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INDUSTRIAL DATAOPS AND UNIFIED NAMESPACE

HOW ARE AI AND DATA ANALYTICS RESHAPING MANUFACTURING?

In today's manufacturing and supply chain landscape, integrating AI and robust data operations is critical for maintaining a competitive edge.

In the increasingly competitive landscape of global manufacturing and supply chain management, eliminating waste and unlocking efficiency gains has become essential to stay profitable. Exposing the hidden inefficiencies by harnessing machine, process and other related data has become critical. With the increase in the popularity of use cases for AI and analytics and reduction in the entry cost and tech threshold for companies to digitize, enabling AI systems and digital tools to break complexities and improve the lives of planners to plant managers is viable and attractive. However, to deploy and sustain this at scale, organizations require robust foundational industrial data operations capabilities. This means fundamentally rethinking existing processes, resource allocations, and data infrastructures.

Establishing these foundations can be challenging. Businesses face significant hurdles, such as ensuring high-quality data, enhancing data accessibility, and overcoming the inertia of existing suboptimal IT/OT architectures. These challenges are compounded by the complexity and fragmentation of systems, which often result from rapid, uncoordinated technological implementations. With a modernized infrastructure that can support advanced analytics and scale flexibly, companies can avoid becoming mired in a cycle of inefficient investment and technological redundancy. Addressing these foundational challenges is imperative for businesses that capitalize on AI and data analytics.

A modern IT/OT infrastructure that includes not just compute and network components but also tools and automation to ensure efficient delivery is crucial for optimizing resources, maintaining security standards, and ultimately defining a company's digital journey's success. Companies must prioritize strategic overhauls of their data and technology systems to break free from legacy constraints, unlock the full potential of digital transformation, and move toward a future of software-defined manufacturing and operations [read more about it here].

In modern manufacturing, integrating industrial data operations fundamentally transforms practices by harnessing the power of connectivity and real-time data. Enabled by connectivity across devices and facilities, communication across production lines and logistics significantly enhances operational synchronization and adaptability. This real-time data access is critical for decision-making, enabling managers to respond quickly to changes, optimize resources, and predict potential issues, creating a solid foundation to remain efficient. Furthermore, deep data analysis exposes hidden inefficiencies—often termed the "hidden factory"—highlighting areas for innovation and continuous improvement. Overall, the strategic deployment of technologies to utilize industrial data revolutionizes manufacturing processes and sustains a competitive edge in a rapidly evolving industry.

TRADITIONAL INDUSTRIAL DATA ARCHITECTURES

Traditional industrial data architectures are becoming less suitable for modern manufacturing due to their rigid, layered structures, which allow only point-to-point data transfer.

Many modern manufacturers operate with a technology stack that is rigid and compartmentalized, leading to data silos and increased costs. This structure also hinders the seamless integration of data. This setup results in several significant challenges. Data silos emerge, confining information to specific layers or systems, complicating data integration from diverse sources, and increasing costs. Such fragmentation hinders a unified, real-time operational view and impairs data-driven decision-making across the enterprise.

Moreover, these traditional architectures struggle with the increasing volume, variety, and velocity of data from modern industrial systems. Adapting and scaling existing structures to incorporate new technologies and data sources typically demands considerable investments in technology and expertise. Reliance on proprietary interfaces leads to vendor lock-in and technical debt, reducing flexibility and making adopting new technologies or switching solutions difficult. Furthermore, restricted data access limits cross-functional collaboration and reduces the effectiveness of data across different applications, stifling innovation.

While traditional models enabled information collection and connectivity, the evolution of the ISA-95 stack introduced a hierarchical organization of IT and OT systems with clearly established levels. This layered approach helps organizations invest appropriately and prepare systems for real-time data capture and flow. The ISA-95 stack focuses on Manufacturing Operations Management and Standardization, improving interoperability, role definition, data contextualization, and alignment with business objectives. It enhances scalability and Industrial Internet of Things (IIoT) integration, even with legacy devices. However, as new technologies and solutions emerge, interconnectivity between systems becomes more critical to optimize operations within these levels. When systems cannot communicate effectively, data silos and ad hoc solutions arise.

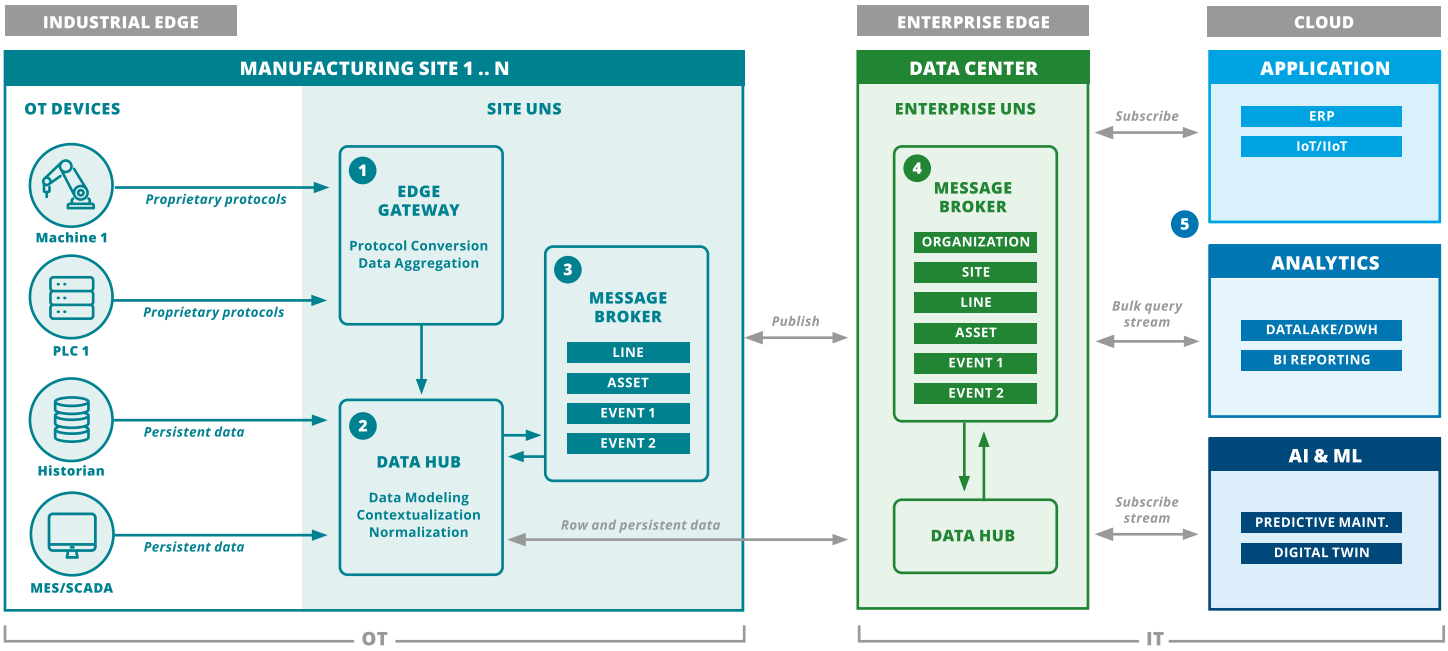
This challenge has led to the adoption of Unified Namespace (UNS) and industrial DataOps integration, which act as intermediaries to integrate information regardless of operational protocols. Modern, unified data architectures support seamless integration, scalability, and accessibility across an organization. By breaking down data silos and enabling real-time data exchange, these architectures facilitate better decision-making, enhance operational excellence, and foster innovation in a rapidly changing technological environment.

UNIFIED NAMESPACE AND INDUSTRIAL DATAOPS

In the increasingly competitive landscape of global manufacturing UNS is an emergent architectural strategy that centralizes diverse data sources into a unified, contextual framework. It establishes a single source of truth for real-time data, enabling precise and accessible information across different business sectors. In UNS, each component—whether Programmable Logic Controllers (PLCs), Supervisory Control and Data Acquisition systems (SCADA) systems, Manufacturing Execution Systems (MES), or Enterprise Resource Planning (ERP)—is treated as a node within a vast ecosystem. These nodes publish data to UNS, where it can be accessed by other nodes via subscription, simplifying data flow and reducing the need for complex system-to-system connections.

UNS data organization often follows a semantic hierarchy aligned with ISA-95 standard guidelines, enhancing systematic categorization and retrieval of information. UNS frequently utilizes IIoT protocols like MQTT, which is known for its efficiency, scalability, and secure data exchange capabilities. Its adaptability is highlighted by its compatibility with various platforms that meet minimum technical standards, including MQTT and Sparkplug. This flexibility allows customization to meet specific organizational needs, making UNS pivotal in enhancing operational visibility and agility for modern digital enterprises. It also serves as a foundational component to enable software-defined manufacturing and operations in the future.

REFERENCE ARCHITECTURE



1

EDGE GATEWAY

Edge gateway applications and hardware connect to sensors, PLCs, and machines to translate proprietary industrial protocols to open standards like OPC UA and MQTT.

2

DATA HUB

A data hub models and processes data and brings various sources into context. Built for industrial DataOps, these hubs can connect to OT and IT methods and parse, cleanse, and transform data so it is ready to consume.

3

MESSAGE BROKER (SITE)

The site message broker utilizes a lightweight publish and subscribe mechanism like MQTT to serve as a single source of truth for industrial edge applications and higher-level broker enterprise brokers.

4

MESSAGE BROKER (ENTERPRISE)

Like the site broker, the enterprise message broker serves as the single source of truth for the enterprise's current state. It is highly available and scalable, with transformed consumable data available for any current or future application to subscribe to.

5

SUBSCRIBERS AND CONSUMERS

UNS allows any application or system to subscribe to the information needed without complicated data manipulation. Connectivity can be via event-based subscription, streaming data applications, and prepared data payloads: Analytics, business intelligence, persistent data stores, AI and ML, and ERP.

Industrial DataOps is a cutting-edge approach designed to enhance data integration and security, which is crucial for improving data quality and streamlining preparation times across enterprises. This approach has emerged as a vital category of software solutions tailored to the architectural needs of industrial companies transitioning into Industry 4.0, digital transformation, and smart manufacturing.

Industrial DataOps solutions perform data contextualization and standardization and ensure secure data flow to applications operating at the edge, within on-premises data centers, or hosted in the cloud. These solutions significantly boost data utilization efficiency, enhancing data analytics' velocity, reliability, and quality. As the volume of data from industrial sensors and controllers continues to grow, the importance of Industrial DataOps becomes increasingly paramount. Originally conceived as a set of best practices, DataOps has evolved into a distinct and mature methodology in data analytics. For manufacturers, Industrial DataOps is an essential tool to establish and maintain a robust data infrastructure, enabling them to achieve and sustain digitalization effectively.

BENEFITS OF UNS OVER TRADITIONAL ARCHITECTURE

The Unified Namespace architecture not only simplifies data management and reduces IT/OT complexity but also enhances operational agility, making it a superior choice for enterprises looking to thrive in the digital age. UNS enhances the ability to scale at high speeds, which makes it a catalyst for innovation and a foundational element for businesses aiming to leverage data for competitive advantage.

By centralizing data from diverse sources into a single, accessible repository, UNS establishes a consistent and reliable single source of truth that enhances data accessibility and integrity across an organization. This centralized approach significantly simplifies the IT infrastructure, reducing the complexity and costs of maintaining multiple systems and custom integrations. As a result, UNS decreases operational expenses and streamlines scaling as business needs evolve, accommodating new technologies and systems with minimal disruption.

Moreover, UNS facilitates real-time data access and universal availability, which is critical for responsive decision-making and effective cross-departmental collaboration. The seamless data flow enabled by UNS supports advanced data analytics, empowering organizations to leverage comprehensive insights for predictive analytics and machine learning applications. This capability drives innovation and maintains a competitive edge in rapidly evolving markets. The enhanced security features inherent in the UNS architecture, such as sophisticated access controls and streamlined audit processes, ensure robust data security and compliance with regulatory standards.

The table below visualizes and compares the core features of traditional IIoT architecture, ISA-95, and UNS.

ASPECT	TRADITIONAL IIOT ARCHITECTURE	ISA-95 STACK	UNIFIED NAMESPACE (UNS)
Structure	4–5 layers: perception, network, processing, application (sometimes business)	Five levels: 0 (physical process) to 4 (business planning and logistics)	Flat, topic-based hierarchy
Data flow	Primarily bottom-up	Hierarchical, mostly bottom-up	Bidirectional, any-to-any
Integration	Can create data silos	Focuses on vertical integration	Seamless horizontal and vertical integration hub-type connectivity
Flexibility	Moderately flexible	Standardized approach	Highly flexible and adaptable
Real-time capabilities	Supports real-time operations	Supports real-time decisions and operations	Designed for real-time data-sharing and decision-making
Scalability	Scalable, but can become complex	Limited scalability due to hierarchical structure	Highly scalable and easily extensible
Legacy system integration	Can be challenging	Well-suited for traditional manufacturing systems	Provides a pathway for integrating legacy systems
Central component	Various (cloud platforms, edge gateways)	Different components across the levels	Message broker (often MQTT and/or Apache Kafka
Data storage	Distributed across layers	Hierarchical databases	Centralized “data lake”
Security	Layer-specific security measures	Well-defined security boundaries between levels	Requires comprehensive security strategy
Standards/Protocols	Various IoT protocols (MQTT, CoAP, etc.)	Specific standards for each level	Often uses MQTT, supports multiple protocols
Primary use	General IoT applications	Manufacturing and process industries	Modern, data-driven manufacturing and IIoT
Data contextualization	Limited, often siloed	Structured within each level	Comprehensive across the entire business
Interoperability	Can be limited between layers	Suitable within levels, challenges between levels	High interoperability across all systems

IMPLEMENTATION STRATEGIES

Building Industrial DataOps and UNS capabilities is not a one-size-fits-all process; the journey may vary depending on your organization's specific needs, resources, and objectives. While your organization may have specific goals, you should consider the following characteristics while designing and implementing a modern IT/OT architecture. This can ensure you're building a flexible solution that enables quality data at scale.

STRUCTURING WITH UNS

UNS is the cornerstone of digital transformation, acting as a single source of truth and a central hub for organizational communication. It provides a structured representation of all events relevant to the business, including ISA-95 Part 2 standards. By structuring with UNS, you can efficiently organize asset hierarchies, allowing seamless data browsing and access across the entire plant and enterprise. This approach helps in breaking down silos and establishing connections, thus democratizing data availability. UNS also enables the separation of data consumption from data production, offering users a more personalized and focused browsing experience. Implementing UNS ensures your organization has a robust IT/OT architecture capable of supporting quality data at scale and driving comprehensive digital transformation initiatives.

PROTOCOL CONVERSION

Protocol conversion is a crucial element that enables seamless communication between devices, systems, and applications that use different protocols. This interoperability is essential for integrating legacy systems with newer technologies, optimizing industrial processes, and enhancing data acquisition. Applications are available in the market that convert data from legacy automation systems to MQTT and OPC UA protocols.

EVENT-BASED DATAFLOW

In an event-based dataflow, messaging protocols (like MQTT) transmit data from one point to another in response to specific events. This means that data is not continuously transmitted but only when a particular event occurs (like a change in temperature or pressure). This makes event-based dataflow ideal for IoT applications where devices must communicate efficiently and in real-time with the central servers, removing point-to-point connections.

DATA HUBS FOR CONNECTING INDUSTRIAL DATA

Data hubs play a pivotal role in integrating and contextualizing industrial data, aligning seamlessly with an industrial DataOps strategy. By facilitating codeless integration with any system, data hubs enhance efficiency in transforming disparate data into a cohesive, consumable format within UNS or other systems. These hubs enable a few experts to work at the intersections of data, accelerating integration and adaptation processes.

In a modern IT/OT architecture, data hubs standardize and contextualize information models in real-time, ensuring that data is enriched with additional meaning or relevance based on its relationships and usage scenarios. This contextualized data becomes a single source of truth, serving as the authoritative reference point for accurate and reliable decision-making processes. Organizations can streamline their data operations by leveraging data hubs, making it easier to model and consume data efficiently and effectively.

NEED FOR INTEROPERABLE DESIGN

Designed for interoperability, the architecture is built with flexibility and compatibility in mind from the ground up. This means that the architecture is designed to be adaptable, scalable, and interoperable with other systems, and it is built using widely accepted standards, open-source software, or publicly available APIs. This approach facilitates more straightforward integration with other systems, future-proofs the architecture against technological changes, and promotes transparency and collaboration. For this purpose, while different protocols like OPC and MQTT are prevalent, choosing the right technology to handle multiple protocols simultaneously is crucial for robust data operations.

SECURITY FRAMEWORKS

In implementing UNS, security is paramount to ensure data integrity, confidentiality, and availability across interconnected systems. A robust security framework should be established, incorporating multilayered defenses such as encryption, authentication, and access control mechanisms. Encryption ensures that data transmitted within UNS is protected from unauthorized access, while strong authentication protocols verify the identities of users and devices interacting with the system. Access control mechanisms, including role-based access control (RBAC) and least privilege principles, restrict access to sensitive data and functionalities based on user roles and responsibilities. Additionally, continuous monitoring and auditing of UNS are essential to detect and respond to potential security threats in real time. By integrating these security measures, organizations can safeguard their UNS against cyber threats and ensure their interconnected systems' secure and reliable operation.

CHALLENGES AND CONSIDERATIONS

Despite UNS's numerous benefits, which can significantly enhance organizational value, it's important to be mindful of the associated challenges.

TOPIC	CHALLENGE	CONSIDERATION
Data governance and standardization	Establishing consistent data governance policies and standardization across diverse data sources can be complex. Additionally, achieving this at scale with many sites can be challenging compared to deploying at a single facility.	Enterprises need robust data governance frameworks to ensure data integrity, accuracy, and consistency. This includes defining clear data ownership and usage policies and complying with regulatory requirements.
System integration and compatibility	Integrating legacy systems and ensuring compatibility between different technologies can be difficult	A detailed assessment of existing IT/OT infrastructure and systems is crucial. Enterprises may need to invest in middleware or adapters to ensure seamless integration without disrupting existing operations.
Performance and system optimization	As data volumes grow, ensuring optimal system performance and maintaining seamless operations within UNS can become challenging.	It is essential to plan for performance optimization from the outset. This involves choosing scalable technologies and architectures to handle increased loads and data complexity.
Security and privacy concerns	Centralizing data increases the risk of breaches and data leaks	Enterprises must implement robust security protocols, including end-to-end encryption and secure communication protocols. Regular security audits and strong authentication mechanisms are essential.
Technology and vendor lock-in	Dependence on specific technologies or vendors can limit flexibility and control.	Enterprises should take a holistic view of their technology stack and architecture strategy aligning decisions to required business capabilities. Value captured from increased capability, speed, agility, and cost should be evaluated against the benefits of strategic vendor partnerships and any drivers of risk, complexity, and technical debt.
Change management	Resistance to change from within the organization can hinder the adoption of UNS.	Effective change management strategies, including training, communication, and stakeholder engagement, are critical to ensuring a smooth transition and adoption.
Cost implications	Initial setup and ongoing maintenance of UNS can be costly.	Conduct a thorough cost-benefit analysis to understand the financial implications. Consider phased implementations and self-funding transformation by leveraging speed to scale, unlocking value early, and using that savings to support funding the broader transformation.

CASE STUDY

ISSUE

A global transportation client experienced a substantial increase in shipment volume, compelling it to begin nearly 24/7 operations that limited maintenance windows for its facility distribution assets. At the same time, the company faced hiring difficulties and rising wages in the challenging US labor market. The organization needed a predictive maintenance strategy for its facilities to reduce capacity loss, drive efficiencies, and optimize delivery service levels

SOLUTION

We recognized the importance of adopting a modern architecture strategy to enable the client to scale outcomes, connect disparate systems at different facilities, and merge that data at the edge before sending it to the cloud for analytics. We recommended that the client adopt a Unified Namespace to facilitate its operational data management needs.

This initiative aimed to establish a standardized and centralized data hub across the client's network. The strategy involved utilizing PLCs and a variety of sensors as data sources, with the intention of processing and merging this data at the edge before its transmission to the cloud.

The architectural framework enabled real-time data processing for multiple facilities at the edge, which was subsequently consolidated at a central location. Thus, individual facilities were linked to a centralized hub encompassing all locations, creating a unified namespace.

IMPACT

This setup allows any system within the network to instantly subscribe to data from different data sources for approximately 25,000 assets spread across more than 40 facilities, facilitating clean and centralized data management. It meets the operational, business, and IT needs for predictive maintenance and has simplified the integration of future use cases.

CONCLUSION

In conclusion, Unified Namespace and industrial DataOps mark a significant turning point in manufacturing data management, essential for future-proofing businesses in the fast-evolving digital age. As the landscape of Industry 4.0 expands, the efficiency of data collection, processing, and utilization enhances operational capabilities and becomes critical for organizational survival and growth. UNS offers a unified, standardized platform that simplifies the integration of diverse data sources. At the same time, industrial DataOps equips businesses with the tools and methodologies to convert raw data into actionable, valuable insights.

These systems collectively deliver a robust framework that supports several key operational benefits crucial for adaptive, future-ready manufacturing environments. The flexibility of UNS allows for seamless integration of emerging technologies and data sources, ensuring businesses remain at the cutting edge of innovation. This adaptability and the scalable nature of industrial DataOps prepare enterprises for future expansions and complexities. Additionally, the real-time data processing and analysis facilitated by these integrated systems empower rapid decision-making and enhance operational agility, providing a competitive edge in today's fast-paced market.

Moreover, UNS and industrial DataOps break down traditional data silos, fostering a culture of collaboration and enabling a comprehensive view across operations, which is vital for continuous improvement and innovation. The foundation laid by these technologies is also instrumental in advancing the use of AI and machine learning, driving significant efficiencies, and pioneering new capabilities in manufacturing. As these technologies evolve, their role in promoting sustainability, enhancing risk management, and empowering a data-literate workforce will be indispensable. By investing in UNS and industrial DataOps, manufacturers are not merely optimizing their current processes but strategically positioning themselves for sustainable success and leadership in the future landscape of smart manufacturing. The path to fully optimized manufacturing data continues, but with these tools, organizations are well-equipped to navigate and thrive in the complexities of the digital future.

ABOUT DELOITTE

Deloitte brings expertise and a proven track record in implementing UNS and industrial DataOps solutions. With a deep understanding of industry-specific challenges and a comprehensive approach to digital transformation, we help organizations seamlessly integrate these advanced systems into their existing infrastructure. Our tailored consulting services, cutting-edge technology solutions, and robust analytics capabilities ensure that businesses can maximize the value of their data, improve operational efficiencies, and achieve sustainable growth. By partnering with Deloitte, companies can leverage best practices, innovative methodologies, and strategic insights to stay ahead of the competition and thrive in the ever-evolving landscape of Industry 4.0.

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