Urban water systems management

A data analytics approach

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Acknowledgements

Elements of the work reported in this publication were supported by the EU Seventh Framework Program (FP7) under grant no. 619795.

EP 105

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Executive summary

Urban water systems are responsible for abstracting, treating and delivering clean water to consumers, and, subsequently, collecting, transporting, treating and releasing waste water safely back into the environment. These systems are among the most critical of a nation's infrastructure and are often complex, interdependent, spead out physically over a wide geographical area, and subject to various constraints such as reliance on ageing assets. In many cases these systems are operating at capacity and frequently require expansion to respond to new developments and wider urban growth.

The adoption of new information communication technology (ICT) to enable the water network operators to intelligently monitor, analyse real-time information, and take appropriate actions, is seen as a key way of reducing the strain on urban water systems. This is achieved by increased efficiency instead of expansion. ICT acts as a key enabler to integrated water resources management – essentially the holistic management of water resources.

To this end, the water industry has begun a transformation through the use of smart systems. A big part of this is the increased adoption of sensors, analytics software, and decision support tools. However, current smart systems technologies are severely lacking in integration between their different elements. Furthermore, they lack the ability to contextualise the large amount of data collected from urban water systems in a way that promotes scalability, portability and future adaptability.

This publication focuses on how to rectify this problem by using an approach driven by semantics. Semantics is the study of meaning. In the context of smart technologies deployed in urban water systems, it means describing the physical, virtual, social, economic, and organisational elements and features within a smart water system, and the relationships between them, in a computer interpretable manner.

This publication proposes a viable solution to the problems of achieving efficient and scaleable use of large scale data in urban water systems, in the form of a reference architecture that uses a semantic description of the smart water domain. Exemplar use cases of the reference architecture are presented, along with a methodology of how a concrete implementation can be deployed on an urban water system.

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Introduction

Urban infrastructure systems are complex, interdependent and subject to various constraints. They constantly require maintenance, retrofitting and renewal under tight financial constraints, while at the same time operate at capacity and require expansion to respond to new developments and wider urban growth. It is becoming essential to work towards a tight integration between building systems (in particular utility systems, including energy and water) with infrastructure systems at a district and wider city level. This will help alleviate the current endemic ‘infrastructure gap’ with a new value proposition centred on sustainability and resilience.

Infrastructures are interdependent within a complex urban fabric. They rely on various sources of financing and investment, including government, industry and specific local taxation. Infrastructure is also maintained and developed in a very fragmented landscape under the control of a wide range of regulatory bodies.

Urban water systems are responsible for abstracting, treating and delivering clean water to their consumers, and, subsequently, collecting, transporting, treating and releasing waste water. These systems are among the most critical and complex, spread over a wide geographical area using ageing infrastructure.

In this context, the demand on water resources in the urban environment requires more efficient water management to deal with urbanisation and population growth, more complex water facilities in new buildings, and the deterioration of existing water infrastructure. There is an urgent need to reduce the water abstracted for use in buildings, promote water savings, stop wastage, and promote the use of water-use performance metrics. The ability to intelligently monitor the water network in urban environments, and analyse real-time information using smart technologies, will provide optimised alternatives to take better actions to balance the conflict between water demand and provision[1].

In order to reduce water use in buildings, and by extension in urban areas, several options are available[1, 2], including:

- raising awareness to improve behaviours
- changing the pricing policies
- metering water to both detect leaks and raise consumer awareness
- limiting water use by regulatory requirements
- installing more efficient water-using products
- planning buildings so they are more water efficient
- using ‘alternative’ water sources, eg rainwater or greywater.

In fact, there is a tendency for water wastage simply due to the way water is allocated and valued. This is currently based upon historical rights, using ‘first-come-first-served’ principles. Water is also ‘locked up’ in abstraction licences because most abstractions only require a third to half of their entitlement. Water allocation does not currently take account of optimising resource availability for water consumption while protecting the environment, or has yet to practically address future demand through population growth and food security. Neither of these approaches has developed sustainable mechanisms to adapt to unpredictable weather patterns due to climate change.

The nexus between energy and water is almost inevitable, as the two are intimately linked. Various industries, including the steel industry, have open abstraction licences for water. Evidence suggests that the more water they abstract, the more energy they consume. The European Commission has defined a clear 2020 target to reduce CO_2 emissions by 20%, and increase the share of renewable energies by 20%. These objectives have been translated into stringent regulations and policies at the European and national levels. For instance, the recast of the Energy Performance of Buildings Directive (2010/31/EU) imposes stringent requirements in terms of energy efficiency for new and retrofitted buildings. At building scale, a great potential exists for energy recovery from domestic water and from bathroom greywater. However, to optimise the benefits of energy-saving methods the components must be maintained.

Environmental assessment methods such as the Code for Sustainable Homes and BREEAM in the UK, HQE in France, and the Sustainable Buildings Alliance (SBA) at the international level, factor in water management. The assessment methods aim to reduce the consumption of potable water for sanitary use in new buildings through the use of water-efficient components and water recycling systems. Credits can be gained that can contribute to higher environmental grading. However, unlike for energy, there is no requirement to meet a given water consumption target or water performance specification.