POSITION PAPER

Cloud Computing in OT Environments

INTRODUCTION

As operational technology (OT) and information technology (IT) continue to converge, businesses are questioning how cloud computing can be leveraged in OT environments. Due to their availability, reliability and performance demands, using cloud computing for real-time applications in OT environments seems inadvisable. However, adopting cloud technology in OT environments can offer numerous benefits in some automation applications, including these:

- Improved data management
- Enhanced analytics
- Cost efficiency and scalability
- Better collaboration

The move to adopt other technologies, such as machine learning (ML), generative artificial intelligence (AI) and cognitive AI, increases the need for cost-effective, centralized, scalable processing power. Achieving this requires businesses to adopt robust security measures, reliable connectivity and effective change management strategies.

As an automation standards and education development organization, ISA is committed to fostering collaboration among stakeholders and promoting the safe and reliable adoption of cloud computing.

APPLICATIONS FOR CLOUD COMPUTING IN OT ENVIRONMENTS

Cloud computing is not a universal solution for OT environments. Business leaders must understand where cloud computing can and, more importantly, cannot be utilized. Because of the high availability and low latency demands of closed-loop control systems, dedicated equipment must be located at or near the physical process. However, several viable OT use cases indicate that cloud computing can be used in those systems. Where large volumes of data require processor-intensive analysis, improved and faster decision-making can be achieved with cloud computing. Furthermore, flexibility and interoperability are required for faster decision support across multiple systems. Common examples of cloud computing in OT environments include the following:

- **Remote Operations:** Hosting infrastructure in the cloud can enable organizations to operate remote facilities from anywhere while providing security, robustness, redundancy and system disaster recovery. Cloud hosting also enables remote system support.

- **Predictive Maintenance:** Machinery providers, particularly those supplying rotating equipment such as gas turbines, routinely process data from operational sites to predict failures and schedule maintenance proactively, reducing downtime and maintenance costs. Processing vibration data, for example, is complex, involving low-pass filtering, Fourier transforms, feature extraction, selection and classification.[1]
- **Smart Manufacturing:** Organizations use cloud computing to optimize their supply chain management, including procurement, material planning, demand forecasting, inventory management and logistics management.[2]
- **Energy Management:** Cloud computing helps address the big data challenge of smart grid energy management, demand-side management programs, building energy management systems, energy hubs and power dispatching systems.[3]

CHALLENGES USING CLOUD COMPUTING IN OT ENVIRONMENTS

Unlike IT environments, where resources can be moved from on-premise to the cloud with little visible impact on users, OT environments have unique constraints that create challenges when deploying cloud solutions:

- **Cybersecurity:** Connecting OT systems to the cloud increases the attack surface, making them potentially more vulnerable to cyberattacks.
- **Latency:** Cloud-based operations can introduce latency, so functions in the cloud should not be time-sensitive and require real-time responses.
- **Reliability:** Reliable and high-speed internet connectivity is essential for cloud-based OT functionality. Still, businesses must properly allocate functionality on-site and in the cloud to ensure that a loss of internet connectivity does not impact on-site operation.
- **Compatibility:** Integrating legacy OT systems with modern cloud platforms can be complex and may require significant reengineering.
- **Cultural:** Staff accustomed to traditional on-premise systems and associated workflows may resist cloud-based OT systems. Additional training must be provided to enable them to support the new infrastructure.

CALL TO ACTION

Cloud computing has many potential benefits in OT environments, but it must be implemented with great care by properly qualified experts who follow rigorous industry standards and best practices. ISA is committed to leading these efforts, fostering collaboration among stakeholders and promoting the safe and reliable adoption of cloud computing.

We call on industry leaders, policymakers and academic institutions to join us in this mission. By working together, we can develop the necessary standards, provide valuable education and training and drive advancing a resilient cloud infrastructure that benefits industry as a whole.

WHERE TO START

As a nonprofit, international professional association, ISA develops widely used safety, security and performance standards for automation. ISA is the primary developer of a series of international consensus standards addressing the security of industrial automation and control systems. The ISA/IEC 62443 standards provide a flexible and comprehensive framework to address and mitigate current and future security

vulnerabilities in those systems. These are among numerous ISA standards and guidelines that support manufacturing and supply chain efficiency and safety.

ISA actively supports global efforts to establish training and competency programs as part of its commitment to educating and certifying automation professionals. An example is the Automation Competency Model developed by the US Department of Labor. This model defines the key skills, knowledge and abilities that automation professionals need at every career level, from entry-level to advanced. Recognizing that the automation profession is constantly evolving, the model is updated regularly to ensure that emerging technologies are included.

ABOUT ISA

The International Society of Automation (ISA) is a nonprofit professional association founded in 1945 to create a better world through automation. ISA empowers the global automation community through standards and knowledge sharing, driving the advancement of individual careers and the overall profession. ISA develops widely used global standards, certifies professionals, provides education and training, publishes books and technical articles, hosts conferences and exhibits and provides networking and career development programs for its members and customers around the world.

RESOURCES

isa.org/standards	138+ standards for automation, cybersecurity and more
isa.org/training	Unbiased, real-world training courses, personnel certifications and certificates that help engineers and technicians take the next step in their automation career
isa.org/join	Membership in ISA offers unparalleled access to technical discussions and resources
isa.org/events	Network, hear best practices and be part of the automation community dialogue at ISA events

WORKS CITED

[1] E. Uhlmann, A. Laghmouchi, E. Hohwieler, and C. Geisert, "Condition Monitoring in the Cloud," Procedia CIRP 38 (2015): 53–57, ISSN 2212-8271, https://doi.org/10.1016/j.procir.2015.08.075.

[2] Das, S., "Why Cloud Computing is Essential for the Modern Manufacturing Industry?," Manufacturing Tomorrow (20 January 2023), retrieved 8 January 2025, https://www.manufacturingtomorrow.com/story/2023/01/why-cloud-computing-is-essential-for-the-modern-manufacturing-industry/19950/.

[3] Yousef Allahvirdizadeh, Mohsen Parsa Moghaddam, and Heidarali Shayanfar, "A Survey on Cloud Computing in Energy Management of the Smart Grids," International Transactions on Electrical Energy Systems 29, no. 10 (2019), https://doi.org/10.1002/2050-7038.12094.