W I D E

Decentralized and Wireless Control of Large-Scale Systems

Advanced control and real-time optimization of large-scale and spatially distributed processes based on the integrated use of distributed model predictive control and wireless sensor feedback.

KEYWORDS: distributed model-predictive control, wireless sensor networks, networked control

At A Glance: WIDE

Decentralized and Wireless Control of Large-Scale Systems

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Partners:

University of Siena *(Italy)*
Honeywell Prague Laboratory *(Czech Republic)*
Royal Institute of Technology *(Sweden)*
Technical University Eindhoven *(The Netherlands)*
E-Senza Technologies GmbH *(Germany)*
Barcelona Water Distribution Company *(Spain)*
Technical University of Catalonia *(Spain)*

Duration: *36 months*
Start: *Sep 2008*
Total Cost: *2.7 M€*
EC Contribution: *1.8 M€*

Contract Number: *INFSO-ICT-224168*

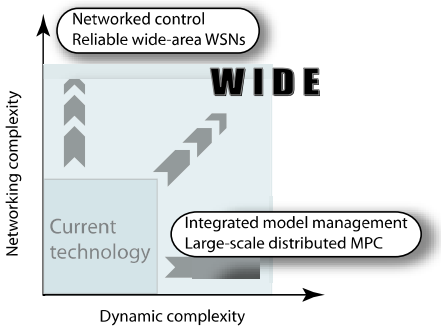
Main Objectives

Increased global competition and an urgent need to address sustainability and resource-efficiency of operations force European industries and large-scale infrastructure operators to look for efficient real-time decision-making systems that allow them to react rapidly, consistently and effectively to a continually changing economical and environmental landscape.

***WIDE** will focus on advanced control of large-scale processes, exploiting feedback from wireless sensor networks and on validating the approach on a real city water distribution system*

Advances in optimization tools and the emergence of new highly pervasive, cheap, and reconfigurable wireless sensing technologies now motivate the research for novel distributed layers of plant management that are highly coordinated through the plant-wide circulation of information. The WIDE project aims at developing a rigorous framework for advanced control and real-time optimization of truly large-scale and spatially distributed processes, based on the integrated use of distributed model predictive control and wireless sensor feedback.

WIDE envisions a generic modelling and control design method for large-scale distributed systems such as manufacturing and process plants and large scale infrastructures, proposes a new engineering approach to the design of scalable distributed model predictive controllers that optimize operational efficiency under resource and safety constraints while ensuring robustness to component and communication failures, and enables the use of wide-area wireless sensor networks (WSN) for closing the control loop.



Technical Approach

WIDE addresses the question of how to operate a wide-area physical system to maximize an overall economical/environmental performance measure under operational constraints, drawing from a broad range of information sources.

There are three clear issues that obstruct this approach in practice: *computational* issues (centralized solutions are not viable because of problem size), *communication* issues (restrictions in communication and sensor technologies prevent that all information is gathered at all times in a central location), and *control* issues (robustness to process uncertainty and instrumentation failures, scalability, re-tuning of control design).

By taking advantage of recent advances in optimization and communication technologies, WIDE proposes to address the computational, communication, and control issues by developing novel *distributed* and cooperative optimization-based *model predictive control* algorithms that exploit information from *WSNs* to enhance their coordination for the best global performance.

Key Issues

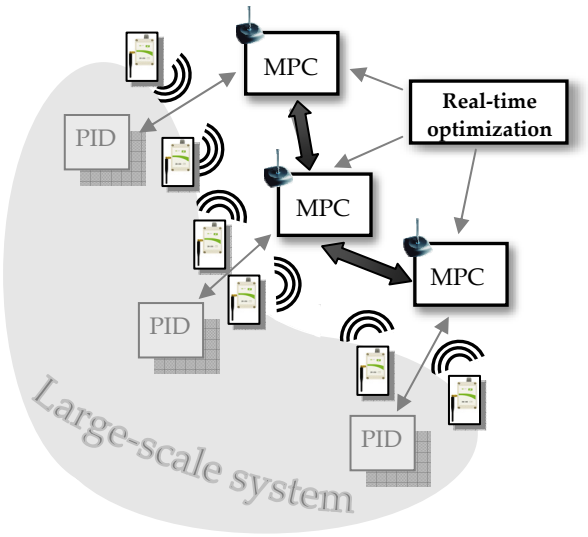
The WIDE project will face the following key issues:

1) Develop a unified, distributed, and multilayer modelling and goals/constraints specification framework that ensures cross-layer and inter-layer compatibility, responsiveness to structural changes in the process, consistency with measured data.

2) Develop new techniques for designing and coordinating a network of MPCs to achieve the best performance of the system and robustness under uncertainty and possible physical and topological constraints.

3) Develop methods of cooperating WSN and advanced process control by developing transmission and networking technologies for reliable wide-area wireless sensor networks, and new methods of MPC design that, aware of communication and power-consumption aspects of the network, ensure an optimized controller/wireless-sensor operation.

4) Demonstrate experimentally the viability and efficiency of the general approach on the water distribution network of the city of Barcelona.



Expected Impact

WIDE will create a unified and scalable theoretical framework and a *Matlab/Simulink toolbox* for advanced control and optimization of large-scale processes and critical infrastructures. The exploitation of WSNs and the inclusion of these networks into the control framework will improve responsiveness, robustness and fault tolerance with clear economical and environmental benefits.

WIDE will enhance flexibility by real-time responsiveness of the plants / infrastructures to changes in the economic environment as well as equipment / network reconfigurations and failures. The scalability and re-configurability of the proposed solution contribute to the overall productivity and reduce installation time and costs.

WSNs provide real-time low-cost in-situ measurements that will be used to improve the overall control and coordination of the system, including resource management. Extensive distributed sensing enables predictive maintenance and lifecycle control, thereby preventing accidents with otherwise disastrous impacts on the environment. As a by-product of the overall distributed control system, data acquired pervasively by inexpensive wireless sensors are useful per-se for wide-area environmental monitoring.

Due to the general applicability of the tools developed by WIDE more benefits in the management of natural resources and of the environment are foreseeable in other domains like gas/oil distribution, lagoon and marine systems, electrical networks, urban and extra-urban traffic flows.