Autonomous Control of Large-scale Water Treatment Plants based on Self-Organized Wireless BioMEM Sensor and Actuator Networks

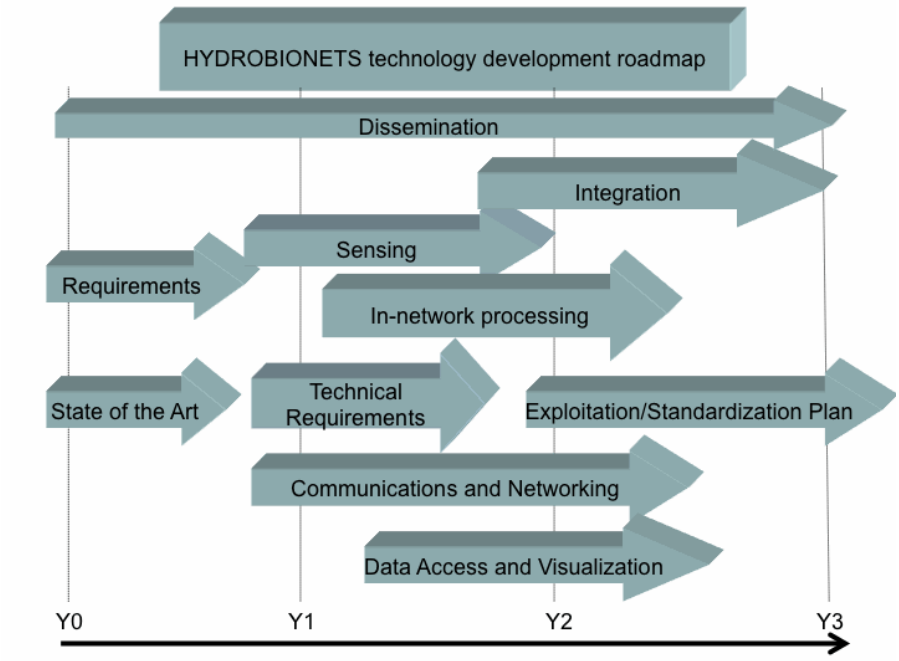
SEVENTH FRAMEWORK PROGRAMME

Hydrobionets

HYDROBIONETS is developing the world's first real-time micro-biological wireless networked control system for water treatment and desalination plants, providing the fundamental design principles, signal processing and communication algorithms, and the implementation of a Wireless BioMEM Network (WBN) with distributed multi-sensing and multi-actuation capabilities, demonstrating the detection and avoidance bacteria biofilm formation in membranes, as well as increasing the productivity and energy efficiency of these industrial plants.

Key Innovation

The HYDROBIONETS project focuses on the research and development of Self-Organized Wireless BioMEM Networks (WBNs) and their integration in a global system to monitor the complete water cycle in large-scale water treatment and desalination plants. The key feature is the integration of BioMEM sensors and actuators in motes and the adaptation of the network function to the specific requirements that this type of application imposes. The WBNs will achieve a distributed monitoring of critical parameters, representing a novel instrument that can be successfully applied in a short term to the great challenge that represents the dense wireless networked control of microbiological parameters of water in the different stages of process in these plants. A world-class interdisciplinary team formed by materials, sensors, microsystems, communications, signal processing, control and networking experts, as well as end-users, has been assembled to investigate, develop and validate the WBNs. This is a novel and ambitious approach in the field of microbiological water monitoring and control where several different disciplines converge.



Measurable Goals

The measurable goals of the project include: (a) prediction and avoidance of membrane biofouling, thanks to a more powerful multi-sensing and multi-actuation over the feed water (not available before in these plants); (b) increased productivity of the plant and reduction in costs due to both an increased lifetime of membranes and savings in power consumed by the high-pressure pumps; (c) improved management of the industrial plant in general; (d) an improved data access and visualization of the various processes in the plant.

At A Glance

Contract number

287613

Project coordinator

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Project website

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EC contribution

2,350,000 Euro

Project start date

1st October 2011

Duration

36 months

Technical Approach

The main technical objectives of HYDROBIONETS are the following:

- Derivation of novel theoretical and algorithmic tools capable of combining different disciplines such as Networking, Communications, Biotechnology, Signal Processing and Control, leading to a fundamental understanding of the capabilities and limitations of WBNs.
- Design of novel distributed microbiological multi-sensing and multi-actuation devices integrating simultaneously continuous data measurement (especially biofilm formation and biocide level control), acquisition, data validation and biosensor self-calibration properties, as well as capability of computation and wireless communication.
- Definition of a network architecture and communication protocol set that can support monitoring and control over the WBN and provides interface or interoperability towards other ICT infrastructures in the controlled environment.
- Design of novel distributed processing algorithms to extract useful information, optimizing the cooperative tasks (signal acquisition, detection, prediction, actuation) under challenging constraints, namely: a) low SNR of BioMEM signals; b) time variation of response between different types of BioMEMs; c) spatio-temporal correlation of the measurement data; d) control algorithms that are distributed and robust to the uncertainties introduced by the coding, processing, and networking protocols, and are able to satisfy the desired control requirements.
- Integration of sensor data with metadata and static information from the plant in order to provide intelligent ways to identify and visualize crucial information either from the raw data or from processed data, with the goal of improving the capability for early warning and early response to certain events in the industrial plants, as well as for modelling the behaviour of the various parameters.
- Demonstration and validation of a real system solution for spatio-temporal dense monitoring/assessment and control in a large-scale water treatment or desalination plant showing the various gains.

Project Partners

Universidad de Valencia (Spain)

CSIC-CNM (Spain)

FORTH-ICS (Greece)

KTH (Sweden)

MFKK (Hungary)

Acciona Agua (Spain)

iXscient (UK)

Demonstration and Use

HYDROBIONETS will perform a practical deployment and demonstration of a WBN demonstrator working under real conditions in water treatment and desalination plants, providing several tangible improvements in the functioning of the plants such as: an increase in reverse osmosis (RO) membrane lifetime due to early detection of bio-fouling; improved optimization of biocide and cleaning agent doses for RO membrane cleaning and recovery; more efficient disinfection stages in the process and an improvement in the assessment of the efficiency of pre-treatment stages before the membranes; better control of aeration process (and reduced energy consumption) for avoiding fouling of the ultrafiltration membranes. This will lead to increased productivity and lower operating costs. In seawater desalination plants, the WBN will monitor the bio-fouling potential of the seawater, as well as at the different pre-treatments steps, and most importantly, before the reverse osmosis membranes. Moreover, the biocides, such as chlorine, used for disinfection, will be also controlled so that it is reduced just before the reverse osmosis membranes because they can be damaged by the oxidants. The developed multi-sensing and control system will be installed in one of Acciona's water plants.

Scientific, Economic and Societal Impact

Knowledge developed during the HYDROBIONETS project will open new horizons. Although we focus on a specific system (WBNs for water quality monitoring in water treatment and desalination plants), the main project results and outcomes are NOT application specific. Rather, they can potentially cover a broad spectrum of societal needs including distributed WBNs for monitoring water supply networks, the environment, etc. The work will lead to the development of future innovations with expected benefits such as improving quality of life, safety and security of water supply. Implementation of HYDROBIONETS technology in other applications such as control of food or air quality, monitoring of human health, or defence mechanisms against bioterrorism will be also of great interest to industry and the general public. HYDROBIONETS is also expected to have an impact on the competitiveness of European water treatment and desalination, since the application of the WBN to reverse osmosis desalination will decrease the costs in use of chemicals, membrane replacements and energy, which contribute approximately 45% of the total cost of desalinated water. In addition, all costs related to other maintenance issues will be also significantly reduced. On the societal side, the improvement of water treatment provided by HYDROBIONETS can better the livelihood of the concerned European populations, by increasing the production of drinking water supplies at a lower financial and energy costs. This project will also identify and analyze possible contributions to standardization in different directions: interaction with national and European water-related standardization organizations, as well as standardization of configuration interfaces and inter-operability between the different types of networks and platforms that are present in industrial water plants.