

Interactive comment on “Real-Time Hydraulic Interval State Estimation for Water Transport Networks: a Case Study” by Stelios G. Vrachimis et al.

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We would like to thank the Reviewer for providing constructive comments which helped us in improving the quality of the manuscript. To address the Reviewers concerns, we have made significant changes in Section 3 of the revised manuscript. The answers to the Reviewers' comments follow, indicated in italics:

1. The practical problem as described in Section 3 does not seem to require a hydraulic solver. Per Line 17, Page 5, “the challenge ... is the difference between the volume of water entering and exiting the transport network”. Because the

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pressures are not relevant here, for the network topology shown in Figure 2, a simple mass balance model is sufficient to represent the relationship:

$$q_0 = A \frac{dL}{dt} + q_1, q_1 = F_1 + q_2, \dots, q_{16} = F_{16},$$

in which A is cross-sectional area of the tank, and F_i is the demand at the i -th node. The linear system allows a straight-forward computation of the bounds of flow rates that can be used in diagnosing the system.

We thank the Reviewer for pointing out this issue. We agree that for the specific example in Section 3, due to its topology, a simple mass balance could give an estimate of the inflow q_0 , at each time step which can be compared with F_0 for diagnosis purposes. In the revised manuscript, in Section 3, we change the case study network with one that contains loops and requires a hydraulic solver in order to determine the flow rates. This helps to demonstrate the capability of the algorithm to generate bounds on flow rates regardless of the network topology. Additionally, an example of simple mass balance is given to highlight the importance of considering measurement uncertainties when determining if there is unaccounted-for water in the network. It is possible that an operator detects mass imbalance when in fact the system is operating normally and the difference is due to the measurement uncertainty. We further explain this issue in Section 3, and propose a solution using the bounded estimates of the algorithm.

2. The discussion between Line 11, Page 6 to Line 4, Page 7 is inconsistent with the proposed algorithm. The computation of θ in Line 12-16 seems to suggest that there is a constant unaccounted-for flow, but “it was eventually validated that there was a metering error at the tank inflow”. If the method “could not confirm whether the difference ... was due to background leakage ... or metering error”, why do we compute θ in the first place? The anomaly should be evident by just comparing the SCADA measurements at q_0 and the interval estimates of q_0 generated by the algorithm.

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We thank the Reviewer for giving us the opportunity to clarify this issue. In the revised manuscript, we have replaced the scenario in Section 3.2 with the comparison of the mass balance methodology (which uses uncertain sensor measurements) with the bounded interval state estimation (which considers the measurement uncertainties). In the revised manuscript, the discussion does not focus on the calculation of θ which may be inconsistent with the algorithm, as pointed out by the Reviewer, but rather on how to enhance the mass balance methodology using the interval estimates generated by the algorithm, to detect the existence of unaccounted-for water.

3. Section 3 “Case study: Limassol, Cyprus” does not provide sufficient information about the performance aspect of the algorithm. More specifically, important topics, such as (1) time and number of iterations needed to obtain convergence in the state estimates and (2) how the sizes of bounds change with each iteration, are not discussed. These pieces of information would be beneficial in evaluating the overall feasibility of the algorithm in this and potentially further studies.

We thank the Reviewer for indicating this omission. In the revised manuscript, more information about the algorithm performance (i.e. simulation time and iterations) is included. The size of bounds at each time step depends only on the measurements at that time step, as the tank level is measurable. Thus, the effect of accumulating uncertainty due to the dynamic calculation of tank levels does not affect the size of the bounds. These issues are clarified in the revised manuscript.

4. Due to the limitations above, the paper does not convincingly establish the necessity and applicability of the proposed method in addressing the problem shown in the case study. A better application of the interval estimator may be in a looped distribution system with both flow and pressure bounds estimated for event/fault detection. The reviewer therefore could not recommend the manuscript for publi-

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cation in DWES.

We thank the Reviewer for the suggestion. We have added a new Section (3.3) demonstrating the applicability of the algorithm in a looped distribution system as well as its use for leakage detection.

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