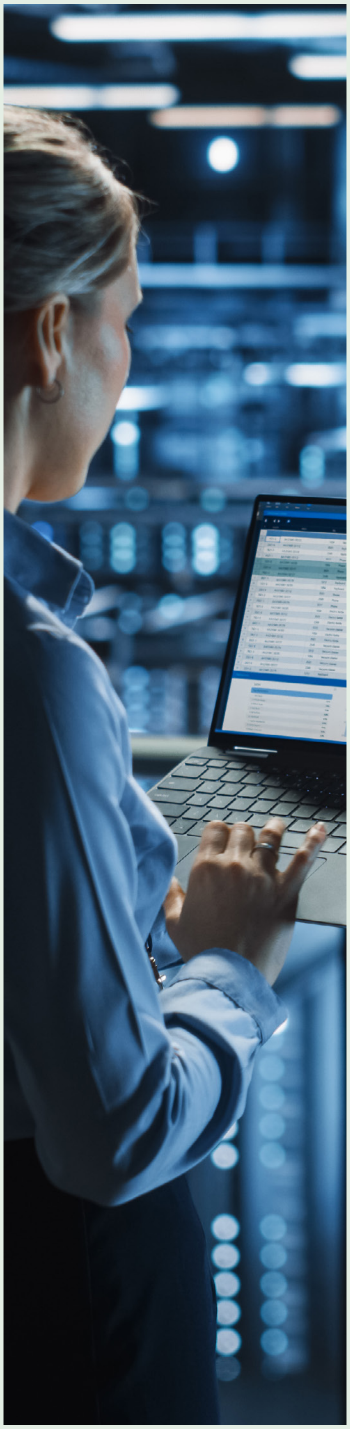
WHITE PAPER



# ROLE OF ADVANCED PROCESS CONTROL IN ADVANCING INDUSTRY 4.0

## Focus on Process Industries

Industry 4.0 brings in the age of cyber-physical systems with advanced digital intelligence. Process industries are no exception with multiple time-consuming processes generating large amounts of data from the various layers of instrumentation and control systems. This necessitates advanced measures for controlling complex processes to unlock the full value of automation by reducing variability, improving throughput, and influencing sustainability goals. While these controls are increasingly important in process manufacturing environment, traditional implementations focused on feedback and feedforward based regulatory controls. This introduces Advanced process control (APCs) that utilize several techniques, statistical models, and mathematical methodologies to optimize process control by controlling several variables. However, implementation of APCs has been segregated and monolithic. This means that they only aim to achieve optimal control at a localized stage of the process and limits the ability to achieve overall optimal plant performance. Therefore, to achieve a holistic control aiming at plant wide optimization, a platform-based implementation approach is crucial, that allows multiple variables to be processed and analyzed simultaneously. This paper, therefore, aims to address how a refresh of APC strategy (APC 4.0) is required to achieve new levels of benefits previously unobtainable.

Infosys®
Navigate your next

## Table of Contents

## 1. INDUSTRY 4.0 FOR THE PROCESS INDUSTRIES

While discrete manufacturing industries have immensely benefited from Industry 4.0 applying data-driven decision-making across operations revert to maintenance, there is a huge opportunity for the process industries in terms of how they implement new process innovations and identify improvement opportunities through the better adoption digital capabilities. This means a much better and effective control of a sequence of complicated processes that include managing raw materials, machinery, and labor, to optimally produce a finished product. This is arguably the most important factor in achieving business outcomes for process industries. Traditionally, the industry has heavily relied on logic-based controllers like PLCs, PIDs, and DCS to have a near real-time level of control (Basic Process Control) placed closest to the process.

However, Industry 4.0 approaches help shift the overall control from a "local" process control to "process-wide" management, that can elevate on to the next stage in the by optimizing the control performance and overall productivity further. This opens a wide range of business benefits by fostering integration of control, automation, operations, maintenance and intelligent decision making, as explained below.

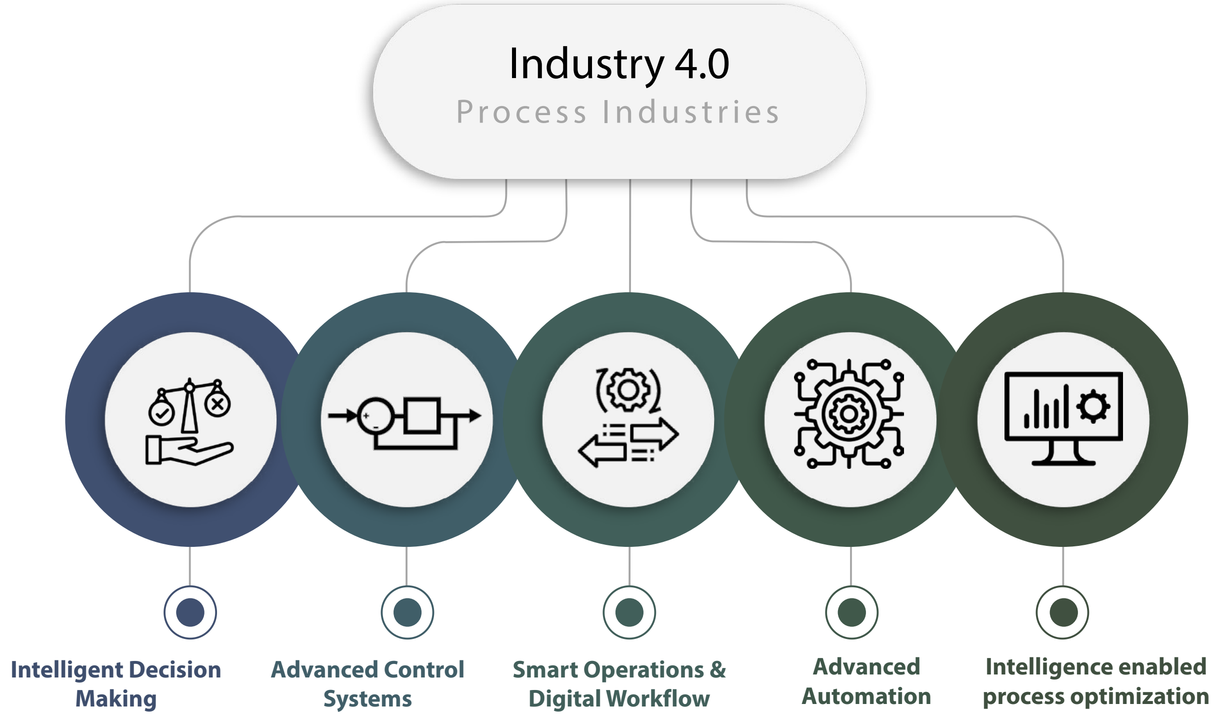



*Figure 1: Key enablers for a useful I4.0 implementation*

**Intelligent Decision-making**
is an outcome of the implementation and effective utilization of decision support systems built through the analysis of useful and contextualized data

**Advanced Control Systems**
typically exist in process industries as APC. The goal is to, however, evolve beyond the traditional implementation towards an integrated, platform-based approach

**Smart Operations & Digital Workflow**
as a result of having seamless integration both horizontally and vertically thus allowing people, processes and equipment to perform effectively

**Advanced Automation**
enabling reducing human intervention and non-value adding activities through technology enabled automation of processes, data collection and decision making

**Process Optimization**
beyond existing reach is achieved through data analytics, recommendation systems, artificial intelligence, and machine learning based insights.

## 2 ENVISIONING APC 4.0

The ISA-95 standard defines the enterprise control system architecture that explicates the interface between various technology layers of the plant; from process-level devices all the way to business systems organized in an inter-dependent hierarchy. The performance of control of any individual layer therefore has a direct impact on the entire process stability, product quality and manufacturing costs. Here, advanced control strategies for dynamic processes are implemented, including model-based controls that can efficiently manipulate key process variables and simultaneously achieve one or many objectives. Therefore, model-based advanced process control strategies are commonly implemented in the process industry.

### 2.1 APCs OF TODAY

The industry has spent significant effort on APC implementations for many years, with the objective of achieving process and economic benefits. However, APC implementation and optimization practices have been disconnected with multi-vendor products and systems, where each manages the individual units of APCs instead of integrating them to manage the entire process unit's performance efficiently. This means that they only achieve optimal control at a localized level (local maxima) of the process. A closer look at current APC implementations reveals that the performance of the overwhelming majority is limited because of the following reasons -

- APCs of today are monolithic, as they have been primarily limited to Model Predictive Controls only.
- They are implemented in individual and separate modes of APCs for a particular stage, each with its own structure and parameters.
- Dominant focus on modeling and optimization isolated to a specific process stage, even though controlling a single variable could affect multiple other variables.
- They are not implemented on a platform approach, thus lacking interoperability with other systems like ERP, MES and PIMS.
- The majority of the implementation is through commercial, off-the-shelf products, built and maintained by third-party vendors. The software needs to be purchased and separate license agreements made with defined pre-conditions.
- Lack of key competencies within the organization, resulting in heavy dependence on external parties, and hence lack of in-house capabilities and high cost and maintenance.

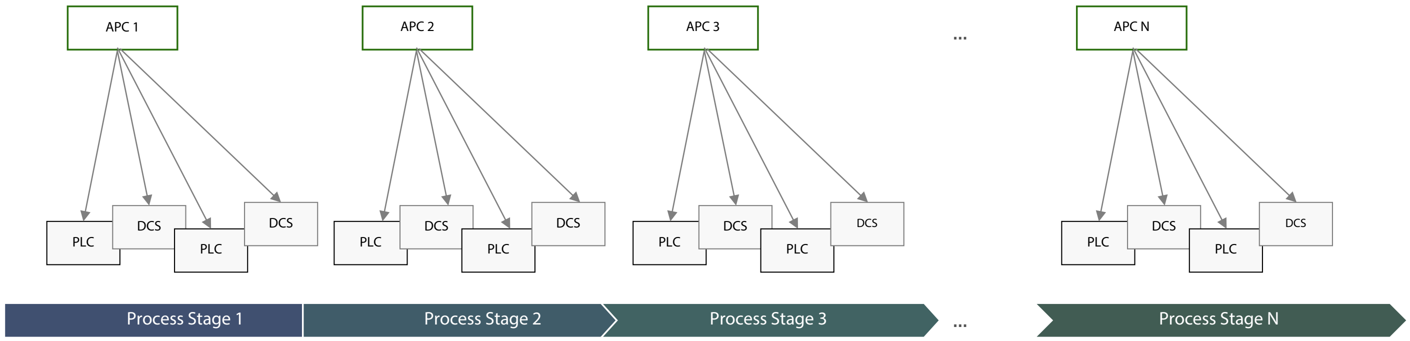



*Figure 2: Classical Implementation of APCs*

Therefore, there is a need to revisit industrial APC strategies to realize the real benefits of APCs to thrive in a digital future. Apart from just the control method, there are many other aspects of APC implementation that need to be developed/revamped to allow for benefits to be harvested at the enterprise level.

## 2.2 APCS FOR THE FUTURE

APCs can be only good at the objective they are meant to fulfill as long as the right constraints and setpoints defined.

Building a manufacturing process model based on mathematical logics to identify and understand the multiple critical variables affecting the desired result is vital to developing an APC strategy. Advanced control strategies, which often include Model Predictive Control (MPC),
are then instituted to manipulate multiple inputs and outputs process variables in parallel and simultaneously achieve one or many objectives. Therefore, APCs have good model accuracy using all available knowledge of the process, including human operators. This model and the setpoints should be regularly adjusted (optimized) for desired target values (known as "set points") in response to changing conditions, such as temperature, pressure or incoming feedback. Many companies, however, do not revisit their setpoints, or even if they do, it is still static. Many factors contribute to what a particular setpoint should be. This includes everything from the micro level of process variability to the macro level of business goals. The ability to intake data from all levels of an organization and therefore have better setpoints and realistic targets would mean that APCs must be integrated horizontally, across all process stages and vertically through all levels of the business and their respective technology systems.

### 2.2.1 APCs on a Platform

Interlinking APCs and all the key process variables throughout the process allows for a complete plant-level process control model, wherein each APC's set points and control method would be based on upstream parameters and downstream inputs, in an integrated fashion rather than linearly. This allows for greater accuracy and effective plant-level control over the entire process.

At the same time, vertical integration with enterprise systems allows APCs to have more to have more "Objective" control rather than "accurate", aligning with key business objectives. A key aspect of this is the ability to leverage digital intelligence from historical and real-time data analysis, and the understanding of the overall process, using a big data (or similar) platforms. Recommendation systems, predictive algorithms and relational analysis are a few of the many intelligences which can be used to improve the set point of APCs.

All this is highly possible in the age of Industry 4.0, where the objective is interoperability between technology and systems. This sets up a centralized platform on which APCs are implemented, thus allowing free-flow communication between APCs. This platform approach to APCs also will enable them to act as "Applications," which means they can be updated, added, deleted, and modified through the platform, thus enabling rapid growth and adaptability. Architecturally, an Industrial Edge could serve as an APC hosting platform. Edge computing offers proximity to the process, allowing for fast-paced control of the process layer through the APCs. At the same time, integration with other systems, either locally or in the cloud, introduces intelligence and achieves business-level objectives through efficient process control.

Maturation in digital and more specifically, Industrial Internet of Things (IIoT) technologies along with advancement in unified and open architectures (e.g., OPC UA), holistically bring together discrepant products and systems, setting up a secure and reliable interoperable architecture. Such an approach enables seamless interaction between multi-vendor APC vendors leveraging platform independent service-oriented architecture based on standard data exchange principles on a single extensible framework. Such an approach with an inclusive goal will bring together multiple aspects, such as multi-variable control, integrated UI definitions, quality and detailed calculations into a single platform thereby minimizing time to deploy and reducing complexity of maintenance to achieve a reliable performance.

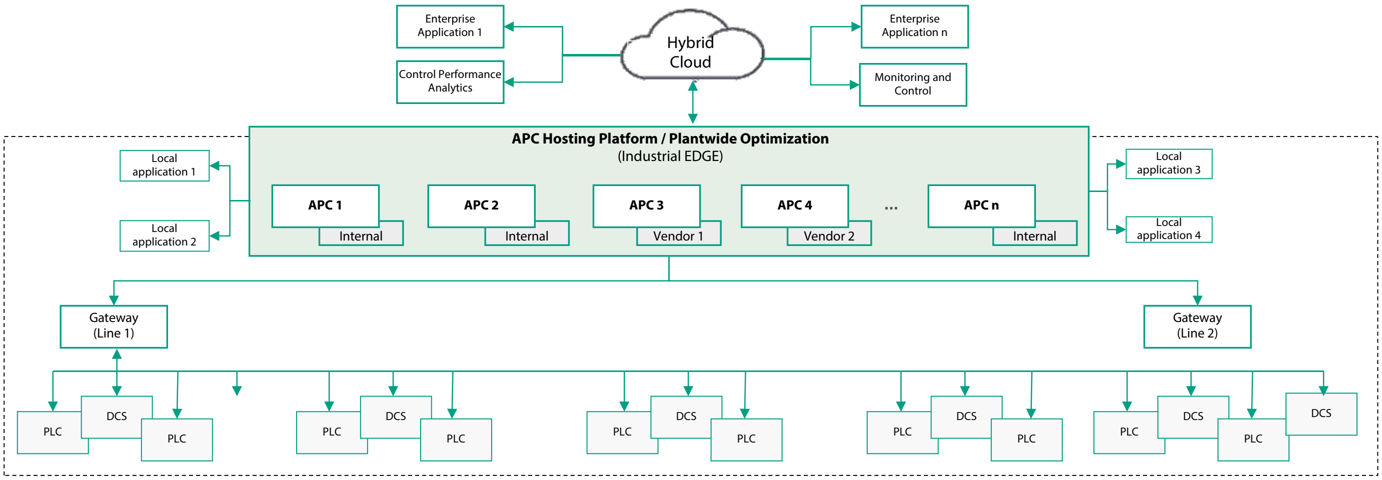



*Figure 3: Industrial Edge as the APC platform*

## 2.3 ONE 'PLANT CONTROL MODEL' WITH CENTRALIZED INTELLIGENCE

This is where 'One Plant Control' helps through multivariate control by efficiently managing relationships between manipulated and control variables. It helps unlock the total value of automation, thus pushing the outcomes beyond the set limits of the process. By integrating digital intelligence using data-driven algorithms and automation to improve process stability, quality, and profitability. This will redefine the setpoint by involving cross-process dynamics and varying business objectives. The process constraint limit itself can be pushed and redefined. The result is a dynamic setpoint based on a dynamic process constraint, through which the process is perfectly controlled to provide the highest productivity within the safety limits and at the most optimized costs.

This platform based approach in this paper therefore aims towards a single,, intelligent "Plant Control Model." This means that the entire plant is modeled as a single closed system, with the various process stages and their constraints in a closed loop system.

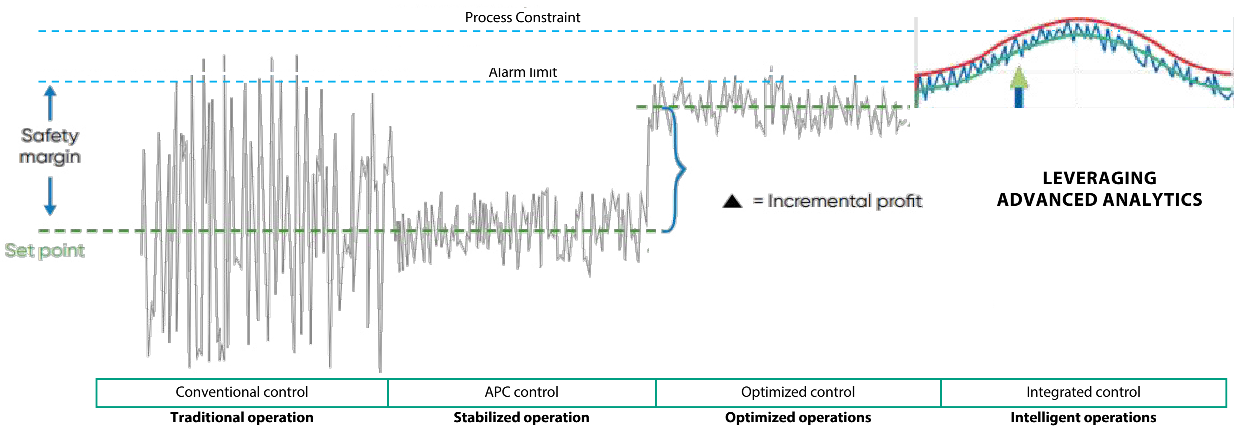



*Figure 4: Pushing limits, with a centralized control model*

## 2.2.2 Summary of benefits

- A platform-based approach that promotes interoperability between production processes and business systems to bring substantial energy savings, increase ore recovery and optimize product mix based on real-time data on pricing and ore feed properties.
- Platform approach for handling industrial processes with multivariable processes instituting the ability to provide control solutions using numerous variables, constraints, feed-forward, and feedback with delays and processes with strong interactive loops.
- A platform facilitates the interaction between APC vendors and the process.
- A platform environment which is holistic in nature will minimize the time needed to develop APC apps.
- Ability to leverage cloud for advanced analytics.
- Moving beyond local optimum to identify the plantwide optimal operating points and coordinate between multiple variables to set up a plantwide and holistic control strategy for optimization.
- Optimize overall manufacturing operations and improve performance to improve the bottom line.
- Greater control, better adaptability and minimal disruptive implementation procedure which serves to better manage individual APCs
- Predict the future trajectories of the plant outputs for a given sequence/circuit of future control signals.

There are certain key prerequisites that need to be considered while setting up such a platform based approach. These are primarily:

## Being independent of vendor-lock in

- Avoid extensive dependence on vendor specific solutions, leading to lock-in
- A platform approach that allows solutions from in-house and vendors solutions to co-exist as necessary
- Ownership over the platform (regardless of whether it was developed fully internally or co-developed with vendors)

## Being flexible and scalable

- Solutions need to be adaptive to allow highly scalable implementations
- Seamless integration and interoperability between various layers of the hierarchy
- Flexible engagement models with partners, start-ups, external experts and third-party vendors

## Achieving a modular approach to APC implementation

- A modular implementation requires a platform to be established as the base
- APC solutions act as modular applications which are implemented on top of this base platform

## Enable agile in-house development

- Agile, rapid application development
- Low-code approach to develop APC solutions
- Development without the necessity of coding knowledge
- Strong external engagement with industry experts

## About the Author


### Ashesh Vignesh,

**CONSULTANT, INFOSYS**


He is a digital solutions consultant. From a humble start as a hands-on, instrumentation and control engineer working on the shopfloor and now with a masters in data science from Deakin University, he has great experience in helping companies from various manufacturing industries to assess, analyze and deliver strategic roadmaps and successful implementations.


### Nampuraja Enose,

**PRINCIPAL - ADVANCED ENGINEERING, INFOSYS**


He heads the 'Industry 4.0 Centre of Excellence' and led the development of 'Industry 4.0 Maturity Index' in a consortium led by Acatech (German academy for Science and Technology), together with scientific partners from leading universities and research institutes. Prior to this current role, he was leading the 'Asset Management Innovation Centre' for Infosys Labs.