

## Accepted Manuscript

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PII: S0167-739X(17)32887-X  
DOI: <https://doi.org/10.1016/j.future.2018.07.019>  
Reference: FUTURE 4337

To appear in: *Future Generation Computer Systems*

Received date : 16 December 2017  
Revised date : 20 June 2018  
Accepted date : 11 July 2018

Please cite this article as: E. Curry, W. Derguech, S. Hasan, C. Kouroupetroglou, U. ul Hassan, A real-time linked dataspace for the Internet of Things: Enabling “pay-as-you-go” data management in smart environments, *Future Generation Computer Systems* (2018), <https://doi.org/10.1016/j.future.2018.07.019>

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# A Real-time Linked Dataspace for the Internet of Things: Enabling "Pay-As-You-Go" Data Management in Smart Environments

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## Abstract

As smart environments move from a research vision to concrete manifestations in real-world enabled by the Internet of Things, they are encountering a number of very practical challenges in data management in terms of the flexibility needed to bring together contextual and real-time data, the interface between new digital infrastructures and existing information systems, and how to easily share data between stakeholders in the environment. Therefore, data management approaches for smart environments need to support flexibility, dynamicity, incremental change, while keeping costs to a minimum. A Dataspace is an emerging approach to data management that has proved fruitful for personal information and scientific data management. However, their use within Smart Environments and for Real-Time data remains largely unexplored.

This paper introduces a Real-time Linked Dataspace (RLD) as an enabling platform for data management within smart environments. This paper identifies common data management requirements for smart energy and water environments, details the RLD architecture and the key support services and their tiered support levels, and a principled approach to "Pay-As-You-Go" data management. The paper presents a dataspace query service for real-time data streams and entities to enable unified entity-centric queries across live and historical stream data. The RLD was validated in 5 real-world pilot smart environments following the OODA (Observe, Orient, Decide, and Act) Loop to build real-time analytics, decisions support, and smart apps for energy and water management. The pilots demonstrate the RLD enables incremental pay-as-you-go data management with dataspace support services that simplify the development of applications and analytics for smart environments. Finally, the paper discusses experiences, lessons learnt, and future directions.

## Highlights:

- Defines the requirements and high-level design of a real-time linked dataspace for Internet-of-Things enabled smart energy and water environments.
- A principled approach to "Pay-As-You-go" data management using dataspace support services offering tiered levels of support.
- A dataspace query service for real-time data streams that enables unified queries across live streams, historical data, and entities.
- Demonstrates the use of the approach within the OODA (Observe, Orient, Decide, and Act) Loop to build real-time analytics, decisions support, and smart apps for smart energy and water management.
- Experiences and lessons from 5 real-world pilot smart environments.

**Keywords:** *Smart Environments; Data Management; Internet of Things; Water Management; Energy Management; Dataspace; Linked Data; Semantic Web; Event processing; Distributed systems*

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