Many-objective Optimal Meter Placement for Pipe Burst Detection

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ABSTRACT
Meter network is defined as a group of meters spatially distributed throughout a WDS. Therefore, meter network’s reliability is defined as the network’s ability to persistently provide useful measurement/data for various WDS operational and management purposes (e.g., leakage/pipe burst detection) with acceptable accuracy and precision and without missing data. This study proposes a many-objective optimal meter placement model (MOMP) for water distribution system (WDS) pipe burst detection to (1) minimize the normalized total meter cost, (2) maximize the detection probability (DP), (3) minimize the rate of false alarm (RF), and (4) maximize the meter network’s mechanical reliability (MR).

A novel approach for quantifying meter network’s MR is introduced in this study, based on single meter failure condition. The proposed MOMP model also determines the optimal ratio between the pressure and pipe flow meters given a predefined number of meters. The proposed model was demonstrated on the Austin and Balmera networks with different configurations, characteristics, and numbers of components. It was confirmed from the results that a nonlinear trade-off relationship exists between DP and RF, and the Balmera network has higher detectability than the Austin network because of its high connectivity. Another nonlinear trade-off relationship was identified between DP and MR as more pipe flow meters are included in high-DP optimal meter set. Note that pipe flow meters detect different burst events while pressure meters identify a large set of the same bursts.

Solutions with the same level of detectability were selected from the two study networks and compared to confirm the adopted meter location strategies. Regardless of study network, pipe flow meters had a tendency to be placed at informative locations (e.g., main lines). On the other hand, pressure meters were located at the end of network or within looped subarea of the network in the Austin network whereas they were installed in a low-pressure zone in the Balmera network. It was confirmed that pressure meters play a different role for pipe burst detection in different network of different characteristics.

Keywords: Water distribution system, Pipe burst detection, Meter mechanical reliability

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