# Intelligent measurement, diagnostic and control systems

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***Inteligentné meracie, diagnostické a riadiace systémy***

*Paper deals with problems of „intelligent", alternatively „smart" measurement, diagnostic and control systems. These one acquire on present time the hard importance as a new group of technical means. The great numbers of world producers vend fairly wide range of products and devices from „smart sensors", over „smart instrumentation", further more „smart controllers", to „smart or intelligent actuators".*

*Term „intelligent systems" is also conform or even misapply (primarily from the marketing reasons point of view) with the program solution of non-traditional or more less standard control functions and with them connected algorithms. On the contribution are summarized the basic views on the „intelligent" devices and connected with them „advanced, or robust control algorithms", which are acceptable for theirs installation at the industrial practice.*

***Key words:*** *smart sensor, intelligent instrumentation, controller, measurement system.*

## Introduction

The digital measurement, diagnostic and control of complex industrial processes are nowadays a standard for achieving high efficiency and reliability of production. The adaptive controllers based on modern control theory are under-exploited. A decade ago ambitious research started blaming the lack of computer-aided-commission support for this state and as an output are new devices - "smart instrumentation" The incorporating of microelectronics and microprocessor technologies into sensors, controllers and actuators has enabled more functionality such as smart or intelligent and digital communication capability to be built into the instrumentation. This enables the transitioning of sensors and other devices into digital instrumentation domain.

Instrumentation manufacturers are seeking ways to build low-cost smart sensors, controllers and actuators systems to meet the continuous demand for more sophisticated applications and ease of uses. The rapid development and emergence of smart sensor and intelligent instrumentation on the field network technologies have made the networking of smart transducers (sensors and actuators) a very economical and attractive solution for a broad range of measurement and control applications. However, it seems that industry is in a crossroad and this predicament has imposed unnecessary economic burden to both instrumentation end users and vendors to support the variety of networks.

On the typical present industrial enterprise we can describe the structure and link up of separated control levels and their adjoined technical devices, included rather kinds and connection of computer networks, by Figure 1.

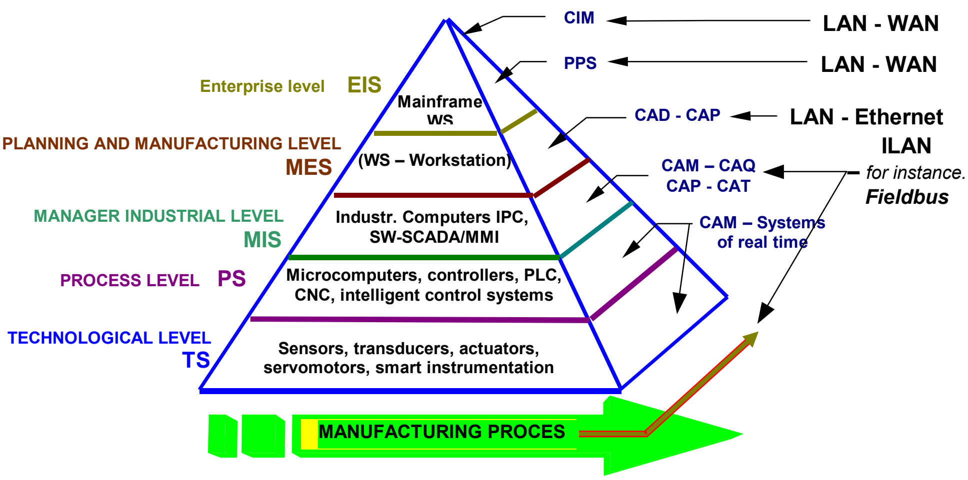


*Fig.1. Hierarchical multilevel structure of industrial enterprise.*

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(Recenzovaná a revidovaná verzia dodaná 19.11.2003)

## Adaptive control systems and intelligent controllers

Over the last several decades, computer control of manufacturing systems has been the focus of extensive research. Advances in microprocessor, computing, networking and interfacing technologies have improved capabilities of industrial automation and control systems substantially over this period. However, these control systems are proprietary and still have problems in areas such as interoperability, scalability, and lack of standard user interfaces. The development of open architecture control systems addresses some of these problems, in varying degrees. Open architecture control systems shift the focus of automation from being hardware centric to software centric, providing further flexibility. The focus is now shifting to the distributed hierarchical control systems (Smutný, 2002).

Intelligent control systems have concentrated on low-level mechanisms or limited subsystems and we need to understand how to assemble the components in architecture for a complete control system. A mind is a self-modifying control system, with a hierarchy of levels of control, and a different hierarchy of levels of implementation. Intelligent instrumentation needs to explore alternative control architectures and their implications for management minds. Architecture provides a framework for systematically generating concepts of possible states and processes (Lin and Su, 2000).

Traditional data-acquisition systems require reams and bundles of cabling to interconnect variable sensor types or smart instruments to multiple signal-conditioning circuits. This is both an expensive and time-consuming method, plus it isn't flexible when more instrumentation and controllers must be added to an industrial or wireless network. This not only limits instrumentation portability, but also requires the storage of calibration data and engineering units with no standardized output format possible (Smutný, 2002). On the Fig. 2 we can see block schema of adaptive selftunning controller and on Fig. 3 is example of this new type on intelligent instrumentation (sensor, controller, valve together).

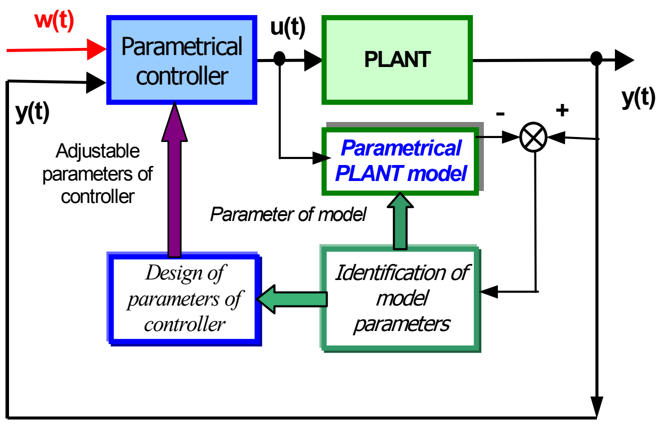


*Fig.2. Block schema of adaptive selftunning controller.*


*Fig.3. Example of intelligent control system Valtek StarPac®.*

The Valtek StarPac® intelligent system includes a microprocessor-based controller and process sensors mounted on a control valve. The system provides single-loop measurement and control of flow, pressure, or temperature, and allows data acquisition necessary for valve or process diagnostics. Intelligent systems can improve plant operation at a lower installed cost than conventional control systems. Installation of a total control loop is simplified by mounting the microprocessor directly on the valve with the pressure, temperature and flow sensors, eliminating separate line taps. The overall complexity and potential for leaks in a process system are reduced with fewer penetrations in the flow stream.

The StarPac unit can be programmed to operate as a traditional control valve (responding to a 4-20 mA controller) or as a stand-alone controller or transmitter requiring only a 24 VDC power source and air supply. In the stand-alone (controller) configuration, StarPac responds with PID action to: a 4-20 mA analog control signal, a digital signal through the serial data port, or a preprogrammed set point that is held with no external communication. A personal computer can be used to set operating and tuning parameters or reading diagnostics, but it is not needed for ongoing StarPac operation. DCSs can be linked to the StarPac unit if they support Modbus (WWW-1).

**Priority of Intelligent Manufacturing Systems (IMS) with smart instrumentation:**

- **Better Process Operation:** Mounting the process sensors close to the final control element reduces lag and dead time, enabling much faster response. The high turndown results in better process control over the operating range.

- **Real-time System Analysis:** SCADA/MMI program supports an ability to gather and send process data allows up-to-the-minute engineering analysis, aiding in reducing production costs and enhancing the process.
- **Wide Versatility:** Multiple control modes - including for instance fluid flow, upstream pressure, down-stream pressure, differential pressure and temperature- permit intelligent systems to be used in a wide variety of process applications. Remote sensors can be tied into the smart unit for control of other process parameters. Cascade action is also supported.
- **Simple System Configuration:** Smart software is easy to use, allowing the system to be set up or reconfigured quickly as needed by the user to optimize the process system.
- **True Distributed Process Control:** The intelligent unit can take load off a DCS by distributing measurement and control to the field. This allows the DCS to function as a process supervisor, acting on information from the whole system.

## Conclusions

The era of present day manufacturing systems with its hard-wired interconnection of manufacturing cells is passing. Future manufacturing systems will be required to be agile, flexible and fault-tolerant. The next-generation intelligent manufacturing systems (IMS) will be multi-agent systems containing distributed control and application entities that dynamically collaborate to satisfy both local and global objectives. They will be implemented within dynamically re-configurable factories having decentralized and virtual organization structure. In such a real-time distributed manufacturing environment, the control relationships among resources will be ever changing and the control algorithms will need to be updated in real-time due to the changes of control relationship.

Using smart instrument network systems can eliminate the difficulties associated with traditional measurement, diagnostic and control systems. Benefits of utilizing a smart instrumentation include a reduction in interconnecting cables, salvaging of existing analog type transducers and controllers, and the ease of use and maintenance. Reliability of the measurement and control system can be improved because of the smart instrumentation self-test capability and the reduced susceptibility to noise of digital signals (EMI, cross-talk, ground loops, etc.).

*Presented results have been supported and achieved during developing the research project MSM 272300012 and GACR 102/03/0625.*

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