TECHNICAL INSIGHT

RTI Connext for Edge-to-Cloud Integration

REAL-TIME DATA COMMUNICATIONS FOR AUTONOMOUS SYSTEMS AND PHYSICAL AI

From agriculture and transportation to healthcare and defense, the emergence of AI and software-defined (SDx) systems is fundamentally transforming how we think about and use data. As intelligent devices and autonomous fleets proliferate, managing reliable, real-time access and control over exponentially-increasing data volumes presents significant architectural challenges. RTI Connext® provides a data-centric foundation designed to address these complex demands head-on.

HIGHLIGHTS

» Achieve real-time performance & reliability at scale

» Simplify application development and empower rapid innovation for physical AI and autonomy

» Protect sensitive information across heterogeneous networks and devices

» Reduce integration complexity and operational costs, now and well into the future

The Challenges of Connecting Autonomous Systems with Traditional Cloud Architectures

Building scalable, reliable and secure cloud backends for autonomous systems and physical AI presents significant architectural challenges. Traditional approaches, often rooted in message-centric architectures designed for less demanding applications, may prove inadequate when confronted with the unique requirements of real-time distributed systems. What are the main drawbacks of traditional cloud architectures?

- **Lack of Real-Time Performance:** Message-centric systems built for IoT are not inherently designed for real-time operations. Their performance, particularly latency, is often unpredictable and can degrade significantly, especially over WANs. This makes them unsuitable for autonomous applications requiring low or deterministic latency and rapid decision-making. Moreover, the latency involved in sending data to a cloud server for processing can be dangerous in time-critical scenarios.
- **Complexity and Data Silos:** Traditional connectivity often relies on maintaining custom gateways and different protocols for various segments of the system – edge-to-edge, edge-to-cloud and intra-cloud. This leads to fragmented, siloed data and costly, complex integrations that are hard to maintain and difficult to integrate across teams and business units.
- **Broker-Based Bottlenecks and Single Points of Failure:** Many message-centric protocols, such as MQTT, rely on central brokers. All messages must pass through these brokers, adding architectural complexity, increasing latency due to overhead (especially with large messages) and introducing potential single points of failure.
- **Limited Data Awareness and Security:** Message-centric approaches typically treat data as opaque messages, lacking an inherent type system or the ability for the infrastructure to understand or filter data based on its content. Security is often applied at the transport level (connection security), lacking the granular, data-level control needed for fine-grained access permissions and end-to-end security across diverse networks and participants.

These challenges result in systems that are expensive to build, difficult to scale and slow to evolve. Additionally, these systems would struggle to meet the strict reliability, performance and security requirements needed for autonomous operations and the next wave of AI applications.

Unlocking AI and Integrated Systems with a Data-Centric Approach

A data-centric architecture, as implemented by RTI Connext, represents a fundamental shift in how distributed systems communicate. Instead of focusing on sending messages between endpoints, the focus is on the data itself. This approach is specifically designed to address the complexities and demanding requirements of real-time, autonomous systems. Here are the main advantages:

- **A Unified, Global Data Space:** A data-centric databus creates a shared global data space where data is published and subscribed to, decoupling applications from the specifics of who is sending or receiving data or where they are located. This simplifies system design and integration dramatically, enabling seamless access to real-time data streams from any authorized point, edge or cloud.
- **The Infrastructure Understands the Data:** Central to the data-centric approach is the use of a unified data model that the communication infrastructure understands. This enables powerful features such as data-aware filtering, allowing applications to subscribe only to the specific data instances or updates they need, reducing bandwidth usage and processing load across the system.
- **Native Real-Time Performance and Reliability:** Data-centric middleware is built for real-time, distributed environments. Connext employs a peer-to-peer architecture, eliminating central brokers. It supports quality-of-service (QoS) policies that guarantee timely and reliable data delivery, even under challenging network conditions, providing the predictable, low latency required for autonomous operations and physical AI.
- **Granular, Data-Level Security:** Security is intrinsic to the data flow in a data-centric system. Data-centric security applies encryption, authentication and access control directly to the data topics, providing fine-grained, end-to-end protection based on user credentials and data policies. This offers a much higher level of security and privacy assurance compared to transport-level methods.
- **Foundation for AI and Analytics:** The ability to provide cloud-based AI, machine learning and analytics applications with real-time access to structured, context-rich data from the edge is essential. A data-centric databus delivers the necessary high-fidelity, low-latency data streams, which in turn supports the multi-modal data processing often required for sophisticated AI and real-time decision-making in dynamic environments.
- **Scalability and Future-Proofing:** Data-centric systems scale naturally with the addition of new participants and data streams. The flexibility offered by decoupling applications through a data-centric databus ensures that the architecture can evolve to incorporate new technologies, hardware and applications without requiring costly redesigns. This provides a path to future-proofing your investment in an environment of rapid change.

By implementing a data-centric architecture with a unified data model, organizations can overcome the limitations of traditional message-centric approaches. This approach provides a robust, scalable, secure and real-time communication platform that powers the next generation of autonomous systems and physical AI, accelerates innovation and enables the delivery of significant business value.

Summary

The rise of intelligent and autonomous systems across industries fundamentally changes the competitive landscape. For organizations deploying autonomous fleets and intelligent devices, the ability to access and utilize data in real-time is no longer a luxury but a strategic imperative to remain competitive and meet customer demands for continuous, real-time information. However, traditional cloud architectures, often built on message-centric paradigms, were not designed for the low-latency, high-reliability requirements of these systems. Relying on these legacy approaches creates significant challenges: data silos fragment critical information, complex gateway and broker infrastructure is hard and costly to maintain, and performance is often unpredictable or unsuitable for time-sensitive operations where milliseconds matter.

To unlock the full potential of your autonomous systems and physical AI, investing strategically in your data architecture is paramount. A data-centric approach, unlike message-centric methods, focuses on the data itself, creating a unified, global data space that is accessible from anywhere. This architectural shift, enabled by and fundamental to Connext, allows the infrastructure to understand the data, facilitating real-time performance, reliable delivery and fine-grained, data-level security essential for mission-critical applications and compliance. By providing developers with seamless, real-time access to data through a common data model, you empower teams to build new applications, integrate sophisticated AI, and adapt system behavior rapidly. This market agility, enabled by a flexible and scalable architecture, is a key source of competitive advantage, allowing you to deliver new capabilities, create new revenue streams from data-driven services and stay ahead in a rapidly changing landscape.

ABOUT RTI

RTI is the real-time data-streaming company for intelligent distributed systems. RTI Connext® software is the critical nervous system for over 2,000 designs across Aerospace and Defense, MedTech, Automotive, and Robotics.

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