FlowSure Leakage Detection System Trial at Portsmouth Water

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Introduction

Portsmouth Water supplies clean drinking water to a population of over 700,000 in an area of southern England which covers 868 square kilometres.

In the context of tightening regulatory and public relations demands, UK water companies are under increasing pressure to minimise leakage. Portsmouth Water wished to assess whether identifying anomalies in flow and pressure data within the water network could help to detect, predict and avoid leakage. If successful, this could reduce costs of contact handling, compensation and regulatory penalties, meet or exceed regulatory targets and improve customer service levels.

An artificial neural network approach to identifying anomalies was originally developed by the University of Sheffield (Mounce et al., 2010) and has been implemented within a software package, FlowSure, by Servelec Technologies.

Following an initial proof-of-principle pilot project, Portsmouth Water decided to trial the FlowSure leakage detection software for a six-month period from August 2016. FlowSure applies artificial neural networks and fuzzy logic to existing flow and pressure data to detect events on the network. Portsmouth Water also tested an alternative leakage detection system during the same period.

Artificial neural network approach

The artificial neural network approach to identifying anomalies uses a period of historical data, typically 3 months, to learn the patterns of a data time-series. Bounds of anticipated behaviour are developed from the outputs of an artificial neural network.

An example set of bounds at alternative confidence levels is shown in Figure 1. The solid line represents the observed flow data. The inner pair of dotted lines represents the bounds within which the signal would be expected to lie 90% of the time. The outer pair of dotted lines represents the bounds within which the signal would be expected to lie 99% of the time.

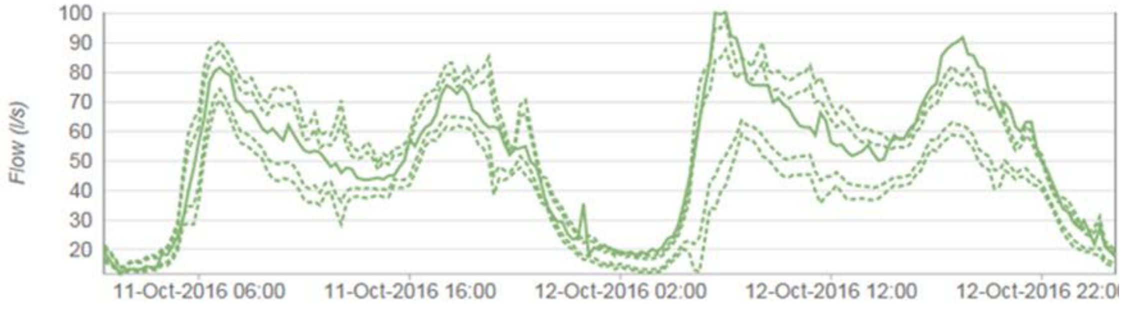

Figure 1 Example comparison of observed data with anticipated bounds.

Observed data outside of the bounds for a sustained period raises an alarm, with a fuzzy logic algorithm used to determine whether an alarm should be raised and provide a confidence level for the alarm.

Proof-of-principle pilot project

In order to demonstrate the principle of using FlowSure to automatically detect flow and pressure anomalies, an off-line pilot exercise retrospectively analysing data from 5 District Metering Areas (DMAs) in the Portsmouth Water region to identify anomalous events was undertaken.

The analysis using default FlowSure parameters raised 7 flow and 9 pressure alarms in the five DMAs examined, with three months of data for each DMA being analysed (excluding data used for the initial training periods). Figure 2 shows an example event identified that appeared to be a data error, or potentially change in network operation (e.g. zone breach).

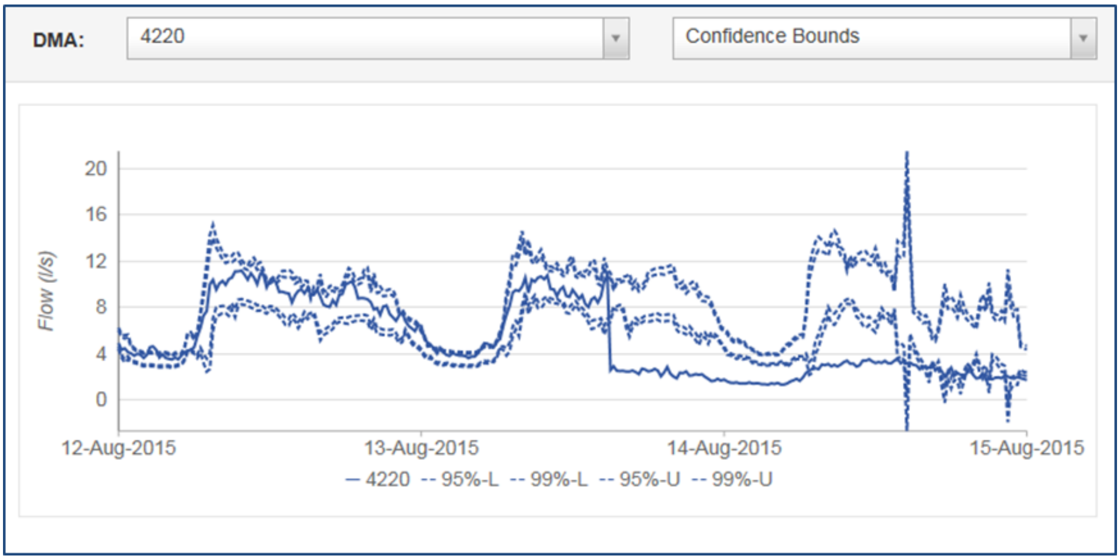

Figure 2 Example event identified during proof of principle trial.

In normal use, FlowSure improves its knowledge of signal behaviour using confirmation of whether or not alarms raised represent genuine network events. FlowSure interprets this corresponding data accordingly and adjusts the subsequent analysis. As no information was provided to Servelec Technologies by Portsmouth Water regarding the occurrence of any bursts or other network events in the dataset, assumptions regarding the interpretation of alarms raised were made by Servelec Technologies, in order to analyse data following the first alarm.

Overall, the offline analysis proved the principle of applying network event detection to DMAs using FlowSure. All DMAs were successfully analysed, artificial neural networks were generated and alarms were raised as appropriate. Portsmouth Water subsequently decided to proceed with an online trial of the system to further evaluate the benefits.

FlowSure implementation at Portsmouth Water

FlowSure was installed on existing Portsmouth Water company hardware and entirely within the corporate network during August 2016 for a six month trial period. The system was configured to import existing flow and pressure data collected in DMAs in the network. The local installation allowed data security to be managed through existing processes and minimise the risk of unauthorised access.

The leakage management team monitored the alarms raised and responded by diagnosing the underlying issue and directing technicians to investigate the affected area of the network as appropriate. An alternative system for raising alarms was also used during the trial and the performance compared with FlowSure.

Figure 3 shows an example burst that occurred at 03:15 on 20th January 2017. The resulting flows in the DMA were substantially outside the confidence bounds for the area. The FlowSure algorithm identified an anomaly, raised an alarm and estimated the size of the potential burst as 2.73 l/s. The system was then used to verify that the burst had been repaired, with the flows returning within the confidence bounds by 18:30.

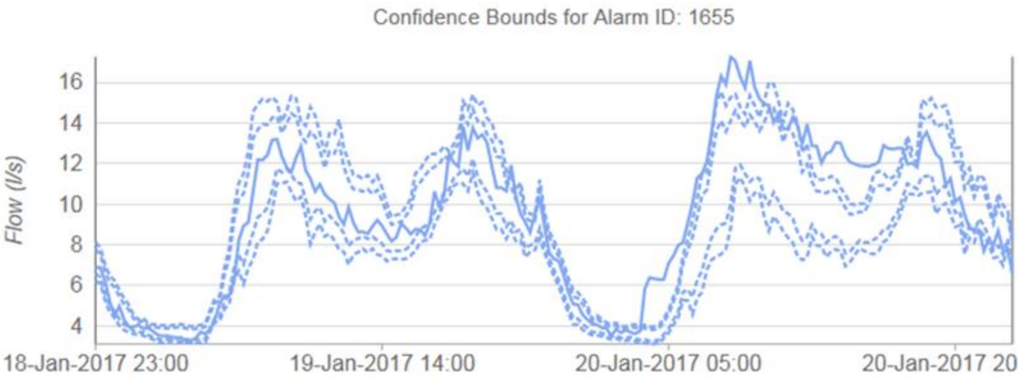

Figure 3 Burst identified and repair verified.

Events identified

In total, 322 confirmed anomalies were identified during the six month online trial. These included signal and data issues, engineered events such as opened valves, low pressure events and bursts. Details of the number of each type of anomaly are provided in Table 1.

Table 1 Events identified by FlowSure during six-month online trial

Type of anomaly	Number of confirmed anomalies
Signal/ data issues	119
Engineered events	95
Low pressure events	9
Bursts	43
Burst repairs	56
Total	**322**

The largest proportion of events resulted from issues with signals or data; highlighting these allowed Portsmouth Water to resolve them promptly and hence avoid loss of coverage of the network.

Outcomes

The trial demonstrated that the neural network approach provided fast and reliable identification of anomalies, with performance improving over time as the system learned from previous events. The ability to prioritise alarms and view a summary map meant that Portsmouth Water was able to respond efficiently. The improved visibility of network performance led to better decision-making regarding the response to unusual flow patterns and improved operational relationships between departments. The ability to proactively identify bursts supported improved customer relations, for example if these were subsequently reported.

A crucial outcome of the trial was the demonstration that large network events could be prevented via early pre-emptive detection of changes. In addition to the direct costs of dealing with such events, the network surges and loss of reputation that occur can have long-lasting effects. Cost savings were also achieved through the reduction in analyst time monitoring the network data, the improved efficiency of leakage detection and reduced costs of lost water.

The period of the trial can be contrasted with adjacent periods when FlowSure was not operational where a number of events occurred on the network that Portsmouth Water were unable to respond to promptly because alarms were not being raised.

Following the trial, Portsmouth Water carried out a cost-benefit evaluation of the trial and decided to purchase a licence and support for the implementation of FlowSure across the network.

References

Mounce, S.R.; Boxall, J.B. and Machell, J. (2010) Development and Verification of an Online Artificial Intelligence System for Detection of Bursts and Other Abnormal Flows. *Journal of Water Resources Planning and Management.* **136**(3), 1–10.