Collaborative Process Automation Systems

Martin Hollender
CHAPTER 1
1.1 Introduction

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The idea for this book came into being during a discussion with Martin Naedele, because we both believed there is a need for a book that makes the CPAS concepts concrete using an existing system and its features. The knowledge necessary to automate a modern industrial plant is so broad that no single engineer can have it all. Such automation projects are usually done by a team of highly specialized engineers. Similarly, a book on CPAS can not be written by a single author. Many existing books on process automation are thick and heavy; for example, the “Handbuch für Prozessautomation” (Früh et al., 2008) includes more than eight hundred pages, and the “Instrument Engineers’ Handbook” (Lipták, Ed., 1995) comes in three volumes totaling several thousand pages. Many existing books focus on control theory. Other books focus on hardware, sensors, and actuators. Very few books, however, span all the important parts of process automation necessary to reach world-class automation. Areas already covered in many other books, such as digital fieldbuses, control theory, or IEC 61131 programming, are covered in less depth in this book and pointers are given to the relevant literature.

The concept for this book is to put modern and important topics, which are often difficult to find in other literature, into a single handy book. Topics cover a well-established state of the art in industrial plants. There is one exception: The current state of the art for OPC are the “classic” standards DA, AE, and HDA. For the brand-new OPC UA standard only a few first products exist. But as I’m deeply convinced that OPC UA will play a central role in future CPAS systems, an extra chapter was added on OPC UA.

This book aims to be abstract, general, and relatively vendor neutral, but many of the examples are explained using ABB’s System 800xA. As Dave Woll writes in his chapter, the term CPAS (Collaborative Process Automation Systems) as defined by ARC (Automation Research Corporation) does not describe a particular commercially available system. ARC’s CPAS definition is an excellent guiding framework covering the essential aspects of modern process automation.
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Overview

The automation of industrial processes supports the storage, transportation, and transformation of raw materials into useful products (see Figure 1–1). Processes can be classified into batch and continuous processes. Batch processes are characterized by the production of a given amount of product in batches (e.g., pills, cakes, or beer). Continuous processes transform raw materials into finished or semi-finished products, usually in a steady-state process. A typical example is refining, where crude oil is refined into gasoline in a continuous process that often runs for years without any interruption. Examples of the process industries include food and beverages, chemicals, pharmaceuticals, petroleum, metals, pulp and paper, cement, and (although the “product” is not physical), power generation. Sensors (e.g., flowmeters or thermometers) are used to get information about the process, and actuators (e.g., valves, pumps, or heat exchangers) can be used to influence the process.

Related subject areas like the automation of discrete (piece) manufacturing, buildings, airplanes, and trains have much in common with process automation but are outside the scope of this book.

Process automation is often drawn in automation pyramids with several automation layers (see Figure 1–2). Such pyramids correlate with the management hierarchy of a company and show how information is more and
more condensed. On the lowest level the system deals with physical values like pressure, flow and temperature whereas higher levels deal with concepts like product quality, production schedule, and profitability. An example are thousands of measurements along a paper reel condensed into a single quality parameter determining the price of the paper reel. The real-time requirements are strictest on the lowest level, where the automation system needs to guarantee response times in the range of seconds and sometimes milliseconds, and relax toward the higher levels, where the time horizon may extend to weeks. The crucial fact is that several different layers with different requirements exist and need to interact with each other.

The ISA-95 series of standards (ISA, 2007) contain the most recognized definition of the different automation layers (Figure 1–3) and are discussed in detail in Section 5.6. In many application areas the control algorithms are mature, and relatively simple PID (proportional-integral-derivative) controllers are sufficient for most of the tasks. While control at the levels 2,1,0 is quite well mastered, the integration of the higher levels now plays a more and more important role in the optimization of production.

The biggest change in future plant performance improvement will come from the empowerment of the operator (Woll et al., 2002). Production will undergo fundamental organizational changes because operators are becoming knowledge workers empowered with information. This proliferation of information is allowing organizational structures to flatten, shifting the authority and responsibility associated with the distribution of information down to lower levels. A higher degree of coordination at lower levels is therefore required.

Another important factor in plant performance improvement is providing a unified platform for plant and maintenance management that also automates the transactions between the automation system and computerized maintenance management systems (CMMS).

As the capabilities of traditional distributed control systems (DCSs) are no longer sufficient to cover all relevant areas of process automation, a new generation of systems was created. The concept of Collaborative Process Automation Systems (CPAS) was developed by Automation Research Corporation (ARC) (www.arcweb.com), a consulting company based in Boston, Massachusetts. A key aspect of a CPAS is the ability to present information in context to the right people at the right time from any point within the system, to include a single, unified environment for the presentation of information to the operator. In addition, a key strength of a CPAS is the ability to extend its reach beyond
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![Automation Pyramid](image)

**Figure 1–2** Automation Pyramid

![Levels of an ISA-95 Functional Hierarchy Model](image)

**Figure 1–3** Levels of an ISA-95 Functional Hierarchy Model
the traditional capabilities of the DCS to include functions such as production management, safety and production-critical control, advanced control, information management, smart instrumentation, smart drives and motor control centers, asset management, and documentation management capabilities.\(^1\)

Safety and control are linked and embedded within the same architecture, providing a common high integrity system environment for production control, safety supervision, and production monitoring. This architecture provides the option of combining control and safety functions within the same controller or keeping control and safety functions separate within the same system. With safety and process applications executing within the same system environment, and even within the same controller, a CPAS can offer safe, instant interaction between applications. Key features of a CPAS include:

- Extensible
- Common Data Model
- Adaptable through Configuration
- Single Version of the Truth
- Interoperable
- Standards Adoption
- Multi-supplier Support
- Security and Reliability
- Actionable Context Support
- Knowledge Workplace Support

Multiple software providers can manage parts of the system’s functionality, but no single software vendor is capable of managing the entire scope of a CPAS. Therefore, application architecture design is crucial for successful projects.

The most important trends that promote change in automation development (Jämsä-Jounela, 2007) include globalization, networked economy, and sustainable development.

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1. Smart instruments include a microprocessor and have much more functionality than just measuring a value. They can include functionality for device management, calibration and diagnosis.
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Structure of the Book

Chapter 1 starts with a general introduction to process automation, represented industries, and historical developments, allowing readers new to the field to build up some context. Next the CPAS concept is defined and explained in detail.

Chapter 2 describes the infrastructure required to build up a CPAS. The chapter discusses the specific requirements that drive the architecture of a CPAS. For example, IT (Information Technology) security was hardly an issue 20 years ago, but in today’s networked economy with its high danger of cyber-terrorism, IT security has become a top priority that needs to be built into a CPAS from the ground up. It also explains why standards are essential for CPAS and introduces the most important standards. It is surprising that many engineers have never heard about important base standards such as XML or OPC. The quality of many automation solutions depends on a thorough understanding of these base standards and the standards that build on them. This book cannot cover each standard in depth, but it tries to help the reader understand their importance and to stimulate further reading.

Chapter 3 explains the engineering of a CPAS. As the cost for hardware has decreased and system complexity has increased, the total cost of a solution is now largely determined by software engineering efficiency. The reuse of best practice solutions in libraries plays a key role.

Chapter 4 covers topics on the lower levels of the automation pyramid. It starts with the description of an Alarms & Events subsystem. In the chapter on the Common Process Control Application Structure, Dave Huffman explains why many principles developed to control batch processes also have benefits for other processes. The chapter concludes with a discussion of control system remote operation and service.

Chapter 5 covers higher level topics (from an automation pyramid point of view) such as information management, enterprise connectivity, and advanced process control.

Chapter 6 discusses operator effectiveness and the role of human operators in highly automated systems. Knowledge about human-machine systems helps engineers to design better human system interfaces (HSI), which results in better overall system performance. The book concludes with a chapter on alarm management.
References


