Semantic Models for Enabling Smart Management of Urban Water Systems

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INTRODUCTION

Smart water initiatives promise to deliver effective, efficient and resilient water value chains through intelligent ICT use, but are facing interoperability challenges similar to those in smart grids. To overcome these, machines must use common data formats and imbue shared meaning in exchanged messages, within a secure communication framework. The role of data and semantic modelling standards is therefore critical towards delivering the benefits of smart water networks. The key issues observed are:

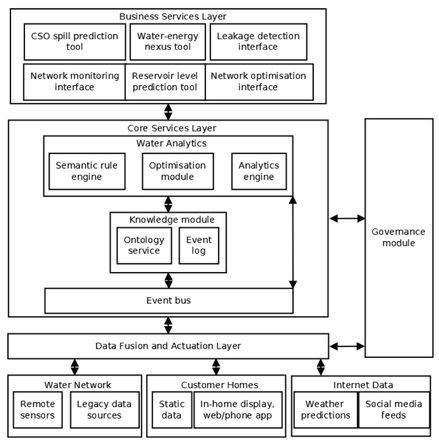
- Water systems need to adapt to reduce consumption whilst remaining economically viable
- ICT facilitates intelligent system management through sensing, analytics, and decision support
- Interoperability across ICT systems poses a critical hurdle towards achieving this
- Semantic models enable shared meaning between human and virtual entities

This work addresses this issue by developing an internet of things platform for the water sector, as well as value-added applications for water utilities and end users. These use semantically driven optimisation, decision support, and user empowerment to drive smart management and behavioural change in the water sector.

METHODS

The work was conducted within the WISDOM EC FP7 project, and the ontology development used the following approach:

- Knowledge acquisition, scoping & specification
- Create meta-model from existing resources
- Enumerate object types in the domain
- Describe domain relationships, properties etc
- Validation by industry experts, and against spec
- Develop web service and API
- Deploy model across 4 pilot sites
- Software performance testing



GET INVOLVED

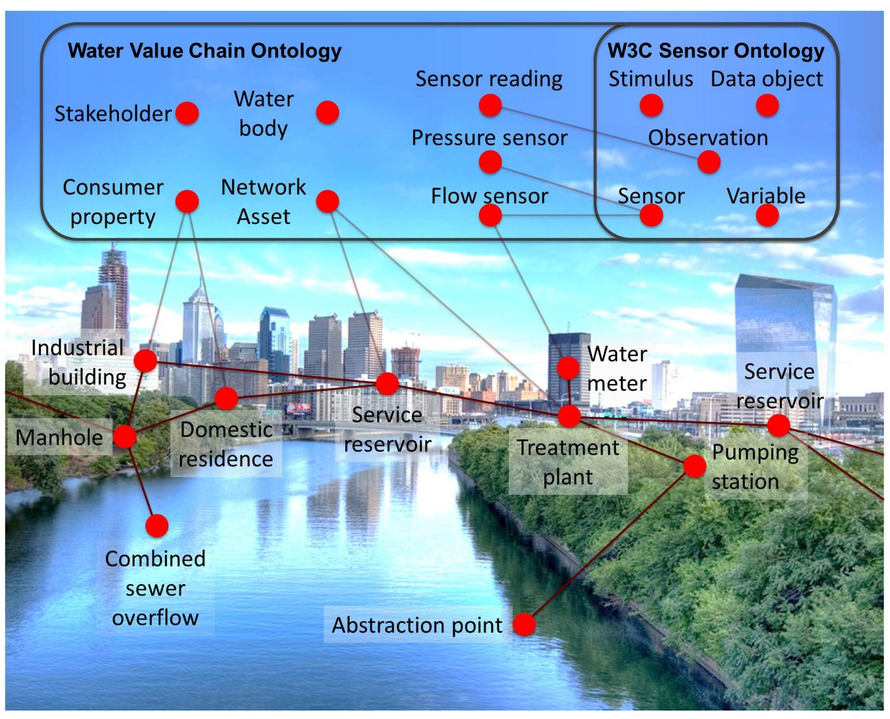
We are looking for participation in a brief questionnaire on domestic water consumption. It should only take a couple of minutes. To participate, please visit the link below, scan the QR code, or leave your email address with a representative near this poster.

https://cardiff.onlinesurveys.ac.uk/water-experts-consultation

Semantic Model

Water Data

- Network topology
- Natural water body descriptions
- Asset information
- GIS data
- Environmental data
- Sensor libraries
- Real time sensor data
- Consumer feedback
- Water Regulations
- Social media streams



Applications

- System optimisation
- Decision support
- Water dashboards
- Hydraulic modelling
- Customer engagement apps
- Leakage detection
- Rule engine
- In-home display
- CSO spill prediction
- Energy-aware DST

RESULTS

The software developed at the integration and application layer was able to add significant value across legacy systems, smart sensors, and remote data sources. The main outcomes were:

- Extensible semantic water models
  - Validated by 11 water organisations
- Web service deployment of ontology middleware
- API for model read/update, built on open standards
- Inference engine based on SWRL rules
  - Virtual sensing capability
  - Regulation checking and alert issuing

The added benefit was reported of avoiding vendor lock-in, hence providing utilities greater buyer leverage and allowing them to evolve their smart capabilities in a stepwise manner.

CONCLUSIONS

The developed internet of things platform was built on top of new semantic models of the water sector, and was able to effectively integrate static and dynamic data. This integrated data sources which are currently stored in silos within and across organizations, to support value-added applications for utilities and consumers.

The project served as a benchmark for ontologies in the field and efficiently used GIS data with dynamic sensor data beyond the capabilities of technologies current in wide use such as SCADA and SQL. The approach was found to be complementary to such systems by adding value without the need to significantly modify existing systems.

We recommend further semantic modelling work to progress towards standardised models for the industry, to support further innovation in the water sector and with other smart verticals.

"Since it is difficult to communicate effectively without a common vocabulary, and even more difficult to develop IT system in such a situation, it is very apparent that a priority should be put on Smart City vocabulary/ terminology and ontologies." -ISO/IEC JTC, 2014

"It was agreed that semantics is the most important hurdle to overcome, even preceding the other priority sectors" – ICT4Water Cluster, Recommendations for Standardisation in the European SMART Water Market

"Most significantly, the explicit representation of meaning that ontologies provide forms an anchor for meaning, a base for shared understanding of the raw data." -IEEE, 2011