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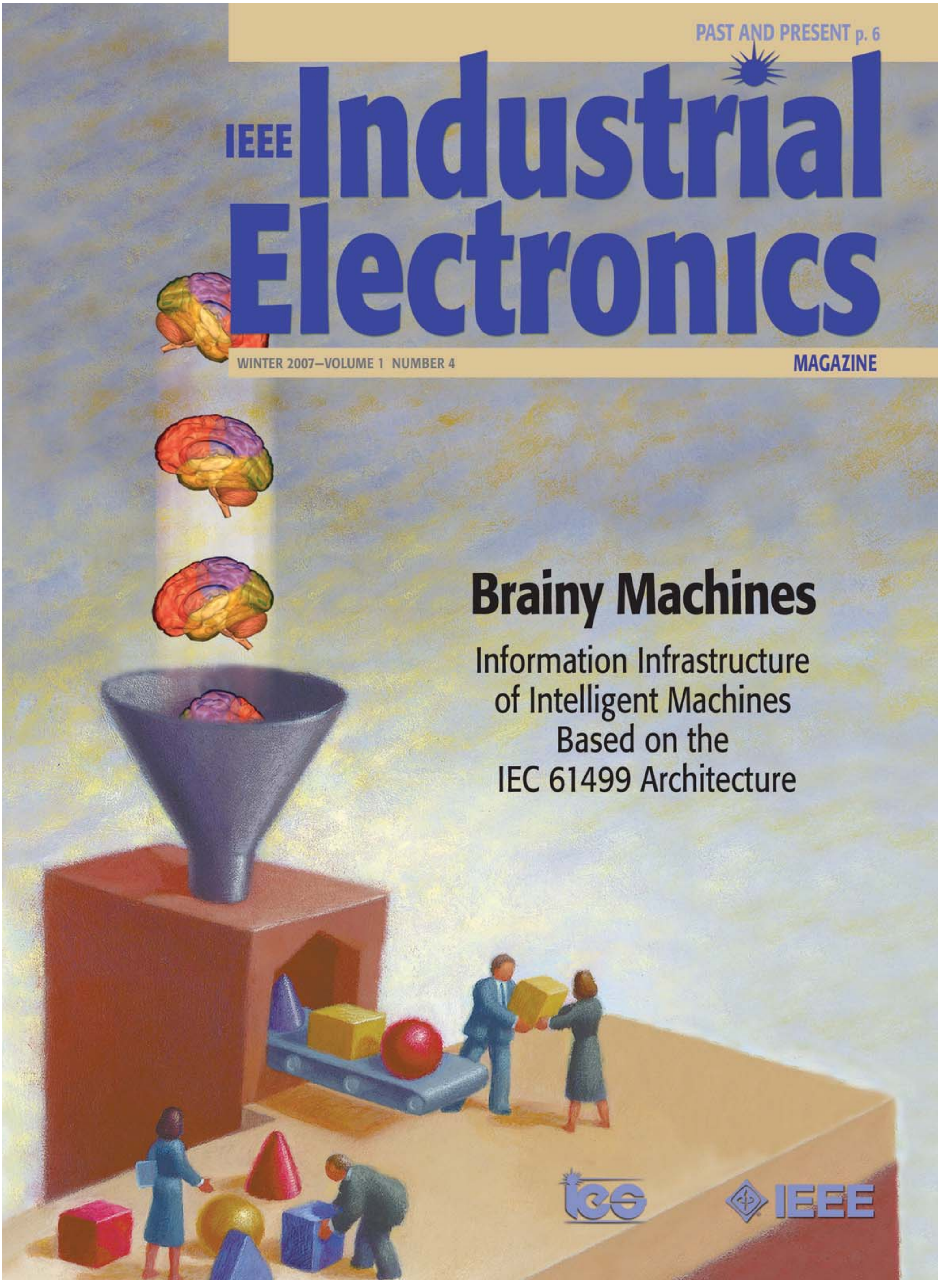

Brainy Machines

Information Infrastructure of Intelligent Machines Based on the IEC 61499 Architecture

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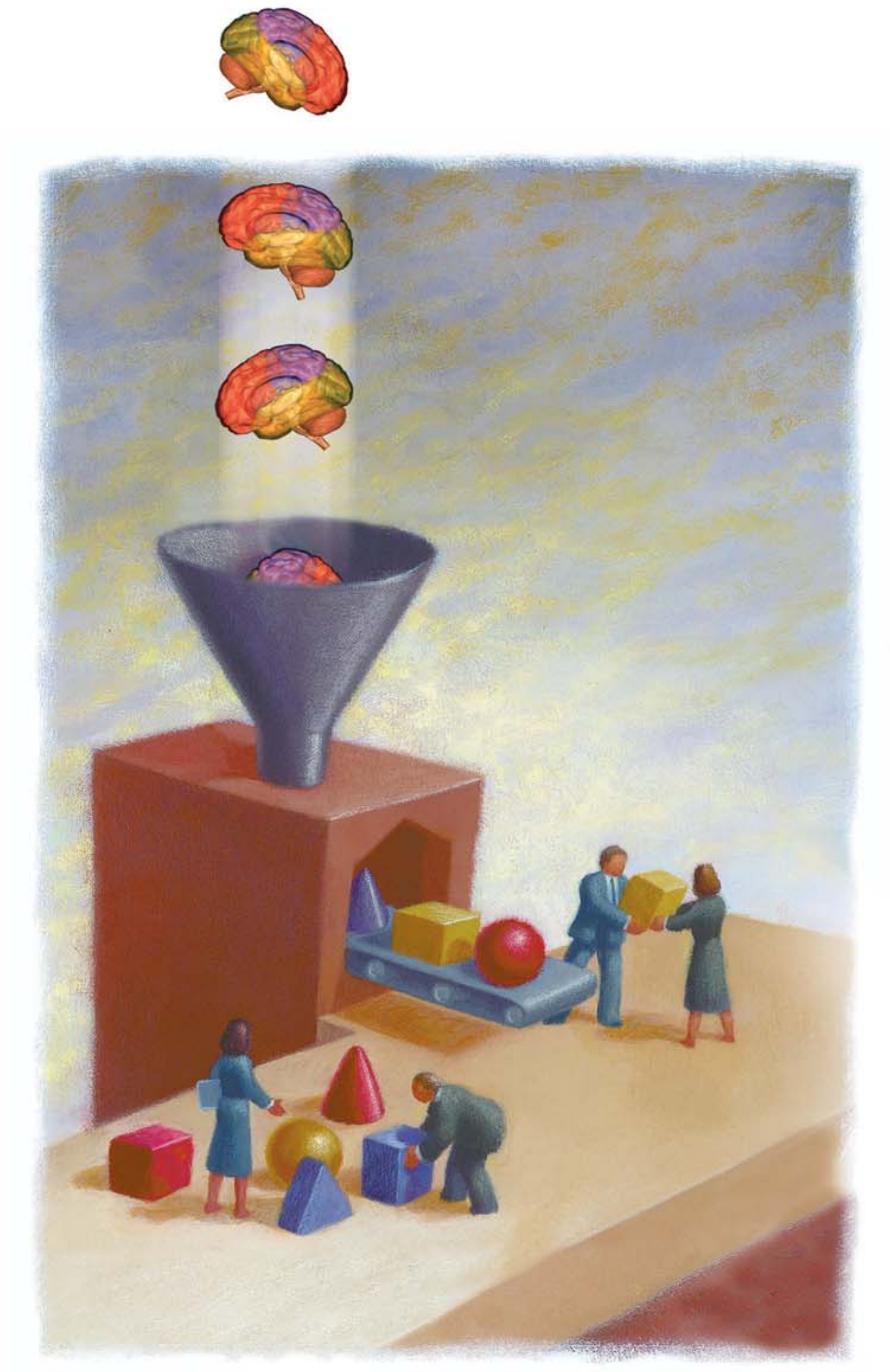
Now That's Smart!

Information Infrastructure of Intelligent Machines Based on the IEC 61499 Architecture



The requirements of flexible manufacturing and material handling systems, such as rapid integration and reconfiguration, as well as the growing information intensity of the production environments imply that manufacturing equipment is becoming more autonomous and intelligent.

A large number of intelligent machine concepts have been proposed in the last decade (see overview in [10]). Their systematic discussion and evaluation is beyond the goals of this article. A few characteristic concepts, however, need to be mentioned. The holonic manufacturing systems (HMSs) [3] emphasize the idea of self-configurability, envisioning that holonic machines will form new production configurations "on the fly," reacting to the external and internal changes. For example, an external change could be a change in the product specification. An internal change can be a break-down of a certain machine in the production system. The reconfigurable manufacturing systems (RMSs) [2] and the intelligent mechatronic actors introduced by Lastra in [10] rely on the "offline" (in advance) customization of the machinery driven by the changing production

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orders and specifications. All these concepts imply the use of a powerful computer "brain" driven by sophisticated software. Several computing architectures for enabling this have been developed, for example Product-Resource-Order-Staff Architecture (PROSA) [4], Plant Automation Based on Distributed Systems (PABADIS) [4], and Malfunctioning Agent Simulation Tool (MAST) [5]. All these require much higher intelligence and flexibility of the low-level control layer than can be provided by programmable logic controllers (PLCs)—current devices that drive automated machines. The programming paradigm of PLCs imposes serious limitations both for efficient project engineering and the implementation of intelligent automation systems.

The latest development on this front is the function block architecture of IEC 61499 [1], which provides a new degree of flexibility in managing embedded control and information processing systems through the lifetime of industrial automation products. The key enablers of the flexibility in this new standard are:

- the encapsulation of knowledge into function blocks,
- the application model as a network of function blocks,
- the device model providing the dynamic configurability features, and
- the coherent model of the distributed system as a collection of devices populated by applications.

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While the research and development on the IEC 61499 implementation and application is gaining momentum worldwide, especially in the last three years (see survey of the relevant research works in [6], [15], and [18]), there is a lack of case studies answering the following questions:

- What differentiates the function-block-based design from the design following the usual PLC paradigm or approaches used in the wider embedded systems?
- Do function blocks really address development of truly intelligent solutions such as plug-and-play (PnP), service-oriented architecture (SOA), and agent-based systems?
- How do the existing computing platforms satisfy the requirements of function block architecture?

This article is an attempt to address these questions and provide some answers. We analyze the potential of the function block architecture on an example of the machinery used in material handling systems, in particular in airport baggage handling systems (BHSs).

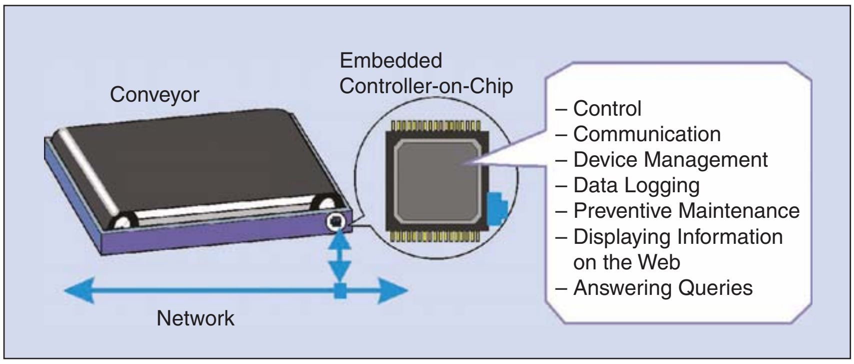

FIGURE 1 – Functions of intelligent conveyor.

The functional requirements of an intelligent machine are discussed. It is illustrated that the existing control architecture, based on the use of PLCs, falls short in fulfilling these requirements. The function block model of IEC 61499 is discussed in more detail and the function block model is used to illustrate the features of intelligent machines and manufacturing systems. We describe an experiment conducted on a laboratory model of an intelligent manufacturing system with the goal of achieving the PnP configurability and reconfiguration by employing IEC 61499 control.

Intelligent Machine Information Processing Infrastructure

Even a relatively simple machine, like the conveyor belt unit shown in Figure 1, can increase its value significantly if equipped with a proper embedded control and information processing device. The embedded device can simultaneously host and implement a number of functions, as shown in Figure 1. The intelligence on the device level extends its functionality, increasing its performance, reliability, and ability to integrate into more complex production systems.

For example, connectivity function (the ability to communicate via networks is a very basic function of an intelligent machine) enables such a machine to communicate with other intelligent machines within a manufacturing cell, as well as with enterprise information systems and human operators.

A natural extension of general connectivity is the feature of "remote control" provided by the device to authorized clients. This function, along with status rendering, can be implemented by an embedded Web server as illustrated in Figure 2.

To provide for connectivity, the embedded controller must implement certain communication protocols. This can be the usual Internet protocol suite; this, however, has some inherited problems not allowing for reliable communication with guarantees of real-time delivery. As a remedy, more robust field area networks can be used (field buses, see [8] for