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SMART WATER MANAGEMENT PROCESS ARCHITECTURE WITH IOT BASED REFERENCE

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Abstract: Water is a vital resource for life, and for the economy. Nowadays, one of the most serious challenges to solve is to manage the water scarcity. Current water management ICT systems are supported by specific vendor equipment, without considering any interoperability standards. The lack of standardization among producer's water ICT equipment hinders proper monitoring and control systems, resulting in low efficiency in water distribution and consumption, system's maintenance and improvement, and failure identification. We provide architecture for sub-system interaction and a detailed description of the physical scenario in which we will test our implementation, allowing specific vendor equipment to be manageable and interoperable in the specific context of water management processes.
Keywords: Water management, Irrigation, OPC UA, Internet of Things.

I. Introduction

Water management is defined as the activity of planning, developing, distributing and managing the optimum use of water resources. These impacts on several key matters [1] of human lives, such as food production, water consumption, sewage treatment, irrigation, purification, energy generation and utilization, etc. The lack of water ICT (Information and communications technology) standards prevents an effective interoperability, and increases the cost and the maintenance of new products. Nowadays there are many small and local producers of specific solutions in a weak and fragmented market. The almost no adoption of complex and interoperable systems jeopardizes the control and monitoring of water distribution networks, preventing also their evolution and necessary improvements, as an adoption of IoT (Internet of Things) paradigm. In addition, current ICT systems for water management are proprietary and packed as independent products; support all management levels from the product development to the communication with management systems. System maintenance and sustainability depends on the company providing it.

II. High Level Architecture for effective water management

Consumers in the water sector provide a weak critical mass to influence in decisions resulting in appropriate changes. The water sector operates in a complex interaction between water resources and the socio-economic and environmental systems. The range of stakeholders is huge, public and private, from global to local companies, supported by national, regional and again local authorities. This different nature in stakeholders and also the various schemes for water governance, which are continuously evolving in every country, are the main reasons for current market fragmentation in water management solutions.

2.1 Requirements for a reference Architecture

We define the following requirements that must be fulfilled to develop a standard water management model

REQ #1: The system should cover these water management functions: remote management of physical elements and operation of basic units; identification of resources in the water network, definition of operations and conditions over the network.

REQ #2: It should support interoperability with other applications such as geographic information systems and also databases containing information regarding soils, weather forecast, environment, farming, etc.

REQ #3: It should provide a flexible and extensible architecture for the integration of various systems. To do that, it must define open interfaces among communication and process control layers, and also integrate IoT systems for a direct access to individual water management devices.

REQ #4: It should support integration with legacy systems, controlling current equipment. Water management infrastructures currently deployed in the countryside consist of many interconnected and simple devices that must be managed using legacy systems. They integrate communication functions, data models, and protocols dependent on an specific technology of the manufacturer. Overriding these systems with new ones is not always a feasible solution.

III. High level Architecture for effective water management

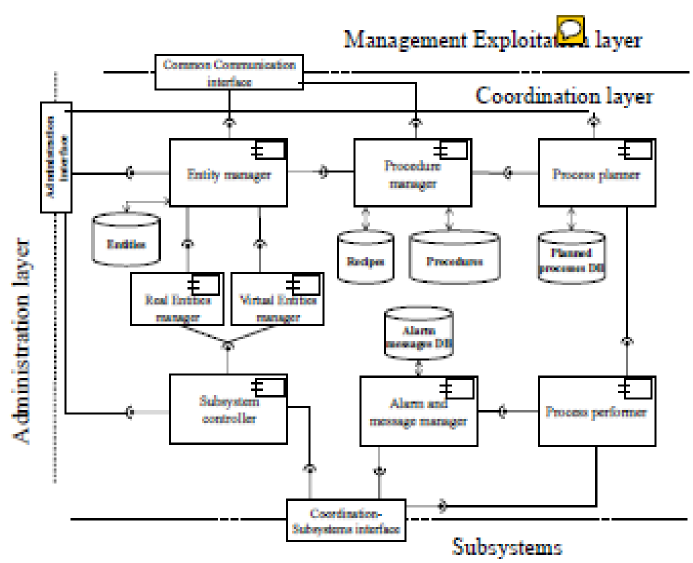
The MEGA architecture is described in Figure 1. The proposed high level model identifies three layers (from bottom to top): the Subsystems layer, the Coordination layer and the Management - Exploitation layer. These layers deal with a common Water Management Model that considers the definition of Entities, Recipes, Procedures, Planned processes, and Alarms. The water management model is the key element for enabling MEGA to provide a common behavior framework. Between the Subsystem layer and the Coordination layer there is a Coordination - Subsystems interface and between the Coordination and the Management - Exploitation layer there is a Common Communication interface. It is also considered an Administration layer that manages the information provided by the Coordination layer through the Administration Interface. We describe the main elements of the MEGA architecture:

3.1 Management and Exploitation layer:

This layer hosts the main applications and services responsible for the efficient management of water infrastructures, and supports the definition and management for the processes applied to those infrastructures. In this layer the Operators (big service companies, and end-users associations among others) drive management processes abstracting from the specific fi- nal systems deployed in the real environment. Services can be executed on local hosts, cloud services or whatever other service environment provided by current state of the art technologies.

3.2 Coordination layer:

This layer supports the interoperability among different management and exploitation systems and the underlying hardware and software subsystems. Based on the definition of a water management model, the Coordination layer perform the following functions:



Administration layer: the administration layer enables the configuration of the different entities defined in the Coordination layer. It provides a user interface that can be consumed by platform administrators to perform administration and monitoring functions. Three main interfaces are defined in this high level architecture, the Administration Interface, Common Communication Interface and the Coordination-Subsystems Interface:

Administration Interface: The Administration interface enables the monitoring of the entities defined and stored in the coordination layer. Specifically it monitors entities, procedures, and processes, and how these processes a being executed into subsystems.

Common Communication Interface: This bidirectional interface provides a common solution in order to handle messages from business processes in the management and exploitation layer and process them in the coordination layer by using industry driven standards such as ISA-95/88 and OPC UA.

Coordination-Subsystems Interface: this interface enables the execution of water management processes in the subsystems. The Coordination layer does not know precisely the internal structure of each subsystem (which is implemented by each company), but can delegate processes and monitor their execution and the status of the physical systems requesting relevant information. This information is collected, processed and further translated to the Management and Exploitation layer. These layers and interfaces rely on how water management elements and processes are defined. Data analysis, collection, process distribution and system behavior are defined into a physical model and a process model.

Physical Model: The physical model enables the definition of the equipment integrated in the water management systems in a hierarchical way. This model identifies in an unique way the entities participating in the subsystem, how the are related and grouped. As subsystems can be heterogeneous and dependent from proprietary technologies, it allows SMEs, which do not have the resources to implement a whole reference system on their own, to develop o reuse a single subsystem.

Process Model: based on the physical model and knowing the process each subsystem is able to perform, simple or complex processes are defined and (i) loaded into the system; (ii) validated according to internal information; (iii) distributed to the suitable subsystems; (iv) executed and monitored; and finally (v) stopped and reported.OPC UA is defined for controlling processes assigned to physical entities. Due to the specific nature of water management systems, MEGA identifies the “virtual entities” as a concept that is defined for facilitating the water management over one specific water system. The virtual entities can be defined as “logic devices generated by the logic operation of an hydraulic entity”. The use of virtual entities enables the definition of processes for such elements that do not correspond to real devices, instead they correspond to a functionality that can be either covered by multiple devices or part of a single device. Due to the virtual nature of such entities, their functional behavior and states will be determined in the Coordination Layer, instead of in the Subsystems. Then, control recipes including procedures for such virtual entities are going to be executed by the Control Layer, as such those recipes are not going to be transferred to any subsystem. MEGA provides a reference Architecture for water management process using OPC UA. Figure shows how the MEGA reference architecture fits into the automation pyramid, and uses OPC UA for communication between the Coordination Layer and the Subsystem Layer.

IV. Conclusions and Future Work Water

Management impacts on several key matters of human lives and several scenarios, such as cities, natural areas, agriculture, etc. Some works focus in the lack of ICT services and tools for water management, which would enable information reuse (goal of the PSI Directive [20]), easier fulfilment of policy regulations and resource monitoring. In this paper we presented the MEGA initiative for defining a reference architecture for water management based on integrating IoT capabilities to achieve a scalable and feasible industrial system. We define the management exploitation layer, coordination layer, subsystems layer and administration layer and the interfaces that enable layer interaction. We also consider the physical model, which defines the physical elements executing water management processes in a hierarchical way, and also, the process model, which organizes the execution of particular processes in water management subsystems. Processes are defined based on automation principles and using the widely used standard OPC UA. We illustrate how such architecture can be used for controlling real water management systems, but still we need to clearly define operation procedures for dealing with many real problems such as physical network definition or identifiers mapping. Finally, we describe the deployment scenario we have defined for validation the MEGA model, developed in Aula Dei, an experimental station on Zaragoza, enumerating the list of functions that we are going to test in this station. We can conclude that the adoption of IoT and OPC UA facilitates water management companies the access to a wider global market and incorporates new benefits to decisions support systems, monitoring, water governance and also water-energy nexus. Future work will describe the performed test and will focus on the contribution to solve coordination problems when executing multiple recipes over the same physical resources, considering priority and conditional executions and also process optimization. 20 An IoT based reference architecture Robles, Alcarria, Mart´ın, Navarro, Calero, Iglesias and Lopez ´

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