ISSN: 2278-4632
Vol-10 Issue-3 No.01 March 2020

OPEN ICT ARCHITECTURE FOR URBAN WATER MANAGEMENT: CHALLENGES AND ADVANTAGES

[1*] *Prof. Bhabagrahi Dash,* [2]*Subham Lenka*
[1*] *Professor, Dept. of Civil Engineering, NIT BBSR,*
Asst. Professor Dept. of Civil Engineering, SEARC, BBSR
[1*]*bhabagrahidash@thenalanda.com, lenkasubham08@gmail.com*

Abstract

The Urban Water project (FP7-ICT-318602) is focused on developing an open and flexible service execution platform and a core of innovative services for urban integrated management using real time data. The emphasis in UrbanWater is put on sharing the same data formats among the different services and developing a set of open interfaces that allow collaboration between services. In addition to this, a central node is being developed in order to provide a single point for monitoring the performance of all implied services, providing security as a service and also a single access point to shared data and services offered by third-party service providers.

Keywords: Information Communication Technologies; Integration platform; Integrated Water Management; Open platform

1. Introduction

A wide range of technologies must work together to offer the necessary sensing, communication, and processing capabilities for the difficult problem of water management. Several parties are involved in installing and operating remedies because of the nature of the issue. Due to the fact that there is very little interoperability, this reality typically necessitates the expensive integration of modules from several solution providers [1].

We discuss the benefits and drawbacks of an open and modular software platform for water management in this essay. In the parts that follow, this platform—which was created as part of the UrbanWater project (FP7-ICT-318602)—is also detailed.

This platform's primary function is to provide as an interface for the various

ISSN: 2278-4632
Vol-10 Issue-3 No.01 March 2020

parts of the water management system. By allowing new modules to connect to the platform via open interfaces and afterwards link to any existing module integrated with the platform, the proposed platform can significantly minimise the integration requirements. In addition to the platform's Application Programming Interfaces (API), the entire platform will be made available as Open Source.

In addition to the platform's Application Programming Interfaces (API), the entire platform will be made available as Open Source. Developers will have access to the tools they need thanks to this, and utilities will be able to launch their own instances if necessary. The ability to use cloud service providers and all the benefits that come with them, as well as the ability to maintain control over their data because it is consolidated in a single node, the platform, are the major obvious benefits for utilities.

Other cloud services may access this node in accordance with the utility's established access policies. The capacity to regulate the data is vital since a significant portion of utilities are public organisations or are subject to severe regulation by public entities.

Challenges

There are a huge number of challenges that have to be faced by an open and flexible Water Management System. Among them, we would like to highlight those that have a special impact in the openness and flexibility of the platform:

- How the data is captured, transmitted, stored and shared with the modules that need this data. Sensors use proprietary protocols, the level of adoption of data standards is still low and interoperability between diverse software modules is also very low.
- Data is owned by water utilities however, they have to share with service providers. Making this process agile without losing data control is also a challenge.
- In addition, most of the water process will imply collaboration of different modules. This will imply in many cases that services from different providers have to cooperate (by using output data or signal events produced by other modules) in order to provide the necessary service to the end user.
- The control of data is a key challenge for an open system since, due its nature, it must allow potential access of new modules to the data while offering an easy way to the utilities to control these accesses.
- To create a platform where new services can be easily deployed reducing the integration tasks.
- Finally, the cooperation of different modules from different providers for delivering a single service makes also necessary to monitor the service level provded by each module and if service level agreements are being followed.

ISSN: 2278-4632
Vol-10 Issue-3 No.01 March 2020

Benefits

UrbanWater will bring several benefits according to the nature of the different modules that are being developed inthis first release of the system:

- To effectively estimate water demand in urban areas in order to efficiently manage water supply chains.
- To reduce waste of water and economic losses associated to leakages in the urban water distribution network.
- To smoothen daily water demand daily peaks in order to allow distributors to save costs related to the urban water distribution networks' management.
- To guarantee efficient and secure computational data management on the base of smart grids' recent and upcoming deployments in Europe.
- To reduce operating and maintenance costs associated with water metering and billing in urban areas.
- To incentivize urban household's to reduce current consumption, soften water demand peaks, using Games and dynamic pricing

In addition to these benefits, some are more specially related to openness of the platform:

- Utilities face different situations in different scenarios. Water management problems will change from one region to another, in addition, regulators and stakeholders will be different. Even the size of the utility will create different needs. A useful water management tool for the utilities has to be flexible enough to be customized for each different situation. Actually, the modules and services required by the utilities will vary significantly. The

  UrbanWater platform will not only provide flexibility but will also foster the development of new modules by 3rd parties increasing in this way a range of available solutions. If necessary, custom made solutions can be also easily integrated in the platform as long as the open interfaces are used.
- The creation of an ecosystem, in which service providers, utilities and stakeholders can collaborate, will also be promoted by UrbanWater and actually the community created around the platform can be an starting point for this ecosystem.

2. The UrbanWater project and its components

The UrbanWater ICT platform is an innovative cloud application to water utilities. It offers different services for reach an efficient and integrated management of the urban water resources. The services offered by the platform

ISSN: 2278-4632
Vol-10 Issue-3 No.01 March 2020

are Decision Support, Billing, Demand prediction, Leakage Detection and many more. The Platform is being developed by 10 different companies around Europe (Two water utilities and eight service providers).

The components

The UrbanWater platform is a modular system offered as a service in which several software modules collaborate among them. The modules use all the information provided by the different sensors on the water distribution network to offer add-value services to water utility operators and household clients. The main modules included in UrbanWater are:

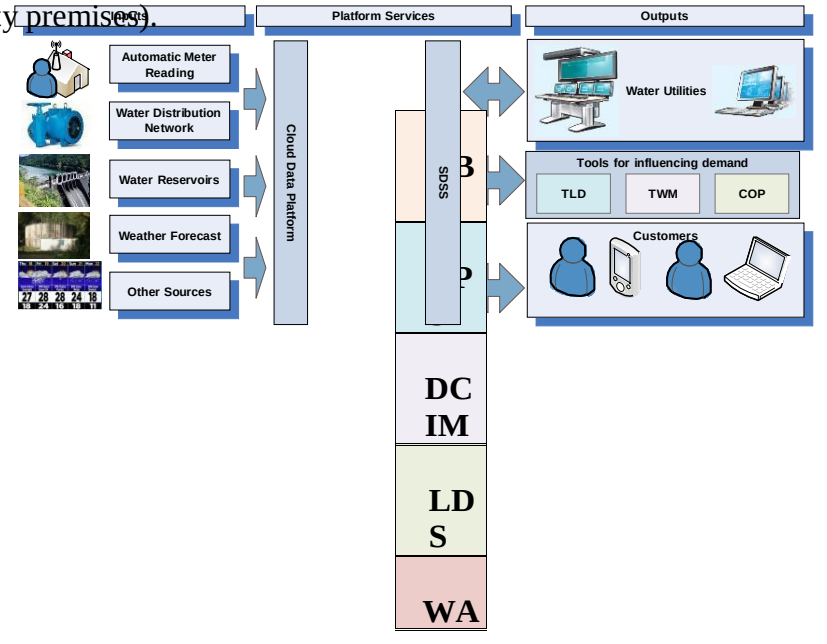
- UrbanWater core platform (UCP) – the UCP is the central module that communicates all other modules, manages accesses to data, monitors the performance of the included services and unifies the GUI elements of the included services.
- Customer's online portal (COP) – is the web module used for the utilities' customers for checking their current consumptions, view tariffs information and access historical consumption data.
- Smart Metering Tools – Automatic meter readers obtain the consumption information from household meters. The project provides a multi-protocol and a multi meter-gateway prototype. This element will allow simplifying deployment of household meters and other sensors reducing the number of gateways in urban scenarios.
- Serious games - Is the main tool to enable the water consumer to understand basic water systems in private environments (at macro and micro level) and uses game mechanics to inform and educate about efficient water consumption to change ultimately user behavior. Two games are available: The Last Drop (TLD) and The Water Mansion (TWM).
- Decision support system (SDSS): A deductive element that provides suggestions to improve the activities related to water supply and distribution management. It acts as an expert system providing support to the decision making process regarding the operation of the elements present in the water supply and distribution network.
- Leakage detection systems (LDS) - Identifies outflows in the water distribution network and alerts the water utilities. It consists of four main components: a mass balance tool, a night flow analyzer, a hydraulic model builder and exploration tool and an alert system.
- Water Demand Prediction System (WDPS) – Provides prediction of water demand based on: water flows at a certain place in the water distribution system, historical weather data and available and relevant other data, e.g. important events, holidays data etc. In

ISSN: 2278-4632
Vol-10 Issue-3 No.01 March 2020

addition, it uses recorded actual demand to perform model tuning and adaptation.

- Water availability prediction system (WAPS) - Calculate the water contribution of future rainfalls to the reservoir's basin. It produces rainfall forecasts that, combined with hydrological models, generate an approach of how will vary the capacity of the reservoir with this water contributions in the next days
- Detail indoor consumption module (DICM) - Presents a mapping between water flow profiles recorded on a smart
meter and the household appliances/fixtures that immediately caused that profile.

- Adaptive pricing system (APS) – Takes advantage where there is a possibility to attain better economic balance by changing water profile use during the day through price responsiveness of consumers, e.g. reducing outwear of the system caused by serving peak demands.
- Automatic billing system (ABS) – It allows to (a) configure innovative tariffs for water consumption and other
water-related value-added services, (b) define product offers, e.g. complex service bundles as one product, (c)
'sell' product offers to customers, (d) automatically charge customers for water consumption in near real-time and
(e) provide up-to-date information about water consumption to all stakeholders including end users at any time.
- Cloud database – Is an online Cloud Platform for the Water industry to manage commercially sensitive data-sets. It offers a hybrid database design with public a private cloud databases (hosted on the cloud and in the water utility premises).



ISSN: 2278-4632
Vol-10 Issue-3 No.01 March 2020

Fig. 1 Services flow

The data

Water utilities have different sources of information, from smart meters to sensors located on the distribution network. In addition with external information sources as weather forecast and calendar information can be used together to offer new add-value services. All this information is stored within the platform to offer the different components an accessible and controlled interface to query these data sources.

It must be mentioned that this part of the system must be also flexible. While there is a trend towards the adoption of smart meters, the level of deployment is still relatively low and the availability of data will change from one place to another.

3. Core platform design

The architecture, which was designed with the aim of simplifying the connection and interaction between the different services as well as facilitating the development of potential new services, is divided into several layers (see Fig. 2): (i) user layer, who represents the users or actors of the platform; (ii) presentation layer, who offers a common Graphical User Interface [GUI]

ISSN: 2278-4632
Vol-10 Issue-3 No.01 March 2020

providing a single user experience for all services (including outsourced services); (iii) service layer, where all services offered in the platform (e.g. SDSS, billing, demand prediction, leakage detection, etc.) are located; (iv) integration layer, which is used by all services to access UrbanWater platform's resources; and (v) data layer, which is the single access point to all information resources provided to the services. Additionally, there are two vertical layers providing management and monitoring capabilities to the IT department of the water utility (green boxes in Fig. 2).

The User Layer

The user layer represents which are the users or actors of the platform. This layer includes:

- Water Utility: Operates the services, manage and monitor the platform (SW and TAVE).
- Service providers: Offer services to water utilities using the UW platform resources (SAGEM, HYDS, UNIZG-FER, ORGA, SGI and AQUA).
- Customers: Customers of the water utility, households or companies which the water utility offer services to them (ex. water distribution, customer consumption analysis, etc.). For example the households can accessto their current consumption or bill using a web application.
- Other stakeholders: Third parties not included in the previous categories. For example city halls, public regulators and others. The platform can offer services for them like open data.

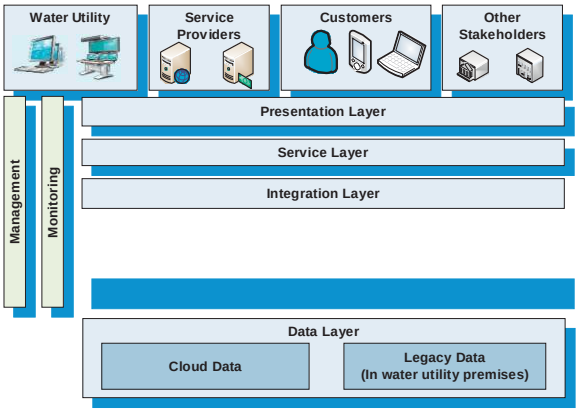


Fig. 2 Layers of the Platform

The Presentation Layer

ISSN: 2278-4632
Vol-10 Issue-3 No.01 March 2020

The presentation layer offers a common GUI for all the services offered in the platform (including outsourcing services). This provides a single user experience when using services from different providers.

The Service Layer

The service layer is where all the services offered from the platform to the user layer are located. These are the services that the water utility operates (ex. Leakage detection), the customer access (household web portal) or others (ex. Open data service).

The integration Layer

The integration layer is used by the services on the service layer to access the UW platform resources. These resources can be used to send messages, events and alerts between different services or modules and offers other functionality (management, monitoring, etc. that reduces the complexity of creating and maintaining outsourced services) to these services. In addition this layer is in charge of the security of the platform. That is to say that it controls that the authentication of the services, controls that the sensible data is encrypted and other rules that are specified by the water utility.

3.4.1. The service bus

The service bus is a key element of the proposed system. It acts as a middleware enabling the three main advantages of UrbanWater:

- Single access point: any service will only to be connected to the service bus in order to be able to communicate with any other module or accessing system data
- Replacement/update of modules: replacing or updating a module is completely transparent to the rest of the platform as long as the services offered by the updated module are maintained.

- Data Management and Security: as there is only one access point to other services and also to data, it is easier to keep control of how data is consumed by the different modules.

The Service Bus is the communication channel between the module and the platform. This means that a module providing output will only need to put these outputs into the service bus and the platform will notify, if necessary, other

ISSN: 2278-4632
Vol-10 Issue-3 No.01 March 2020

modules waiting for this output and will also store it in order to grant future access to this data. On the other hand, a module needing input from other modules will only need to be connected to the service bus and, after properly configuring the data needs of the module, the platform will send to the module any data required whenever it is produced.

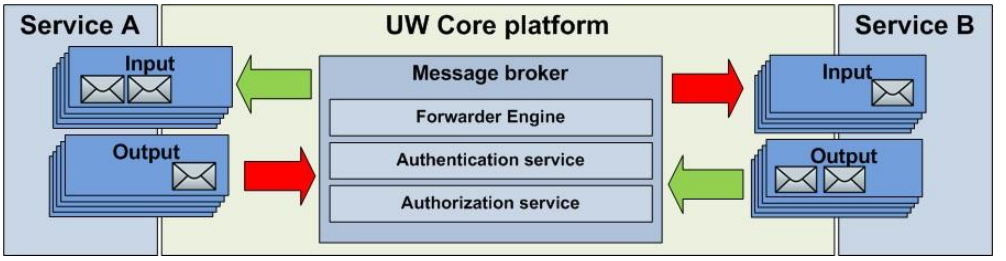


Fig. 3 Service Bus routing engine

According to this explanation, it is clear that the service bus provides a single access point to any service being provided over the UrbanWater platform. In addition, as mentioned above, it also makes service updates/replacements transparent. As described above, modules do not have direct contact among them but only contact thought the platform, due to this fact, a module waiting for data produced by other module (i. e. a Decision Support System waiting for a leakage detection system alarm) will only be subscribed to particular events (i. e. a leakage has been detected). If at some point one modules is replaced by a new version or even by a module from other service provided, this change will be transparent to the rest of modules as long as the new one provides the same features (services and events). In our example, as long as the new module publishes the leakage has been detected event, the change will be completely transparent to the rest.

The Data Layer

The data layer is the single point of access to all the information resources provided to the services. This layer includes the data stored on the cloud platform and other data that may be stored on the legacy IS of the water utility. The data is not accessible directly from the services in order to guarantee the authorization of each service to each type of data, controlling the security and the privacy from a single point.

The monitoring module

ISSN: 2278-4632
Vol-10 Issue-3 No.01 March 2020

In order to ensure that the UrbanWater platform works correctly, a proactive approach is taken. The monitoring module requests and logs the activity of the services to keep record of the unavailability time and the response time of system modules. The monitoring service monitors and displays the status of the services, communications and data sources.

The management module

In a big data world, one of the biggest assets of a water utility is the data generated from meters, network elements and customer information. The UrbanWater platform pretends to keep this information safe while outsourcing services

and allowing third parties to create new applications or services. In order to manage all this complex process, the UrbanWater platform offers the management module. This module allows to:

- add, modify, disable or delete services (Service Lifecycle management)
- control the data access from the services (Information security management)
- create new users and departments on the platform and enable/disable the access to some of the services (Usermanagement)
- add new data bases with information to the platform (Data repository management)
- change the internal configuration of the platform and access to the debug of the information logs (Platformmanagement console)
- provide the possibility to back up the information (Backup management)

These services are designed to be used by the IT personnel of the water utility and are described in detail in this section

4. Open design for flexibility, interoperability and Freedom

The importance of open platform design for public companies provides the following advantages:

- Boost the use of public standards
- Freedom for water utilities to reduce vendor lock-in
- Allow to perform code audits by the water utility or 3rd parties.
- SMEs and small developers can provide services to big clients
- It is easy to deploy a development instance of the platform so testing environments can be built to test the modulesbefore going to production
- It allows developers to provide services based on 3rd party services

ISSN: 2278-4632
Vol-10 Issue-3 No.01 March 2020

The core platform is being developed using Java and the spring framework. The development process use agile methodologies, continuous integration and test driven development. And the latest releases are uploaded to a maven repository. Defining interfaces and documentation are the major pillars of an open platform. The UrbanWater project development website hosts a wiki site where all contributors collaborate on the documentation of the platform. Tutorials and sample code to create new services compatible with the platform are provided on the wiki. Using the sample service skeleton (/trunk/platform/samples/SampleServiceMVC) it is possible to create a service with the minimum functionality (monitoring, scheduler, web interface and service bus connection) in a few steps.

5. Conclusion

The UrbanWater platform faces many challenges especially related to the interoperability of the different modules. The proposed design aims to provide a tool for increasing interoperability of different modules by acting as an interface between them. This will achieved by offering open interfaces to a service bus that will communicate this modules among them managing security and granting access to a central repository of data controlled by the utility. The platform will be released as open source in order to create a community of developers (with special focus in SME) and reduce the vendor lock-in. The UrbanWater platform will be released in Fall 2014.

References

[1] @qua ICT Thematic Network, Current ICT Solutions in Water Business Processes – Limitations & Gaps to be bridged, Deliverable 2.2 & 2.3, Version 2.0, February 14, 2012, 19-20.