A New Category of Optimization & Control Technology

Market Analyst Insights

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About ARC

- Unique research and consulting company, focused on Operational Technology
- Senior people with IT- OT experience and expertise
- Global presence: US, Canada, Germany, France, Japan, China, India, Brazil, Argentina , Middle East
- Established in 1986

ARC Advisory Group

ARC's Research Methodology

4-6 Months to complete a global market analysis

Define a market segment

Define technologies, solutions, services

Primary Research:

Vendor scouting, Financial Reports, Annual Reports, 10Q's

Interviews:

In-depth interviews with technology providers, and end-users to gather first-hand information

Surveys:

Quantitative surveys to collect data from a wider range of respondents.

Case Studies:

Detailed analysis of specific projects or implementations to understand real-world experiences.

Market Data:

Analysis of market trends, buyer and supplier strategies, forecasts, and competitive landscapes.

Why does Industry need a new category of Optimization and Control Technology?

Shortage of APC engineers. Need to better leverage data already collected with improvements in ease of use. Limited cloud adoption.

Need to realize greater process performance, margins, profit, fewer process shutdowns, reduce energy, sustainability mandates

Traditional optimization solutions have limitations, model fit challenges, and a heavy services component
The rise of AI in manufacturing leads to new opportunities.

The History of AI

2009 ImageNet Project – Teaching computers to see

The ImageNet Project in 2009 – 15 Million images, 22,000 classes

Machine Learning Basics – Supervised Learning

amazon mechanical turk

Machine Learning Basics – Unsupervised Learning and Neural Networks

Some Imperfect Results of The Imagine Net Project

AI has Not Been Perfect

Defining the Full Scope of Optimization

New category of Closed-Loop AI Optimization

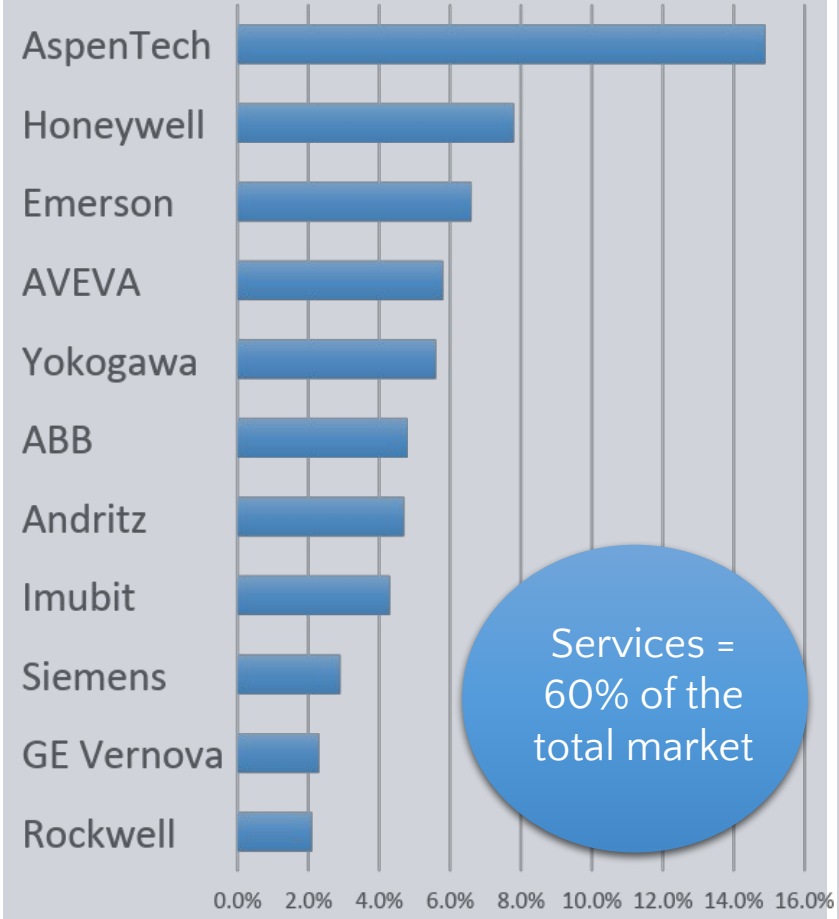
Advanced Process Control (APC)	Multi-variable Predictive Control (MPC) solutions providing closed loop control and provide real-time model-based control of a continuous process using empirical or first-principles models. MPC controllers are configured by process engineers and run in the real-time operational environment.
Online Optimization (RTO)	Continuously monitor the state of multiple processes through a model reference to predict an optimum operation path. Online optimization software typically employs technology for solving simultaneous equations. Presentation of the output of the optimization software may simply must directly set a new target to a lower-level control strategy for operations
Closed-Loop AI Optimization (AIO)	The use of machine learning algorithms, such as neural networks, to directly control plant operations based on model predictions. Techniques can be used to generate an intelligent entity which leverages the knowledge and experience acquired in training to take actions in an environment to maximize the notion of cumulative user-defined reward. Solutions may include a collaborative environment for teams to visualize data, build, train, evaluate, and track the performance of closed-loop AI models.

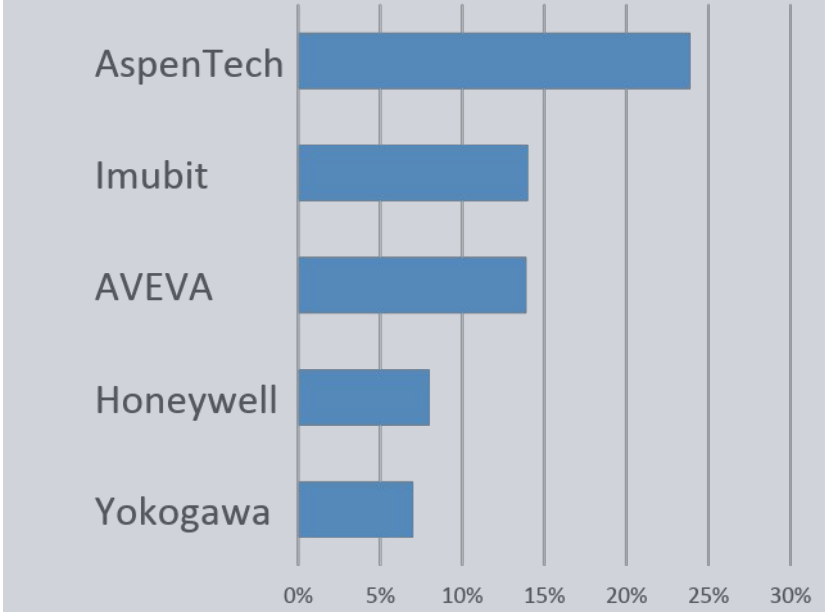
Vendors Included in ARC's Optimization Market Analysis

ABB
Honeywell
Rockwell Automation
ANDRITZ
HeroopSys 和隆优化
Schlumberger
aspentech
IMUBIT
SIEMENS
AVEVA
Intelecy
SUPCON
CANVASS
IPCOS
SymphonyAI INDUSTRIAL
EMERSON
Kelvin
Valmet
GE VERNOVA
NAPCON

APC & Optimization

Competitive Market Shares for a $700M market



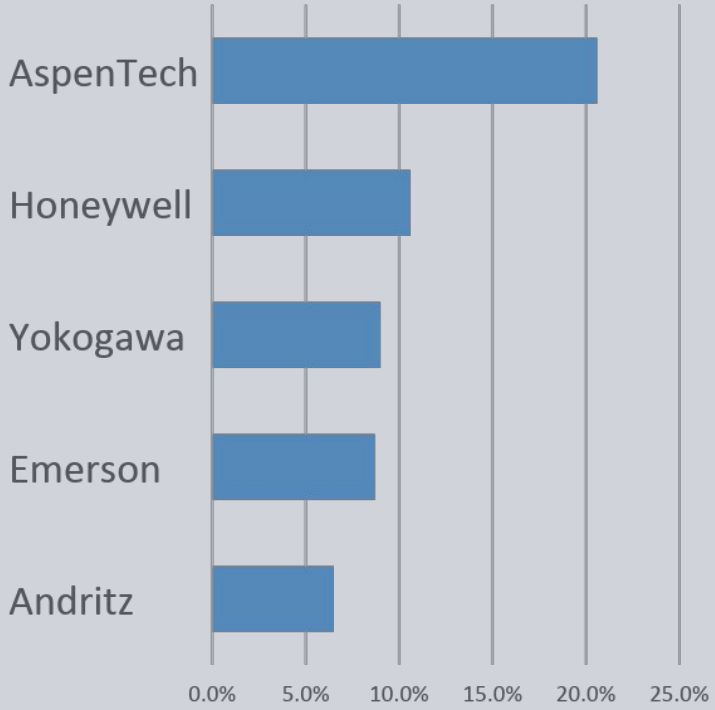


Category	2022	2023	2024	2025
Cement & Glass	-0.3%	-6.2%	-7.8%	4.9%
Chemical	2.7%	4.2%	5.6%	7.4%
Electric Power Generation	4.7%	3.0%	8.1%	8.4%
Food & Beverage	8.2%	20.3%	11.7%	14.0%
Metals	23.1%	-0.4%	8.2%	9.5%
Mining	3.4%	11.0%	12.1%	9.7%
Oil & Gas	15.9%	26.8%	11.7%	10.7%
Other Industries	21.0%	8.1%	8.7%	7.8%
Pharmaceutical & Biotech	13.1%	32.5%	9.1%	12.4%
Pulp & Paper	5.8%	-1.0%	4.6%	4.3%
Refining	3.5%	27.4%	11.7%	12.9%
Water & Wastewater	10.6%	0.6%	9.5%	9.6%
Total	**5.9%**	**12.3%**	**8.8%**	**9.8%**

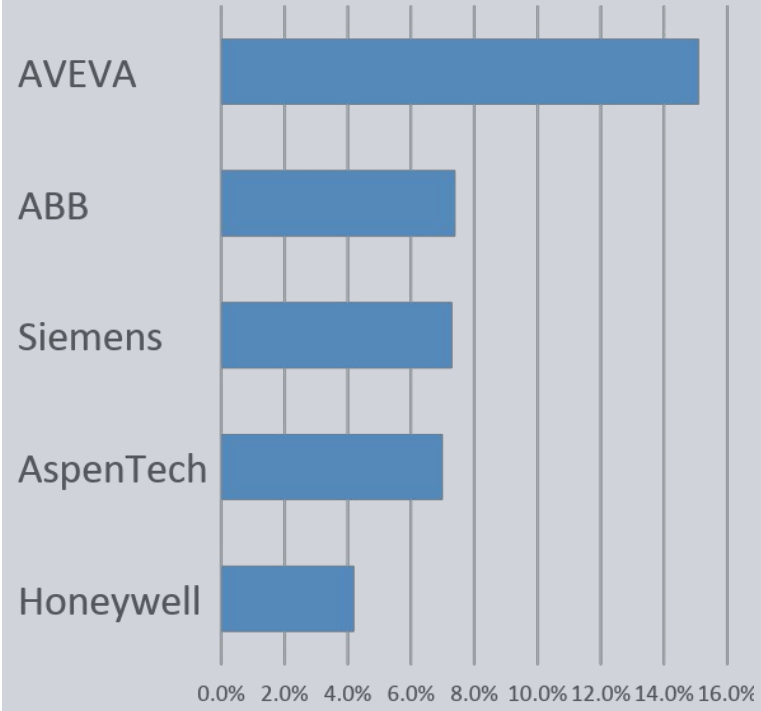
Revenue by Application / Segment

Closed Loop AI Optimization has 10% of the overall market in a few short years

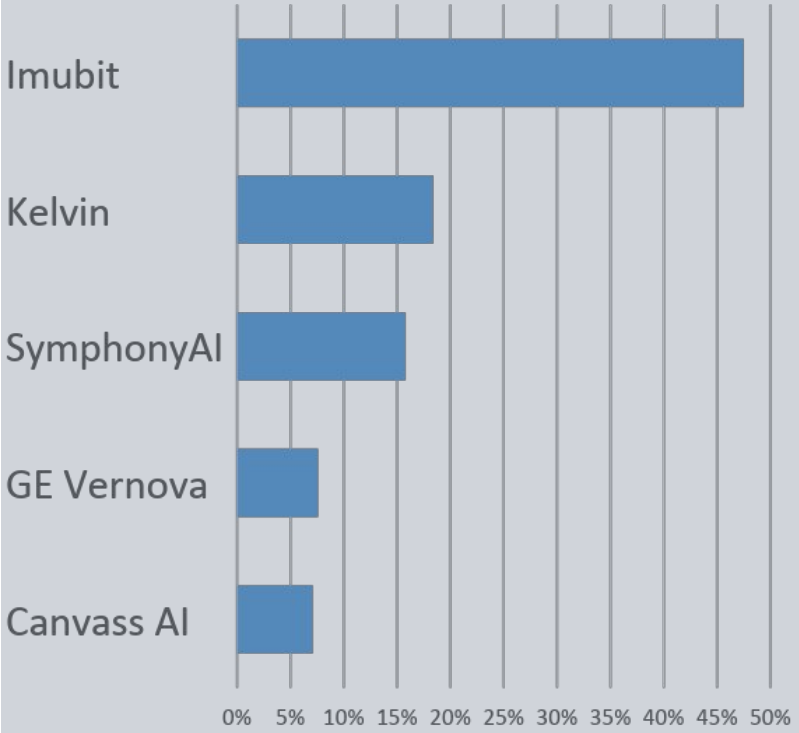
Advanced Process Control APC



Online Optimization RTO



Closed-loop AI Optimization AIO

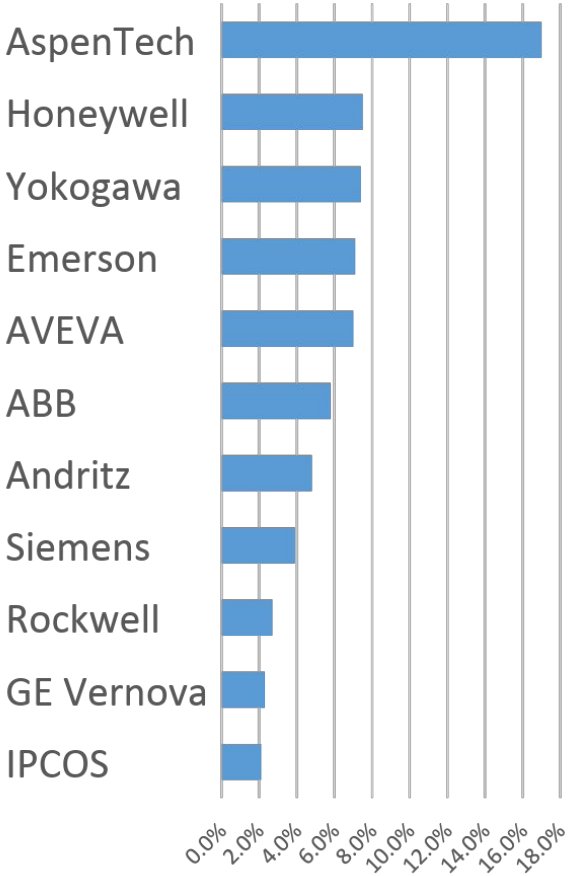


AspenTech acquired DMC in 1996 – Nearly 40 years ago

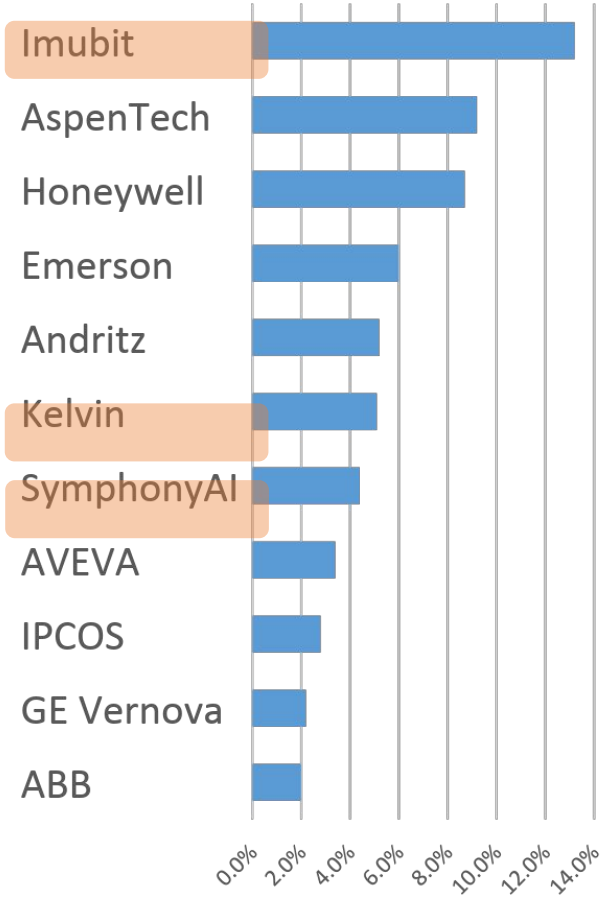
Total Optimization Revenues by Customer Tier

Smaller asset owner companies skipping steps in the technology evoluton

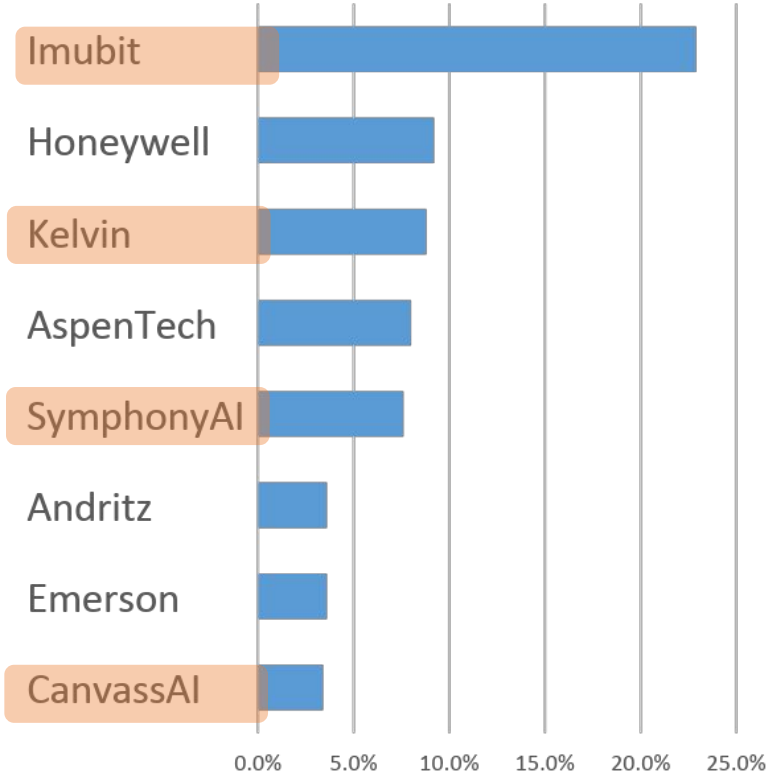
Tier 1 Customers:
Revenue Exceed $1 Billion (all industries)



Tier 2 Customers:
Revenue $250 million to $1 Billion (all industries)



Tier 3 Customer:
Revenue less than $250 million (All industries)



= AIO Vendors

Broad Predictive / Prescriptive Methods

Aligning the maturity of the process optimization stack

DCS Vendors, SIs → Traditional APC → Closed-loop AI Optimization

PID Control - Local Optimization

Best for **Basic Control**

Monitor sensor and error-calculated sensor data in real time to move a control output (Level, Flow, Pressure, Temperature

Advanced Regulatory & Algorithms

Best for **Advanced control** strategies to manage dead-time

Uses soft sensors, Cascades, state-based control, simple multi-output strategies.

APC & RTO

Best for **Complex processes, constraints, Multi inputs and outputs**

Physics-driven calculations, empirical models to assess multi unit objectives and optimize for an objective function

Supervised Machine Learning

Best for **APM and Analytics** for Predicting a future state based on data and domain expertise

Uses mapping to failure modes, specific events, signatures. Probabilistic by design

Reinforcement Learning

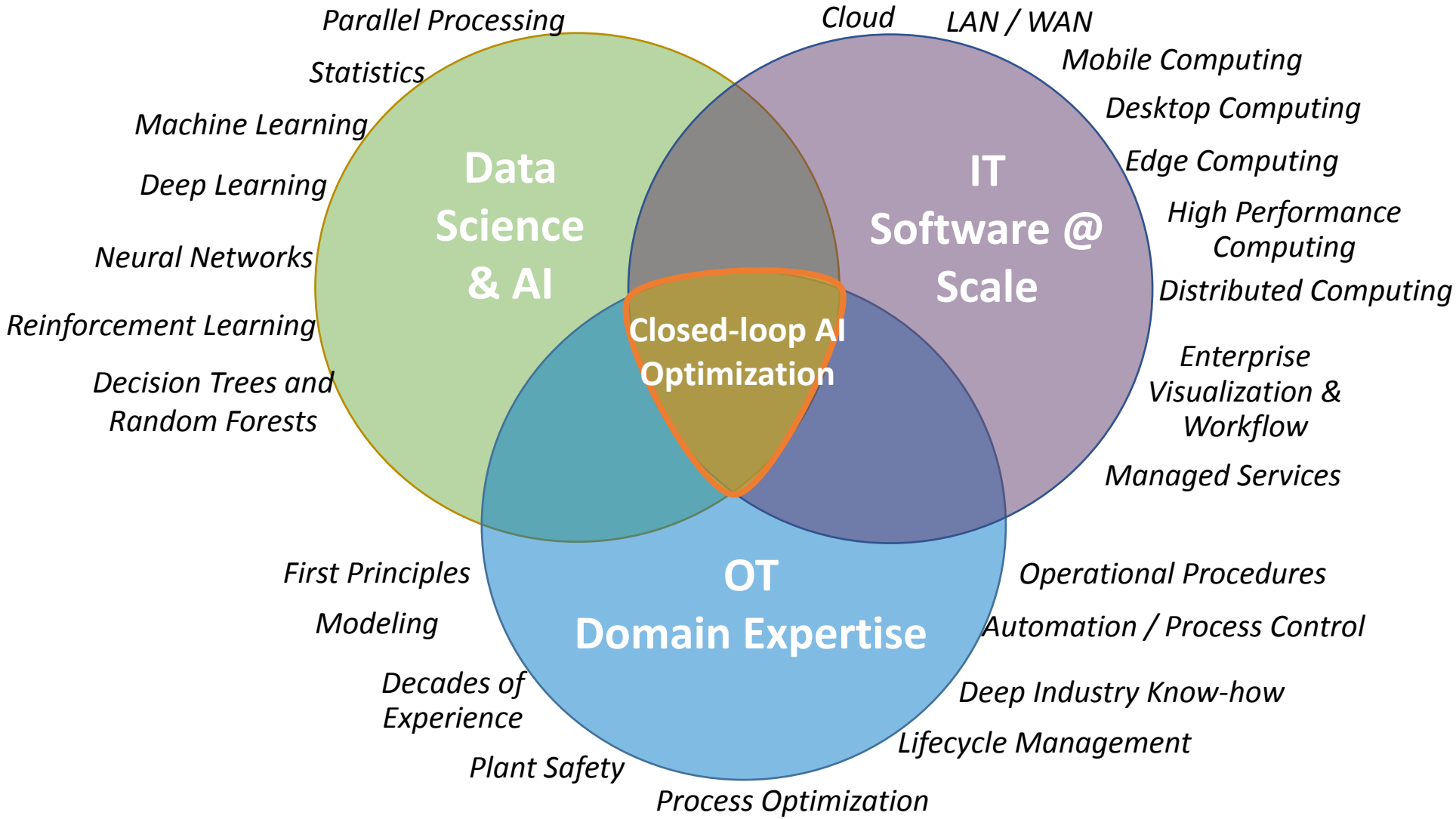
Best for adapting to **dynamic Process**

Precision required using iterative rewards, trial & error in simulation **and domain expertise**)

Cloud enabled

Best-in-class technology so Operations and Engineering teams can focus on their jobs

The Convergence of IT,OT and AI
Fully Democratizing and Embedding AI



Top 5 take-aways

- The Adoption of Closed-loop AI in the process optimization market will accelerate year-over-year.
- APC and hybrid model-based optimization solutions will have a strong presence in design-operate and maintain.
- Closed loop AI Optimization requires a more sophisticated AI framework (reinforcement learning) to support autonomous operations.
- The moving time-series to the cloud is essential to enable AI performance.
- Closed-loop AI optimization will become a critical lever to improve human capability and domain expertise (how things work)

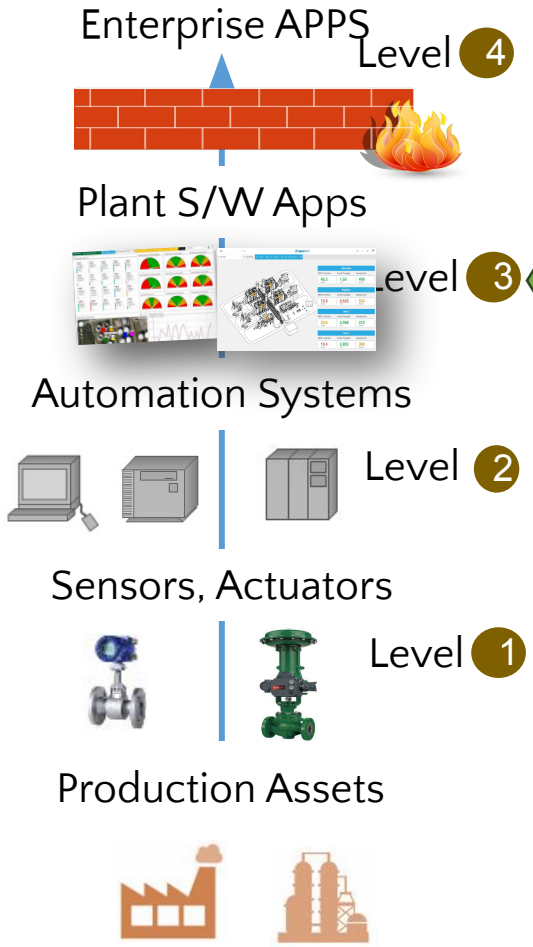
Thank You.

For more information, contact the author at preynolds@arcweb.com or visit our web pages at www.arcweb.com

Digital Innovation Accelerated by the Cloud and the Edge

Legacy architectures are not easily adaptable to innovation

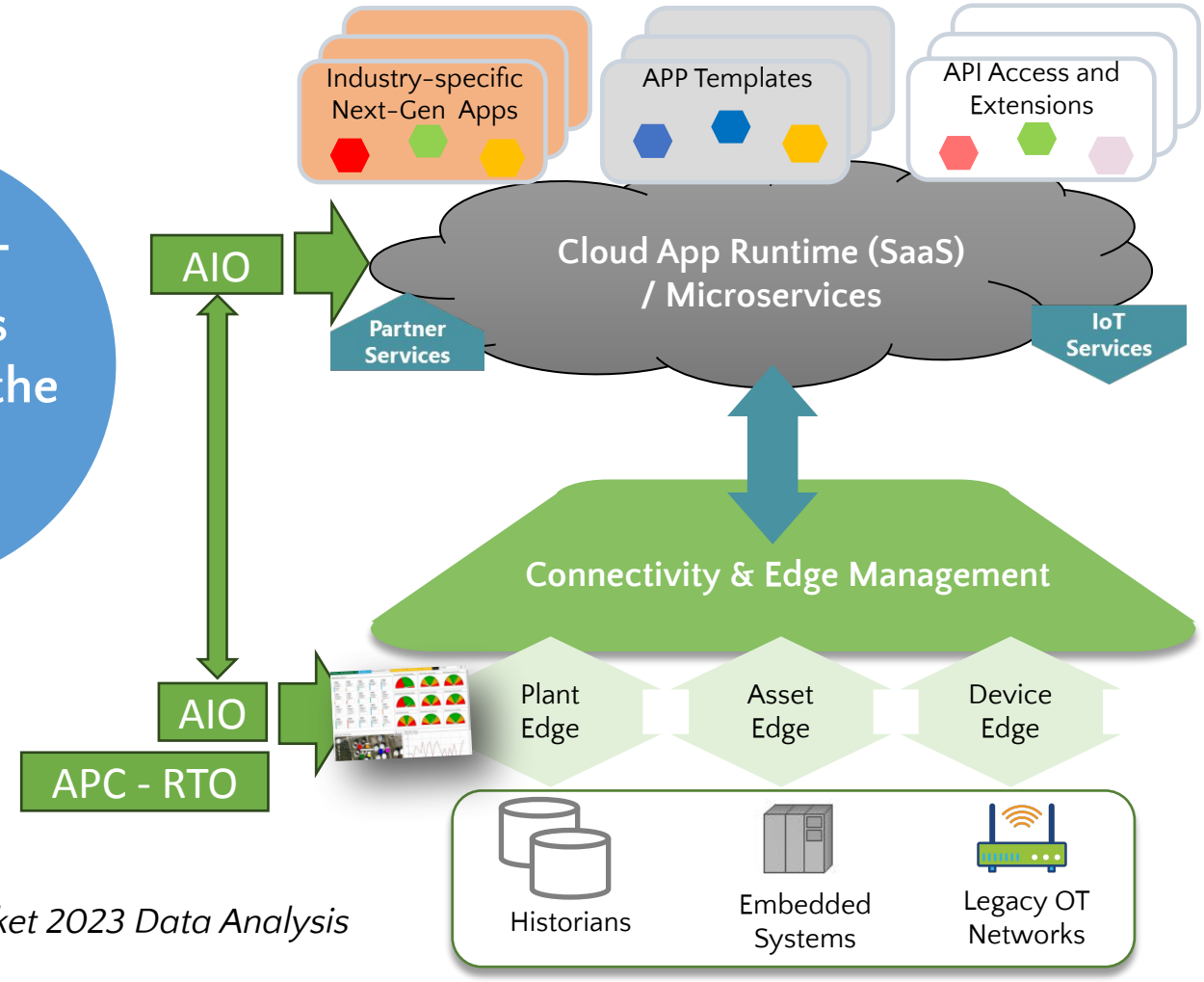
Conventional Model c1980



APC - RTO

<10% of OT software is deployed in the * Cloud

Current IT-OT Stack



** Source: ARC Advisory Group MES Market 2023 Data Analysis*