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ScienceDirect

Procedia Engineering 154 (2016) 11 – 18

Procedia Engineering

www.elsevier.com/locate/procedia

12th International Conference on Hydroinformatics, HIC 2016

Key Challenges For Smart Water

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Abstract

Future water shortages require immediate action on development of resources, reduction of demand and higher efficiency in treatment and transmission. Future flood risk management requires immediate action in risk assessment, defence and alleviation systems, forecasting and warning systems and institutional and governance measures. Technology has been revolutionized over recent years and now, matured with mass production allowing wider uptake of methods and devices. The current situation in the water domain is characterized by a low level of maturity concerning standardization of ICT solutions and business processes. The massive and rapid spread of communicating devices within the Society and their application to the industrial sectors is not coordinated. The only relevant angle for the development of these technologies (M2M) within the water domain has to be based on the identification of the added value provided in each business process by the introduction of the new solutions. In order to identify which and how ICT solutions can be implemented, it is necessary to look at the water cycle through an approach based on functional domains and business processes. The water uses are associated to business processes and are linked to economical and social values. The final step of the approach is then to identify for each business process how ICT solutions can be implemented and provide added value. This diagnostic has to be shared by professionals and operators in order to ensure a coherent deployment. The motivation of the @qua entity (www.a-qua.org) which gathers major actors from water and ICT domains, is now to ensure this role at the interface with the different actors of the water domain and to elaborate a consistent vision for the future of ICT solutions within the water domain.

Peer-review under responsibility of the organizing committee of HIC 2016

Keywords: smart water; ict solutions; water domains; business processes; @qua.

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Peer-review under responsibility of the organizing committee of HIC 2016
doi:10.1016/j.proeng.2016.07.412

1. Background & challenges

Future water shortages require immediate action on development of resources, reduction of demand and higher efficiency in treatment and transmission. Future flood risk management requires immediate action in risk assessment, defence and alleviation systems, forecasting and warning systems and institutional and governance measures. Technology has been revolutionized over recent years and now, matured with mass production allowing wider uptake of methods and devices. After the development phase, technology is now entering an application and implementation phase that is targeting several fields including environment. A relevant example is given by the European Union who has defined a major priority for the next 20 years on "ICT for sustainable growth" with the ambition to lead innovation at the worldwide scale. In such context, ICT refers to technologies that provide access to information through telecommunications. It is similar to Information Technology (IT), but focuses primarily on communication technologies. This includes the Internet, wireless networks, cell phones, and other communication mediums. The current situation in the water domain is characterized by a low level of maturity concerning standardization of ICT solutions and business processes. The massive and rapid spread of communicating devices within the Society and their application to the industrial sectors is not coordinated. The only relevant angle for the development of these technologies (M2M) within the water domain has to be based on the identification of the added value provided in each business process by the introduction of the new solutions.

2. Methodology for needs analysis

Obviously, in the coming years, the new technologies from the IT sector will affect the full water cycle and the management of the water related services. This process represents a major challenge for the 21st century. However, the impact of these new technologies – from sensors to Decision Support Systems (DSSs) - could be stronger and really significant if priorities are properly defined and implemented within the R&D strategies of the main actors of the water and IT sectors. The main driver of the strategy has to be to achieve a comprehensive architecture of an Information System (IS) dedicated to water uses and connected to others systems involved in human activities.

By definition, Information systems are implemented within an organization for the purpose of improving the effectiveness and efficiency of that organization [1]. Capabilities of the IS and characteristics of the organization, its work systems, its people, and its development and implementation methodologies together determine the extent to which that purpose is achieved. The IS is associated to an architecture which provides a formal definition of the business processes and rules, systems structure, technical framework, and product technologies for a business or organizational information system.

In order to elaborate a specific IS for the management of the water cycle, a methodology is needed for identifying priorities and strategic investments to do in the ICT domain [2]. The requested approach has to investigate all domains and provide a map of the various process taking places in the different domains of the water uses cycle. This formalization exercise, using mainly concepts and processes, is now requested in order to ensure the coherence of technical choices in a holistic approach. The methodology has to start from the water cycle, to identify the various water domains and the associated activities. The activities can be then defined with business processes that can be analysed regarding the need of ICT solutions. The key principles of the approach have been elaborated by @qua – Smart ICT for Water (www.a-qua.org). The @qua organisation is created and supported by major actors of the IT and water utilities and more generally by water stakeholders. Within the collaborative entity, several working groups will address practical issues like automated meter reading, real time information of customers and stakeholders, optimized network operation, asset management, geographic intelligence, smart energy grid in water distribution systems and will develop a coherent and shared vision allowing integration and operability for the benefit of water management. The objectives of @qua are to define the specifications for the future and to establish the standards for today and tomorrow.

2.1. Methodology

@qua members have developed a general methodology based around few steps which can be summarized as follow:

- Step 1 - Water business processes and ICT solutions: identification of gaps and expectations of the water domain professionals on ICT solutions;
- Step 2 - Identification and validation of innovative ICT solutions by the ICT professionals with the objective to bridge the identified gaps during the Step 1;
- Step 3 – Develop the "level of sharing" of each ICT solution in order to address interoperability, standards, architecture and roadmap for implementation issues;
- Step 4 – Produce guidelines, standards and specifications on specific ICT solutions needed by the water domain in order to achieve a more efficient water management.

The two main characteristics of the defined approach are:

- the global analysis based on "business processes" and associated added value;
- the definition and the use of concept of "level of sharing" to decide which ICT innovations could be widely disseminated throughout the water profession.

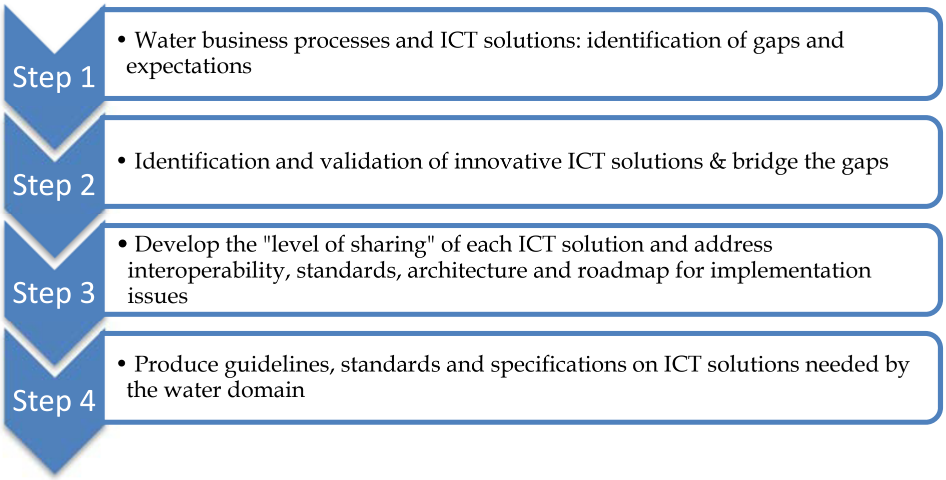

Fig. 1. @qua methodology for ICT needs analysis.

The initial step is dedicated to the analysis of the business processes, both for the artificial cycle and the natural cycle of water, and both for design and for operations. The business processes are described at a macro scale, where the tiny differences between entities are not seen and where just the common "backbone" is visible. These business models are used as "base maps" in order to show the unequipped - or poorly equipped - steps in terms of ICT. A special attention is turned to the analysis of added value of these unequipped steps. The diagnostic characterizes the added value not only on the economic point of view, but also on sociological and ecological dimensions. In addition to the common map of the water business processes itself, the result of this step is the list of the steps / processes that "deserve" to be equipped with new ICT tools. This effort of analysis according to the business processes vision represents an essential input in the water domain. Until now this diagnostic was not established for several reasons and especially due to the low maturity of water industrial domain regarding ICT solutions and uses.

The second step consists in a technologic analysis of the needs and requests written by the water companies' representatives. The step includes not only the assessment of the feasibility, the potential availability and the cost of the requests, but it will also propose other tracks, unimagined or not foreseen during the previous step. The water companies have a partial vision of ICT solutions and they need a better knowledge of the current trends of the ICT industry / market. Alternating the leadership of the steps between the "water people" - water companies and other stakeholders - and the "ICT people" brings an efficient synergy.

The third step is focused on the determination of the "level of sharing". This concept is a central element which is developed and used by the @qua network. For the time being, the use and the implementation of existing ICT solutions in the water domain is made case by case, with a quite variable customization which is covering a simple technical adaptation like wavelength, to in depth R&D development like the use of alternative energy sources for power supply in waste water monitoring actions. This step will analyse the "IS/IT context" parameters in the profession: maturity of the IS, level of integration (integration of the IS itself as well as integration in the business processes), level of alignment with the strategy, and the local parameters (ERP/ software already installed, other relevant IT projects, trends of the local IS/IT market, etc.). This step proposes the ideal "level of sharing", i.e. the level that will maximize the effectiveness and efficiency of the new ICT tools by taking into account the actual current IT/IS situation.

In a final step, the production of the guidelines and specifications whose needs are identified in the previous steps. According to the results of the previous step, these results can go from very generic guidelines to more precise technical specifications such as hardware requirement for sensors, software architecture, strategy for implementation and deployment in water services, metadata architecture, business process description and standards. A similar approach has been partly applied with HarmonIT project (http://www.harmonit.org) on the specific field of the hydroinformatic systems interoperability and the development of the OpenMI standards (http://www.openmi.org). In the case of the @qua approach, the spectrum is much more wider because it's addressing most of the business processes involved in all water uses and domains.

2.2. Application to urban environment

The water cycle can be divided in three domains that are associated to specific activities and business processes [2]:

- Protection of natural environment and ecosystems;
- Natural hazards mitigation and disaster prevention;
- Water uses.

The first domain considers all actions needed to assess and advice on the environmental impacts of development proposals and projects related to specific water uses. Results are used by regulatory services. The domain covers also all conservation actions of water related ecosystems.

The second domain is focused on water related natural hazards mitigation actions. Floods, water-borne and vector disease outbreaks, droughts, landslide and avalanche events and famine are the processes covered by this domain. Every year, disasters related to meteorological, hydrological and climate hazards cause significant loss of life, and set back economic and social development by years. The disaster is defined as a serious disruption of the functioning of a community or a society causing widespread human, material, economic and/or environmental losses.

The last domain covers the added influence of human activity on the water cycle. Generally, the water uses refer to use of water by agriculture, industry, energy production and households, including in—stream uses such as fishing, recreation, transportation and waste disposal. All of those uses are directly linked to specific activities and processes that are potential targets for deployment of ICT solutions. In order to stick to the reality of the water management operated by entities in charge of water services, the traditional classification can be reviewed. The main water uses appear then as: agriculture, aquaculture, industry, recreation, transport/navigation, and urban.

According to the defined water domains, the water uses represent the largest field where ICT solutions can be developed and implemented. Urban water use is generally determined by population, its geographic location, and the percentage of water used in a community by residences, government, and commercial enterprises. It also includes water that cannot be accounted for because of distribution system losses, fire protection, or unauthorized uses. For the past two decades, urban per capita water use has levelled off, or has been increasing. The implementation of local water conservation programs and current housing development trends, have actually lowered per capita water use. However, gross urban water demands continue to grow because of significant population increases and the establishment of urban centres. Even with the implementation of aggressive water conservation programs, urban water demand is expected to grow in conjunction with increases in population. The urban environment is associated to a high dynamic which implies a growing complexity related to number of inhabitants and management of water resources in order to fulfil the needs of population.

The water uses are associated to business processes and are linked to economical and social values. In most of the cases, five major activities are taking place within each water use and appear as invariants. These key activities are [2]: Investigating /surveying, observing / monitoring, designing, building and decommissioning, operating.

The uses in urban environment, carried out by water utilities, can be defined with a limited number of business processes – 29 in total - summarized into the table 1 and which are covering drinking water, waste water and storm water management. From this list of BPs, ICT solutions providing a real added value can be identified. This diagnostic has to be shared by professionals and operators in order to ensure a coherent deployment.

Table 1. Business processes for urban uses.

Business processes	Business processes
1 - Asset management	16 - Water primary network management and water balance
2 - Crisis management	17 - Water secondary network management
3 - Field intervention management	18 - Leak detection
4 - Field works	19 - Meter reading (AMR & MMR)
5 - Use of GIS	20 - AMR & MMR management
6 - Maintenance of GIS	21 - Public service contract management
7 - Management of plant maintenance	22 - Waste water network management
8 - Electro mechanical maintenance	23 - Storm water network management
9 - Laboratory activity and quality control	24 - Waste water treatment plant management
10 - Automation & sensors	25 - Sewer inspection and sewer cleaning
11 - Real time network management	26 - Billing
12 - Planning and design of new assets and plants	27 - Customer care & communication
13 - Water resources management	28 - Innovation & pilots
14 - Environment management	29 - Supports
15 - Drinking water treatment plant management	

3. Towards an Integrated Water Information System

The analysis of needs and expectations in the water domain leads to formulate an Integrated Water Information System. There is a need for an overall consistent approach made of an integrated model of the water business BPs. In other words, the ideal Information System (IS) is based on BP model. In other words, this consistent IS, together with standardised ontologies, is the key to real interoperability. The approach has been already promoted for example within the Smart Water Management Initiative taken by K Water in Korea [7].

Many models of the utilities business can be found on the market, most of them from software vendors, whose objective is selling their software package solutions. Nevertheless, in-house analysis seems to be more relevant. An integrated and internally consistent Information System, covering all the activities of the company, reflects the global vision of the business, and transforms a collection of applications into a "system". This consistent IS can be reach by a real integration and by gateways or interfaces. Targeting an IS, helps to establish a single definition and way of managing each data item, therefore, the processes of generating or capturing data need to be managed and monitored and reference data and how they are shared within the information system has to be defined. But, above all, the target system is fully aligned with the business and can ensure a more accurate concept of investment.

3.1. Basis of the Water Business IS (WatBIS)

The construction of a Target System is based on the analysis of business processes (a business model). Thus first thing to analyse are the "Business Invariants": the functional architecture of the Target System is based on this business process model. In order to search for these business invariants, weak and strong links has to be identified, paying special attention to transversal processes and identifying the core and unvarying (universal) aspects of the water business.

Sharing data and managing data capture are the driving forces behind the design of the system to identify essential data and allow their sharing and to allow the identification of « survival kit », « nice to have » and "luxury" activities. It is possible to adjust the overall design to take into account local conditions, the relative weights of stakeholders and the degree of the Business Unit's maturity.

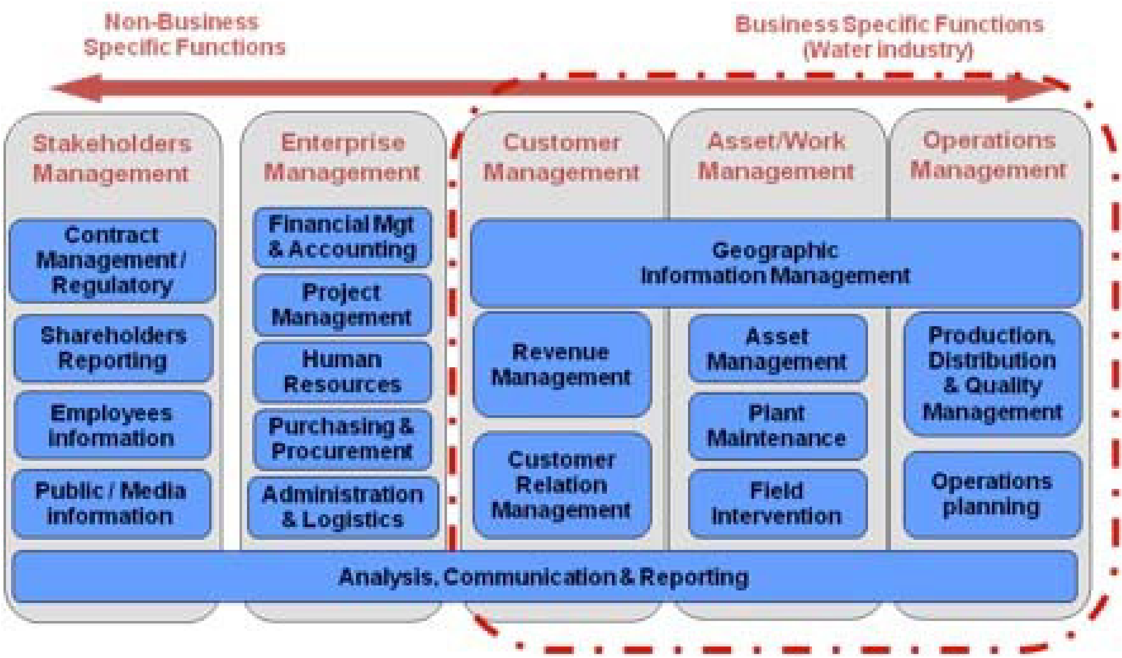

Fig. 2. A map of Water Company's Business.

Water Business IS model are focused on core business, such as GIS, Plant maintenance, CMMS, Work management, Models, as well as Asset Management and events or measurements. However, the "technical" IS are often left aside. In most utilities, the percentage of budget dedicated to technical domains is (and has always been) rather small. Major investments are done in finance, human resources, purchasing, billing, etc. The only "technical" IS that is a source of founding from water business is GIS. Generally, actions and developments in technical fields are very local, without global vision, and therefore, many "un-equipped" functions can be found. The major role of the frame of reference is the repositories of core data.

The "pillars" of the Business Information Systems contain high value data, shared by all business domains. It should be identified and be part of these pillars

- contract,
- customer,
- assets (above- and underground),
- interventions and works,
- events and measurements,
- addresses,
- organization of the BU and of the territory,
- standards, laws, regulations, procedures and instructions

Special attention should be paid to critical part of the Information System. In this case these critical parts are customers, asset management, technical domains in general, contract management, the legacy role of GIS, as well as works & interventions, backbone of the IS of the "technical" domain, details on assets description / (legacy) role of GIS.

3.2. The example of urban monitoring and DSSs

Management of water uses requests to harmonize demands and needs which are getting more and more complex and sophisticated. During the past 3 decades, modelling systems for hydrology, hydraulics and water quality have been used as stand alone products and were used in order to produce an analysis of a current situation and to generate forecast according to different horizons. The current situation, characterized by the fast increase of monitoring devices mainly in the urban environments, requests an integration of the modelling tools in global information systems that are now dedicated to the global management of urban environments and related services. Energy distribution, water distribution, solid wastes collection, traffic optimization are today major issues for cities that are looking for functional Decisions Supports Systems (DSSs) that may integrated the various components and operate in a sustainable perspective. The modelling systems used for hydrology, hydraulic and water quality have to integrate a common framework allowing modular approach and interoperability.

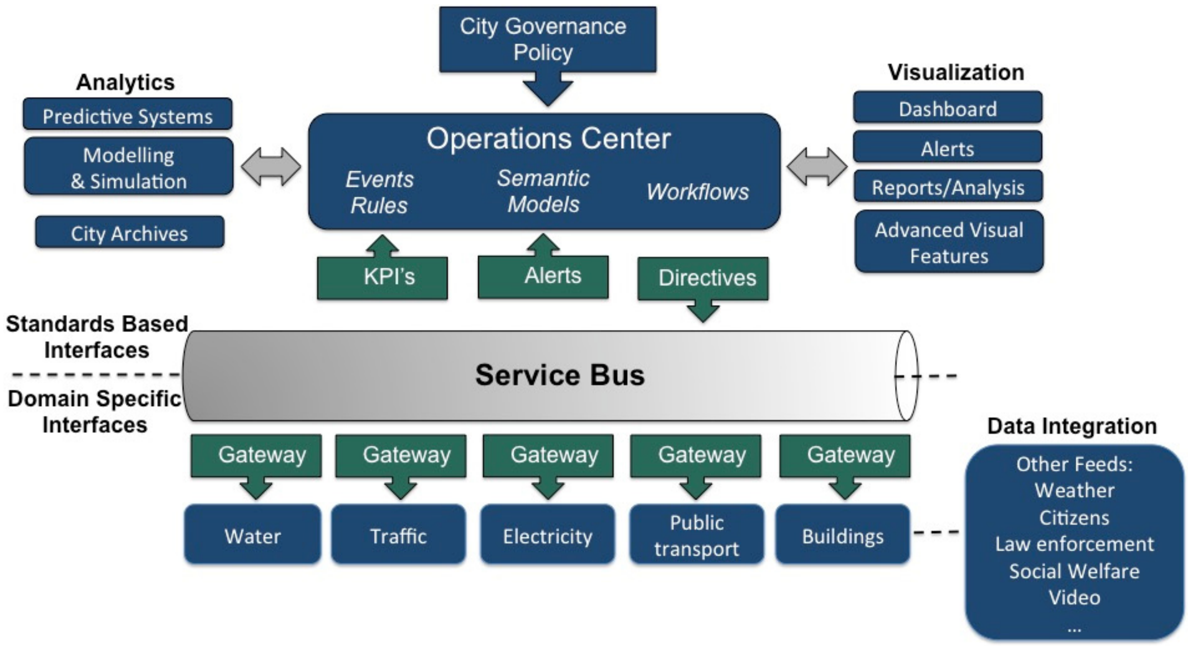

Fig. 3. Concept of hypervision platform dedicated to urban monitoring and management (Adapted from [4]).

By definition Decision Support Systems (DSS) are a specific class of computerized information system that supports business and organizational decision-making activities. In cities, the DSSs are supposed to streamline and integrate rules, procedures and decisions needed for solving complex problems: when relationships between required sets of data are unclear, the data comes in multiple formats and/or pertinent problem-solving methods required to be applied are not straightforward [1,2,3,4]. The growing complexity of urban environments requests to develop a holistic approach that integrates the dynamic of the various functions and services under various situations like flooding or lack of drinking water. In the water sector, the services provided to the inhabitants have been gradually integrated in various platforms that provide a real time overview of the various business processes. Major water utilities like Suez and Veolia have already produced specific services that are integrated in hypervision platforms promoted by IT providers such as IBM, CISCO, Schneider Electric, etc. In most of the cases, the real-time data on water consumption, potential leakages and quality monitoring are available for the technicians and the decision makers. Several experiments have been conducted successfully in Europe, Asia and USA. One of the most impressive achievements takes place in Malta with the full coverage of the country with a Automated Meters Reader (AMR) solution promoted by Suez and IBM [3].

The current demands are in favor of a platform elaborated over a service bus dedicated to collect and integrate field data that are related to various processes including the water services and the natural hazards. Data are formalizes through various tools such as Key Performance Indicators (KPIs), predefined alerts and directives. A synthetic dashboard allows visualizing the current situation. In addition, in order to provide a real support to the decision process, several tools dedicated to the data analysis and to the simulation are interfaced with the core part of the platform. The models used in this analytics domain start with basic statistical tools and go to complex determinist models such as those commonly used in hydroinformatics. This architecture concept for the urban information system is today commonly shared and appears as a consensus solution [4, 5, 6]. However, several serious technical challenges are still there and will request efforts for a real integration and functional interoperability. If the concept is now shared, the maturity has to be gained in particular with the definition of the requested standards for managing the workflows among the various applications. The architecture is based on the interoperability of the various models and is integrated in a platform allowing to organize the workflows of data and the production of real time information's used by the decision makers.

4. Conclusion and perspectives

The Smart Water concept has just emerged with the gradual integration and convergence of ICT solutions implemented within the water domain. The success of the approach that could offer an alternative way for a more efficient water management is fully linked to the quality of the vision developed for the Water Business Information System. A strategic and pragmatic approach, based on business processes analysis - has to be implemented in order to address properly some of the key challenges that are related to interoperability, common ontology, integration, level of sharing and maturity levels. The analysis carried out by @qua has opened the way for the urban environment. The approach has to be extended to all the water domains.

The motivation of the @qua entity (www.a-qua.org) which gathers major actors from water and ICT domains, is now to ensure this role at the interface with the different actors of the water domain and to elaborate a consistent vision for the future of ICT solutions within the water domain. This activity is essential in order to ensure a productive R&D / IT implementation focused on high financial benefit "niches" and to develop agile environments (interoperability) able to deal with the massive flow of data (big data) and constant technological innovation (M2M).

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