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Cloud Computing Solutions For Aiding Urban Water Management

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CLOUD COMPUTING SOLUTIONS FOR AIDING URBAN WATER MANAGEMENT

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The management of Urban Water Systems is a complex problem to not only under viewpoint of water supply but also storm water and sewer systems. Growth of urban areas, rise of the social class and economic empowerment of population mainly in developing countries have caused significant changes under water cycle. Several tools are needed to help water managers in the decision making process. In addition, the availability of these tools may be helpful in providing the regulatory body of rational frameworks for the policy-level decisions. Considering last advances of Information Technology (IT), such as the development of multi-core processors, virtualization, distributed storage, broadband Internet and automatic management, a new type of computing mode (cloud computing) has been produced. It can concentrate all the computing resources and manage them automatically by the software without intervene. Currently, the understanding of cloud computing under water sector still has not completely validated. However, cloud solutions using GPRS/GSM and Internet certainly have helped small water utilities manage better their system without huge investments; when compared to SCADA conventional systems. This paper presents three different applications of cloud computing solutions in Brazil. The first one focused to the monitoring of water loss in real time. The second problem was addressed to the monitoring rain and storm drainage system in order to produce alert systems and design parameters. Finally, cloud solutions were adopted for monitoring water consumption of households. Advantages and disadvantages were discussed and results were analyzed in order to generate future investigations.

INTRODUCTION

The efficient management of urban water systems is a complex problem because to involve interests economic, politic, social and environmental. UN-Water [1] has recently stated that global water demand (in terms of water withdrawals) is projected to increase by some 55% by 2050, mainly because of growing demands from manufacturing (400%), thermal electricity generation (140%) and domestic use (130%). In developing countries such as Brazil where population growth, lifestyle and strong economic development changed last years, demand side water management, asset management and water loss and energy control in water systems are greatest issues next years. If one side water scarcity become a big problem for urban areas, requiring high investments for physical intervention in order to increase the supply, on the other side water systems needs priory to present high performance. For example, Brazil has reported low performance in terms of water losses [2]. The average of water losses is 37.57% as reported by Brazilian System of Sanitation Information [3]. Thus, some issues still are open: why have not water utilities invested in solutions to improve the performance? One of reason origins from institutional organization at water sector; characterized as a market with natural monopoly and without competition. Several studies ([4]-[7]) have discussed about them. The second reason is technical origin. Although communication and sensor technology have catalyzed progress in remote monitoring water systems, the successful operation of urban water systems requires the installation and operation of a wide range of off-line and on-line measuring instruments [8]. In developing countries, such as Brazil, it still needs to extend the level of coverage of sensors for improving the water systems efficiency. Market analysis [3] estimates that less than 10% of brazilian municipalities have deployed Supervisory Control and Data Acquisition system (SCADA).

Recent advances about Information and Communication Technologies (ICTs), Internet and Mobile, have contributed to the improvement of water efficiency. In special, technologies of Cloud Computing that can be defined as the aggregation of computing as a utility and software as a service where the applications are delivered as services over the Internet and the hardware and systems software in data centers provide those services. Also called *On Demand Computing*, *Utility Computing* or *Pay as You Go Computing*, the concept behind cloud computing is to offload computation to remote resource providers [9]. In water industry, it has been noted a timid growth of cloud computing. Karamouz *et al.* [10] developed and discussed a real-time uncertainty model for evaluating flood in cities adopting cloud computing. Wu and Khaliefa [11] developed a prototype of the high performance computing to optimize (schedule) pumps of a water distribution problem.

This paper aims (a) to demonstrate several applications of cloud computing to water management in real life systems; (b) to discuss advantages and disadvantages of cloud computing in water sector including existing technologies; (c) to discuss results under statistical view. The paper does not intend to provide an exhaustive review about cloud computing but to show potentialities mainly as solution for small and medium municipalities, which have not economic viability to deploy hard SCADA systems. Digital sensors, GSM/GPRS Dataloggers and Cloud servers were technologies adopted such pilot experiences.

CLOUD COMPUTING APPLIED TO URBAN WATER SYTEMS PROBLEMS

Urban water systems needs rapidly to be operated using modern and innovative technologies in order to reach future water demands, to minimize climate change impacts in Water Distribution Systems (WDS), to promote the consumer engagement to increase water value, and others. Although SCADA systems are robust, its deployment requires elevated amount of capital, specialized human resources, IT infrastructure investment (local server, radio base station). For some municipalities in developing countries, SCADA becomes economically unviable. The Cloud Computing with GSM Dataloggers collecting data from sensors is a feasible solution because requires just Internet and Mobile Signal. In addition, cloud computing lies in its potential to help developing countries generate the benefits of information technology without the significant upfront investments that have stymied past efforts. This paper deals with the issue of innovation from the viewpoint of applied cloud computing to water sector. The Figure 1 describes the general software architecture adopted in this paper.

Water Loss Problem

Water scarcity has become a major problem for an increasing number of countries. In Brazil, Metropolitan Region of São Paulo (MRSP) has suffered with water shortages almost yearly. São Paulo, with 10 million people living in metropolitan area, has scrambled to supply to population that requires 45 902 liters/second of water [2]. Thus, Water Loss remains as a challenge for utilities mainly in terms of management and monitoring technology. As most of existing technology, e.g. SCADA, has been deployed at production system, water distribution where registers most of leakage occurrences presents low coverage of sensors. The challenging issues are associated to the continuous monitoring in real time so that fast operational decisions could save water. Here, the **Water Loss Control Problem** (P1) is to monitor real losses estimated by Minimum Night Flow methodology [12] in real time. After that, water balance is calculated.

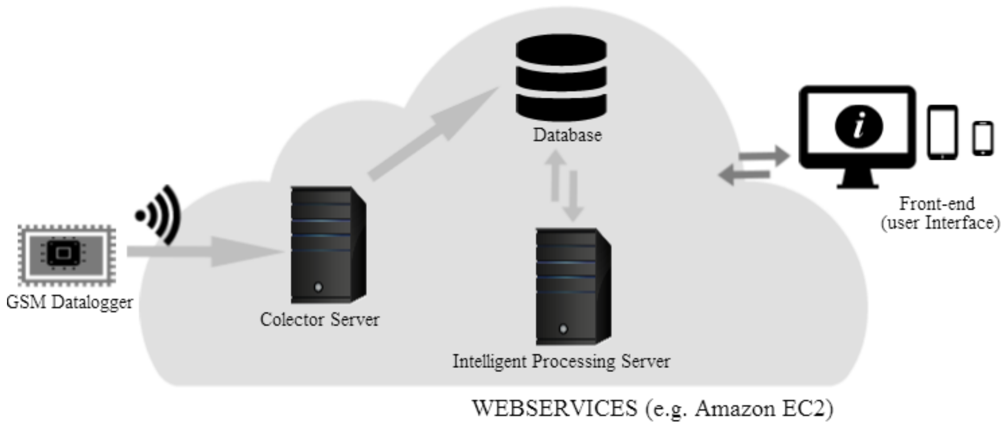

Figure 1. General architecture of cloud computing adopted in this paper

Storm Water Problem

Urban water flooding is difficult to anticipate, and the short response time for the runoff to rainfall means that there is comparatively little time after the rainfall has started for the authorities to take action to protect the urban community [8]. Millions of people yearly are affected by inundation (natural disasters) around the world. Most of such problems could be avoided or minimized adopting flood warning systems. In addition, data from such systems would aid to design defenses systems against inundation, to provide data to construction and urban development. **Storm Water System Monitoring Problem (P2)** in order to real-time identification of anomalies becomes a relevant issue.

Household Water Consumption

Economic and demographic processes have changed substantially the water consumption within Brazil. Residential water consumption previously are determined by seasonal changes, management strategies such as water metering (compared with unmetered homes), water restriction levels, water efficient devices, water consumption information devices and education. Residential water consumption in Brazil has changed substantially over the last decade due to social factors. Residential water use in 2012 was 148 liters per inhabitant per day. Understating the water demand. To understand the water consumption in households aiming management of water demand side, it is necessary to monitor in real time the **Household Water Consumption (P3)**.

CASE STUDIES

Water loss case study

A District Metered Area (DMA), from Corumbá (Brazil) municipality, with 523 connections and 7 kilometers of network (network length) was chosen for application of real time monitoring by cloud computing. Pressure and flow were continually monitored with GSM/GPRS Dataloggers (Figure 2) and INFOSAN SaaS (Figure 3) provided by Optimale LTDA company.

Storm water case study

The city of Campo Grande, Brazil (Figure 4) deployed several storm water stations (Figure 4) in order to monitor in real time rain and drainage water level. Rain and water level have been monitored in real time by INFOSAN dashboard (Figure 3).

Figure 2. GSM/GPRS Datalogger with 3 input sensor and incorporated pressure sensor.

Figure 3. Dashboard of INFOSAN SaaS for monitoring data in real time.

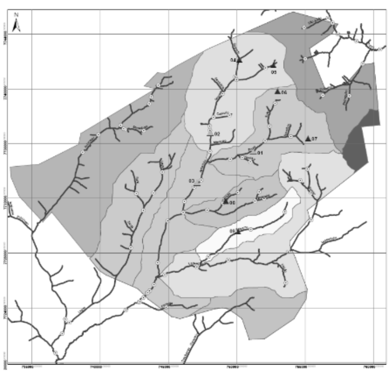

Figure 4. Drainage map of Campo Grande city indicating storm water remotes.

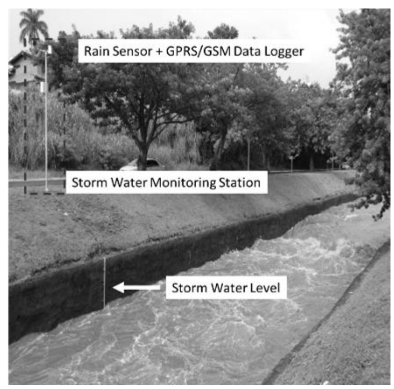

Figure 5. Details of storm water monitoring station

Figure 6. Building with 68 apartments

Figure 7. Household flow meter with datalogger deployed

Household water consumption case study

A building containing 68 apartments (Figure 6), situated in Campo Grande (Brazil) was chosen to deploy a telemetry system, using a Mesh Grid with several radio datalogger (900 MHz) and one GPRS/GSM datalogger that works as a concentrator. The main goal of this project was to monitor water consumption in real time in order to understand their behavior and to detect anomalies.

RESULTS

Water loss case study

With real time monitoring of pressure and flow, it was possible to estimate the real water losses in the DMA, and to calculate how continuous the distribution was. This allowed the utility to expand their monitoring capabilities, optimizing their budget and focusing resources on network improvements. The Figure 8 demonstrates a report screen of the cloud solution for monitoring water networks.

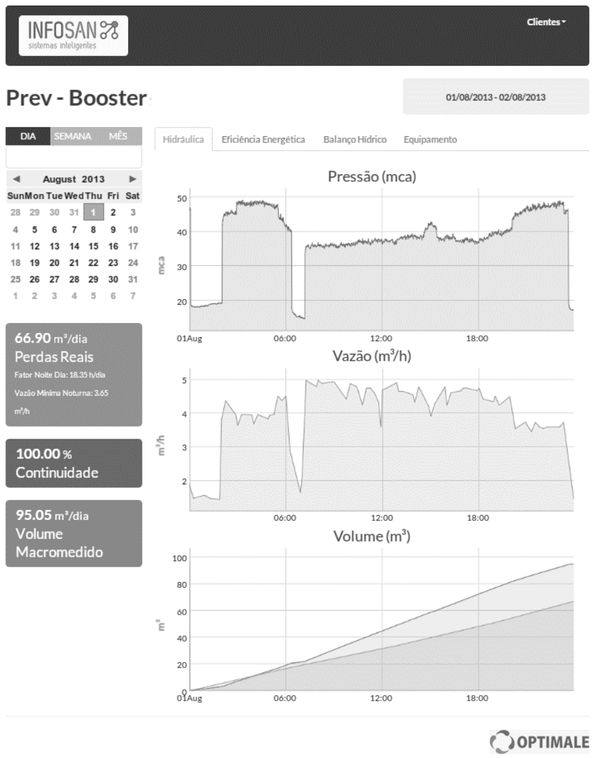

Figure 8. DMA status report

Storm water case study

The real time rainfall and stream level monitoring allowed the municipality to study and develop prevention measures to ensure that the highest rainfalls will not affect the population. During a training period, every rainfall was plotted in graphs like the Figure 9, to find the timeframe between highest rainfall intensity peaks and the stream flooding levels associated. Knowing those thresholds, a series of alerts were configured in the system, sending e-mails or SMS to the authorities that now are able to take necessary actions before accidents happen.

Household water consumption case study

Each household has their consumption pattern estimated using their historical data. Abnormal consumptions can trigger alerts, indicating an internal leak. Every month the systems provide a report for billing porpoises, and generates a ranking with the most “green” houses, with minor consumption of water.

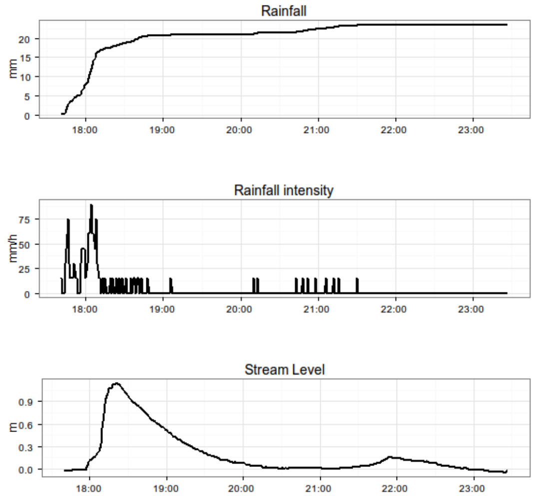

Figure 9. Time series for a rainfall event

Figure 10. Rainfall intensity map for an event.

SUMMARY AND CONCLUSION

Cloud computing is changing the way industries and enterprises do their business. In water sector, it could become a fast solution to improve water management mainly in small and medium municipalities and thus to increase the life quality of population. In this paper, we have tried to show the different applications for urban water problems that will be rapidly solved by real time monitoring. In terms of direct adoption of cloud computing in the water sector, stakeholders should become bold around IT and new business models, e.g., pay-as-you-go, production scaling up and down per demand, and flexibility in deploying and customizing solutions.

Urban water applications demonstrated here reinforced the advantages of cloud computing about availability, scalability and data management. In addition, the possibility to real time monitoring provides several benefits to municipalities such as to identify tactical actions (water losses real time monitoring), to prevent urban disasters and transport accidents (storm water applications) and to understand water consumer behavior (smart water metering). Finally, it is possible to state that several issues to remain open and to need to evolve mainly in terms of Data Analysis using Big Data Technologies.

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