SOLUTION BRIEF

Industrial IoT
Time-Sensitive Networking (TSN) Solutions

National Instruments and Intel deliver accurate, holistic insight for optimized IIoT

Advanced time-sensitive networking controllers enable data-driven industrial operations

"National Instruments chose Intel® architecture as the foundation for the next generation of CompactRIO* because it provides remarkable system performance with low power consumption in a compact board design. This choice resulted in small and rugged controllers that provide improved performance over the previous generation of controllers, can still be deployed in harsh environments, and support the synchronization requirements of time-sensitive networking (TSN)."

—Graham Green
principal product marketing manager, National Instruments

Executive summary

Time-sensitive networking (TSN) is an evolution of the IEEE Ethernet standard that is expected to play a critical role in industrial applications dependent on accurate, coordinated data for insight into equipment and processes. Though industrial equipment is typically designed to collect some data, this information is often neither synchronized nor accessible to support holistic visibility across a factory or among plants in dispersed locations.

With TSN, industrial, energy, and manufacturing sites can acquire and analyze continual streams of closely synchronized data from their assets and processes, providing a detailed and holistic view of operations.

The ability to prioritize network traffic helps to ensure availability of time-critical data, such as control data used to make informed control decisions about various manufacturing subsystems. In today's competitive environment, industry needs insight across data acquisition points and needs this faster than ever before. National Instruments delivers advanced controllers, powered by Intel® architecture, to the industrial and energy sectors for optimized, data-driven operations using TSN.

Challenges

Managers of today's industrial plants and facilities face numerous complex challenges. The systems they are responsible for often have stringent compliance and safety regulations, as well as strict internal targets for reliability, but the equipment is often old, incompatible with modern open standards, and labor intensive to manually inspect. Recent reports from GE found that 82 percent of surveyed companies from a range of industries (manufacturing, energy, healthcare) experienced unplanned downtime over the past three years, with each outage costing an average of USD 2 million.[1] Only 24 percent of operators described their maintenance approach as a predictive one based on data and analytics.[1] Seventy percent of these companies did not have a clear picture of when equipment assets were due for maintenance or upgrade.[2]

These are some of the issues driving executives to expect an ever-increasing amount of data, a fact compounded by the technological gains from increased, affordable, analog-to-digital conversion speeds and network capacity. Traditionally, data has been acquired manually and transferred to a central processing unit in a server room. The sheer volume of data now expected makes this process unmanageable. The simple solution of streaming all of this data over a physical or wireless network is inefficient due to bandwidth and cost limitations. Architectures are needed that support different types of data processing—at the edge, server room, and cloud. Edge processing that extracts features at the place of acquisition reduces the amount of data required to be transmitted, and allows for near-real-time response to control tasks.

With the deluge of data, industry also must rethink storage strategies to support "store-forward" architectures. Storing data at both the edge and the cloud is not only essential in case of network outages, but for the comprehensive analytics (historical and current) that give industrial executives and managers the insight to improve and optimize operations. With the advent of machine learning, data is rarely being used once—industry decision-makers expect more sophisticated data analysis to support new levels of optimization and asset control. Achieving this insight into manufacturing and power plant operations can require terabytes of data.

Both routine operations and innovation are now data driven. When competitive edge depends on bringing new solutions to market faster, accurate understanding of a product's performance for cost-effective prototyping is critical; it is near-real-time measurements and processing that provide this insight.

In addition, there is a move to more closely converge operational technology (OT) and information technology (IT) infrastructure. This enables industry to more easily distribute advanced technologies, but requires new levels of interoperability. In order to maintain the time-critical aspects of OT networks, there must be a way of prioritizing traffic within a standard Ethernet network, as well as synchronizing time clocks. This would help ensure safe and reliable operation of critical assets and data acquisition systems, along with minimal disruption to personal traffic, such as email and web browsing.

The confluence of all these factors makes the expanded use of TSN for industrial operations more important than ever before.

Industrial data is expected to reach 78 EXABYTES by 2020[3]

By 2019, at least 40% of IoT-created data will be stored, processed, analyzed, and acted upon at the edge[4]

Solution

Precision and accuracy have always been important to engineers working in the industrial sector. But today, more industrial decision-makers, such as maintenance and site managers and executives, expect greater insight into how industrial plants are operating. Industries need to understand why and how things are working and why things go wrong. They need access to a constant stream of accurate, well-synchronized, contextual data to understand how a specific industrial setup is operating.

With deep data acquisition experience, NI brings the expertise to gather and assess not only single-point data from the production line or power plant, but also conditioned, contextual, waveform data from sensors. With NI and Intel, industrial infrastructure can increase the edge processing and feature extraction required by modern IoT architecture. NI solutions based on Intel® architecture are enabling a wide range of industrial plants and solution providers worldwide to prototype, test, and deploy more accurate, compliant, and reliable IIoT solutions—while helping to ensure the high levels of accuracy required with TSN.

CompactRIO* powered by Intel architecture provides a high-performance embedded controller that features industrial I/O modules, extreme ruggedness, industry-standard certifications, and integrated vision, motion, industrial communication, and human machine interface (HMI) capabilities. Compatible with TSN (an evolution of the IEEE Ethernet standard), CompactRIO provides high-accuracy data that can be processed at the edge and closely synchronized across a network with devices compliant with the open TSN standard.

NI chose the Intel architecture platform for its scalable road map, high performance, and reliability. The Intel Atom® system-on-chip (SoC) maximizes controller performance, while minimizing size and power dissipation. Advanced features include multicore technology, out-of-order execution, and an integrated GPU for built-in display capability, all in a compact, rugged, and fanless enclosure.

With NI and Intel, the industrial sector can gain the benefits of Industry 4.0—from comprehensive, plant-wide, near-real-time insight into operations, equipment, and workflow to proactive maintenance, increased control, and reduced or eliminated downtime. Continual, contextual data collection and filtering can be distributed, with edge intelligence allowing for immediate action to protect equipment and optimize operations.

- **Industrial-class determinism:** Built-in TSN technology means insights from data arrive on time, every time, from anywhere.
- **Accurate, reliable measurements:** Based on more than 40 years of data acquisition expertise, NI technology can help industrial and manufacturing facilities acquire accurate and reliable real-world data from any sensor.
- **Rugged, synchronized hardware:** CompactRIO is certified to withstand some of the most demanding industrial environments.
- **Superior control:** Optimize processes and asset operation with machine learning models, feature extraction, and nanosecond control at the edge.
- **Open, connected software:** NI software offers world-class integration with third-party analytics packages, databases, and cloud platforms.

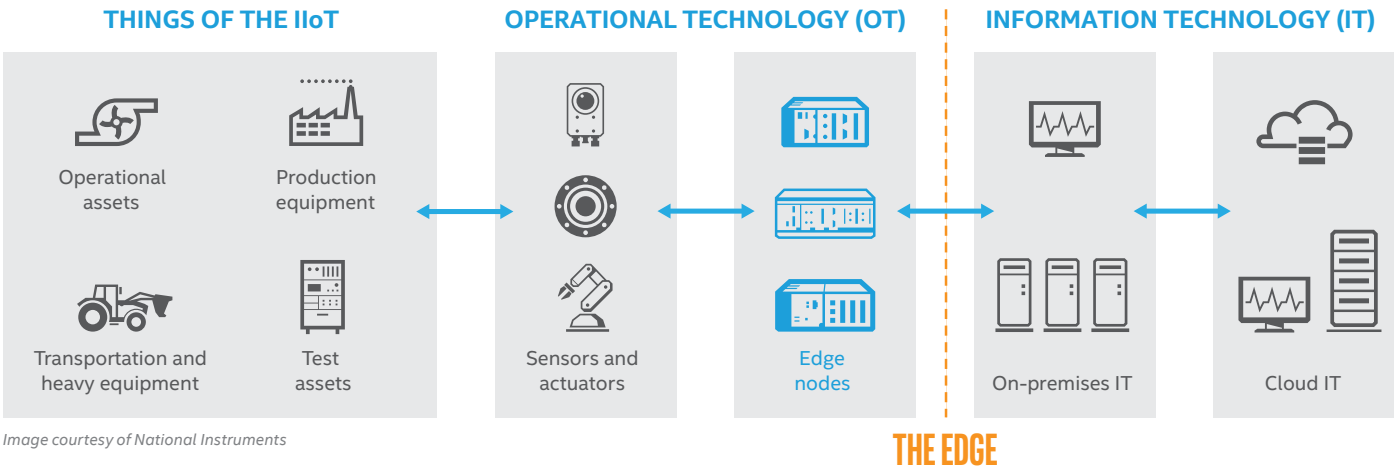


Image courtesy of National Instruments

NI and Intel are helping industrial OT and IT merge to achieve precision performance and operational efficiency

Time-sensitive networking (TSN)

CompactRIO utilizes Intel® Ethernet Controllers to provide the benefits of TSN*

TSN is an update to standard Ethernet IEEE 802.1 that adds network-based time synchronization and deterministic communication. With TSN, IIoT devices can be precisely synchronized over the network, eliminating the need for the signal-based synchronization methods that are common today. This distributed concept of time also enables traffic scheduling and the deterministic transfer of time-sensitive data, which is key for industrial applications such as process and machine control where low latency and minimal jitter are critical to meeting closed-loop control requirements.

How it works in brief

CompactRIO features a heterogeneous computing architecture. It is ideal for measurement and control applications and supports multiple APIs to help quickly accomplish these tasks. The controller combines an embedded real-time processor and a high-performance FPGA.

Each I/O module is either (1) connected directly to the FPGA, providing low-level customization of timing and I/O signal processing, or (2) routed to the real-time processor, using the intuitive NI-DAQmx API* for measurements and control. CompactRIO controllers are TSN-enabled, delivering the TSN technology to an embedded real-time controller.

CompactRIO is optimized to be programmed using LabVIEW*, which allows you to quickly respond to the changing requirements of systems with a single, highly optimized toolchain for every phase of the design cycle. With hundreds of prevalidated libraries, tight hardware integration, and a variety of programming approaches, LabVIEW allows engineers to compile code onto the host, real-time operating system (RTOS), and FPGA to maximize use of their processing power at the edge.

It can be challenging to switch between the prototyping and manufacturing of new systems. With NI and Intel, solution and application developers can use the same, consistent controller and architecture and engineers gain the flexibility to build the systems they need.

CompactRIO* powered by Intel® architecture brings industry essential data synchronization and TSN for operational modernization

Analyze more data and perform more control with the latest Intel Atom processor

CompactRIO controllers use the latest Intel Atom® E3900 series processors to achieve the highest performance ever in a CompactRIO controller. USB3 and ultra-high speed (UHS) SD removable storage address the demands of high-performance data logging with double the memory density and increased performance to allow for more analysis and control.

Display is provided via ruggedized USB Type-C connectors to integrate a human machine interface (HMI) into data logging, control, and monitoring applications. The Intel® processor runs NI Linux Real-Time*, a real-time OS based on a standard kernel and designed specifically for reliable and deterministic operation in long-term deployments.

COMPACTRIO* POWERED BY INTEL ATOM® PROCESSORS *Optimize industrial applications and use cases*	
Powerful coprocessing with a user-programmable FPGA	• User-programmable FPGA allows offloading of time-critical processes for advanced control, signal processing, filtering, advanced timing, and other logic. • Direct access to I/O for high-speed control. • Process and analyze data at the edge to help minimize time to insight and decision-making.
Customizable architecture and integration	• Interchangeable I/O modules provide direct sensor connectivity to signal sources. • Bus/protocol specific modules configured in the real-time OS or via the FPGA allow flexibility in communication and system integration.
Ruggedized for industrial environments	• Compact, rugged package. • Features operating temperature range of up to -40°C to 70°C (-40°F to 158°F); 50g shock and 5g vibration ratings; redundant power supply inputs; and a variety of international safety, Hazloc, and environmental certifications and ratings for operation in harsh industrial environments.
Reduce development time	• Overcome the traditional challenges of programming heterogeneous architectures with the combination of NI Linux Real-Time* and LabVIEW* FPGA. • Develop systems faster by programming both the real-time processor and the user-programmable FPGA with a single, intuitive software toolchain.
Leverage vast NI and Intel ecosystem	• Harness the openness of NI Linux Real-Time through thousands of open source applications, IP, and examples, while collaborating with an active community of users and developers.
Improve security with NI Linux Real-Time	• Boost security and reliability with native support for Security-Enhanced Linux* (SELinux*), a system based on mandatory access control (MAC) that uses a security policy to explicitly specify the actions that each component of the system is allowed to perform.
Connect to the outside world	• Eliminate the need for separate subsystems by connecting components directly to the CompactRIO Controller with built-in processor I/O such as Gigabit Ethernet, serial, USB ports, over a hundred I/O modules with measurement-specific signal conditioning.

"Transformative industrial insights hinge on the availability of accurate and reliable real-world data. With NI's technology providing advanced capabilities in measurement, control, ruggedness, and connectivity, along with Intel's processing capability and expert ecosystem, it's now possible to realize the benefits of the IIoT."

—Graham Green, principal product marketing manager, National Instruments

Conclusion

NI has a long history of bringing powerful processing performance to embedded measurement and control customers by using the latest Intel technology. Equipping systems and devices with connected and synchronized measurement and control technologies unlocks insights that can increase uptime, boost performance, and drive innovation, all while reducing operational costs.

About National Instruments

For more than 40 years, NI has developed high-performance automated test and automated measurement systems to help engineers and scientists solve their engineering challenges now and into the future. NI's open, software-defined platform uses modular hardware and an expansive ecosystem to help turn powerful possibilities into real solutions.

ni.com

Learn more

For more information about National Instruments solutions for IIoT, please visit ni.com/iiot, or to learn about the CompactRIO platform, visit ni.com/compactrio.

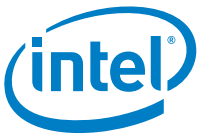
For more information on TSN standards visit the Avnu Alliance at avnu.org.

For more information about Intel® IoT Technology and the Intel® IoT Solutions Alliance, please visit intel.com/iot.

Assess features and specifications and review technical documentation for the latest Intel® processors.

The foundation for IoT

The National Instruments solution is one example of how Intel works closely with the ecosystem to help enable smart IoT solutions based on standardized, scalable, reliable Intel® architecture and software. These solutions range from sensors and gateways to processor, server, and cloud technologies to data analytics algorithms and applications. Intel provides essential end-to-end capabilities—performance, manageability, connectivity, analytics, and increased security—to help accelerate innovation and grow revenue for industry, enterprises, and solution providers.



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Cost reduction scenarios described are intended as examples of how a given Intel-based product, in the specified circumstances and configurations, may affect future costs and provide cost savings. Circumstances will vary. Intel does not guarantee any costs or cost reduction.

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