management, there is a considerable lack of development and standardization of digital protocols. Instead of creating a unique or inflexible design, we wanted to lay the foundations of operation to adapt this environment to the needs of Industry 4.0 and Spanish legislation."

Her master's degree final project is published open access in the journal *Smart Cities* and was supervised by Victor Monzon Baeza, currently a researcher at the University of Luxembourg. Having achieved excellent results, the study was later published in MDPI Smart Cities as a research paper co-authored by Raúl Parada, researcher at the Telecommunications Technology Centre of Catalonia, and Carles Monzo, member of the UOC Faculty of Computer Science, Multimedia and Telecommunications.

A complex architecture

In their view, the renewal of critical infrastructures linked to the water supply chain should be based on an architecture that includes an action and measuring group (a large array of on-site sensors) and an interference-free network to provide coverage and send data to the core computing group, the backbone of the proposed solution. This part of the system would be responsible for collecting all the data from the sensors and executing commands for the actuators.

These commands could be entered manually by the operators in charge of maintaining the system or they could be automated to improve the response time of the water management system. All data would be stored in NoSQL databases such as MongoDB, ideally deployed on high availability servers located in private data processing centers (DPCs). These servers would be backed up and duplicated so that the system would remain up and running in the event of contingencies and would not suffer service outages.

Such information could be extracted and studied through data analytics processors and uploaded to the cloud for further computation and the application of artificial intelligence. The authors propose adopting the NB-IoT protocol for on-site devices, as it uses all the necessary communication security protocols, and the 4G mobile network for connectivity, as it offers a high level of coverage.

Priority one: Security

All systems involved would need to meet a series of requirements in order to comply with current regulatory criteria and achieve optimal performance. These include factors such as high availability, updates without service disruption, a maintenance plan with 24/7 remote

monitoring, and the possibility of homogenizing data yields for processing.

In order to maintain system security, the authors advise having different and segmented infrastructures, whether physical or virtual, and "an infrastructure with high availability with several firewalls in cluster mode, in such a way as to ensure the redundancy of the systems that support the solution."

Villar said, "Cybersecurity plays a vital role in these critical infrastructures, so it's crucial to consider the recommended guidelines. These include distributing firewalls and servers in geographically independent locations to ensure high availability, so that a crash in one of these locations does not affect the rest, and using two DPCs. Nobody wants some hacker to break into the system and leave a town without water."

Automated improvements

This digitalization process could automate many operations and roll out a variety of improvements, such as checking that water purification is high enough so as not to alter the ecological environment, measuring the amount of energy consumed by the system, detecting and acting quickly on leaks in the supply chain, monitoring the level of water purification treatment and determining the average number of hours the water supply service is interrupted per year.

The benefits of the proposed infrastructure would include the low economic cost and low power consumption of NB-IoT sensors; the wide range of sensors available under the LPWAN solution, which allows long-range communication over the mobile network; and the low investment cost, as it leverages the existing 4G radio station infrastructure used by telephone operators. In addition, the use of an open-source management

platform would improve compatibility with other application codes that could be integrated with the platform.

Artificial intelligence

Looking further ahead, the authors advocate the use of hyperautomation and artificial intelligence systems as an additional implementation to be considered in the future to reinforce preventive maintenance of network components and thus prevent incidents owing to worn parts. These robotic processes would also eliminate possible human errors to a large extent, although it would always be necessary to have technical operators on hand to deal with unforeseen issues.

Villar said, "In Spain, water management systems are still very green as far as digitalization is concerned. They are rather old-fashioned and are hard to connect to the internet, but it's the right time to set this process in motion and implement real-time monitoring to avoid wasting this resource, water, that is so precious to humanity."

More information: Cristina Villar Miguelez et al, Guidelines for Renewal and Securitization of a Critical Infrastructure Based on IoT Networks, *Smart Cities* (2023). DOI: 10.3390/smartcities6020035

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