Cost-efficiency of multi-purpose sensor networks for drinking water distribution networks

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Innovations in sensor technology progressively increase the possibilities for drinking water companies to complement water quality monitoring programs by installing networks of real-time water quality sensors. Because of the significant financial and organizational investments, goals and added values of on-line sensor networks are ideally established prior to installation. A sensor network that simultaneously serves multiple objectives can yield higher benefits than single-objective networks (Kroll & King, 2010) and this could modulate the cost-return function towards choices in favor of investment in (multi-purpose) sensor networks.

We investigated the benefits as a function of investments of a multi-objective sensor network in a drinking water distribution network. For Dutch water companies we established that the key reason to invest in a sensor network is to reach and maintain a high level of customer trust. A sensor network has the potential to improve customer trust, not only through prevention or detection of possible water quality incidents, but also by more efficient communication with the customer and improved perception from the media . We selected three objectives related to customer trust that reflect different hierarchical levels in business operations (strategic, tactical and operational).

First, on the strategic level, we investigated the influence of a sensor network on customer trust and media attention in case of potential water quality incidents. Based on answers from a questionnaire to the companies, we found that expectations vary for different water companies and event scenarios.

Second, on the tactical level, on-line monitoring can reveal useful information about the distribution system. Because distribution processes and mechanisms are interrelated, the result of processes can be manifest in different types of measurements. We investigated the resulting information redundancy and if it can be used to extract information and improve knowledge about the system. For example, discrepancies between the expected and measured sensor response can hint at incorrect valve statuses. For this purpose, we used graph theory to calculate interrelated dependencies of parameters and processes and monitor the information flow for a small theoretical distribution network.

Third, on the operational level, we investigated the benefits from a sensor network designed for customer protection from a hypothetical water quality calamity. For this purpose, we used an optimization tool (Van Thienen, 2014) to calculate the likelihood of detecting a water quality event with a sensor network with sensor locations optimized for event detection and calculated how the result depends on the installed number of sensors.

From the results of the three assessments, we analyzed the added-value of a multi-objective sensor approach. In a business-case type of analysis for a medium-sized Dutch city, we compared benefits and costs of a sensor network. This can serve as a basis for investment scenarios for drinking water companies and the design of a multi-objective sensor network.

LITERATURE

Kroll, D. and King, K. (2010), Methods for evaluating water distribution network early warning systems. Journal AWWA, 102:1, pp.1-11.

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