NIDays

ENGINEER NEXT

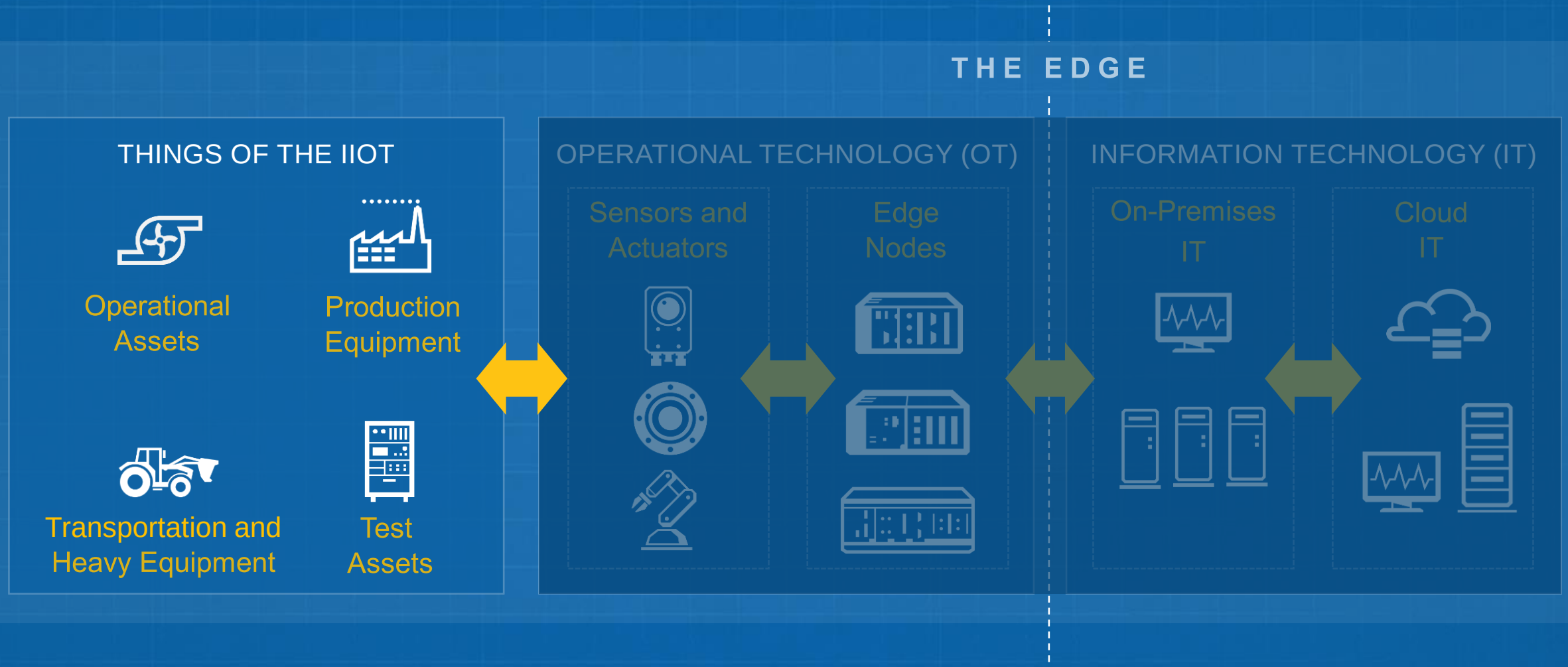
An Introduction to TSN

Claudio Cupini

National Instruments Italy

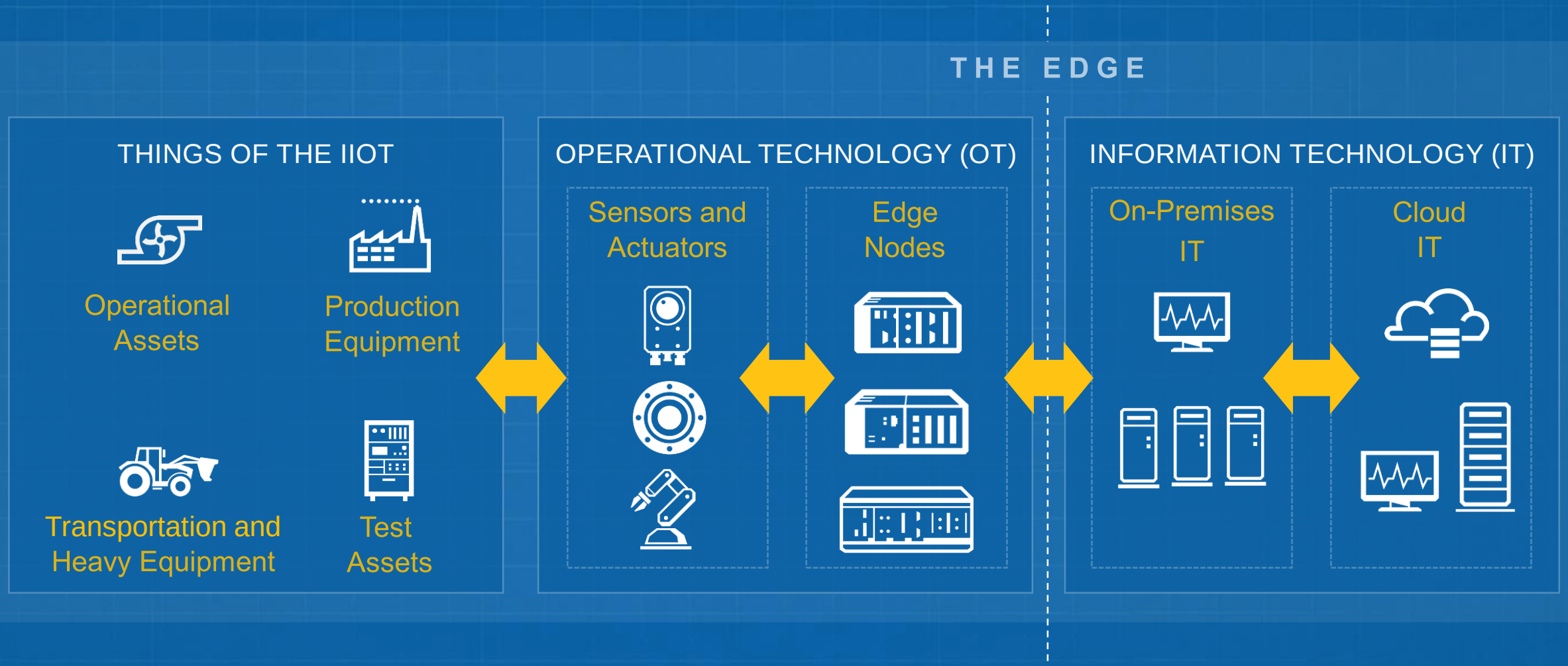
Field Marketing Engineer

Industrial IoT Architecture



NATIONAL INSTRUMENTS

Industrial IoT Architecture



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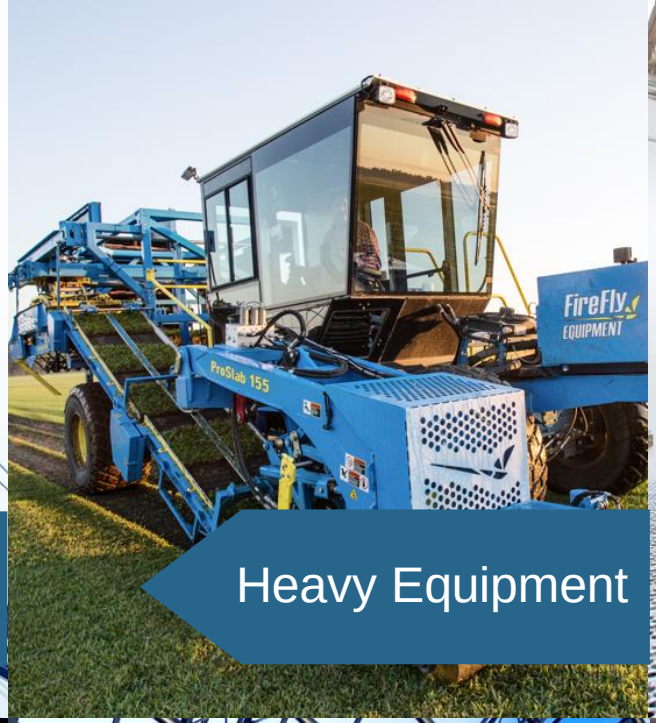
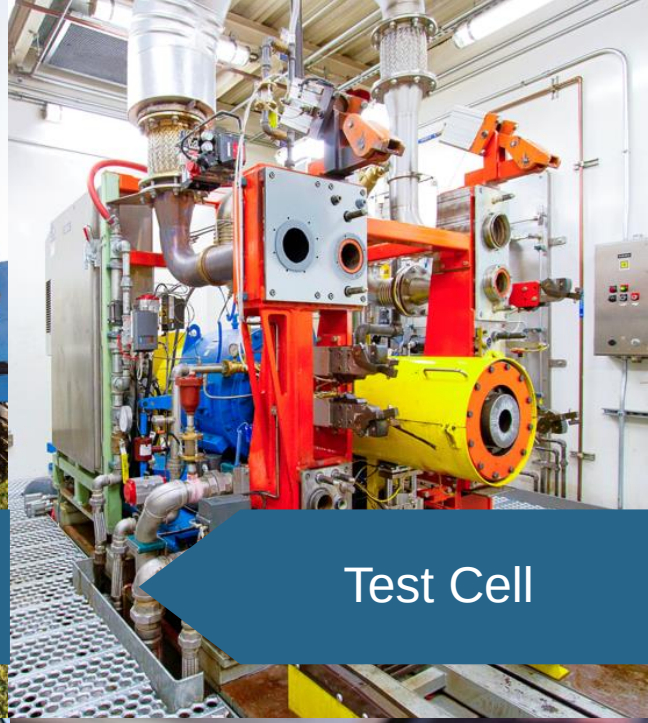
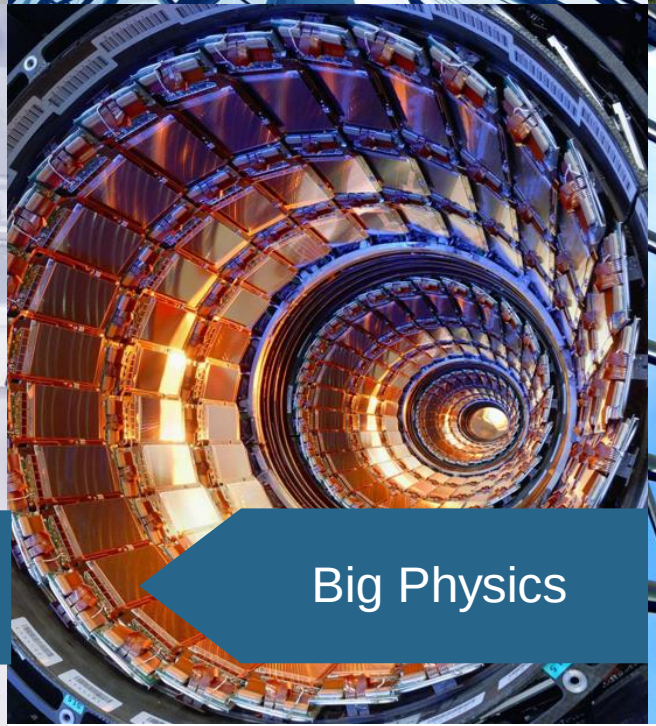
Machine Control


Smart Grid


FireFly
EQUIPMENT
ProSlab 155
Heavy Equipment


Test Cell

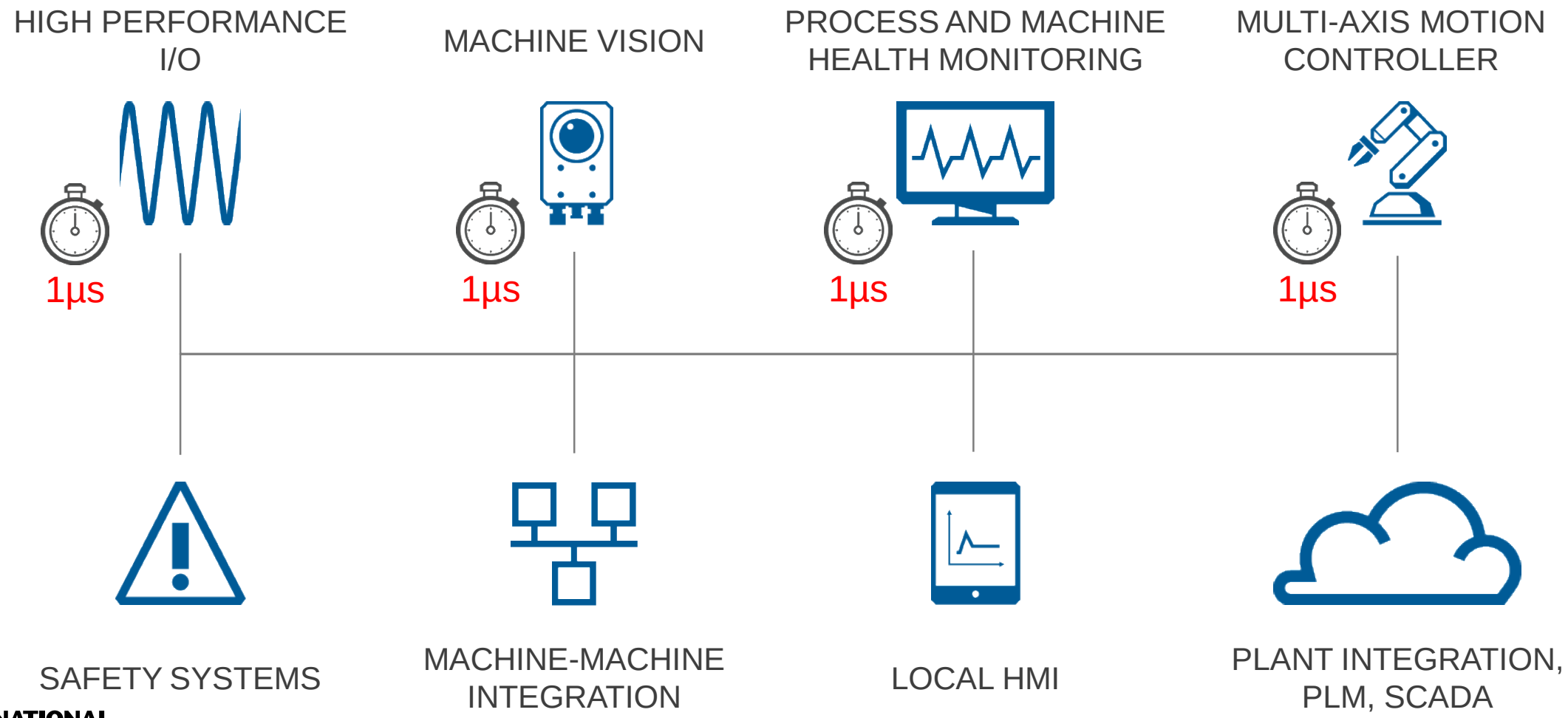

HIL


Big Physics


Structural Health

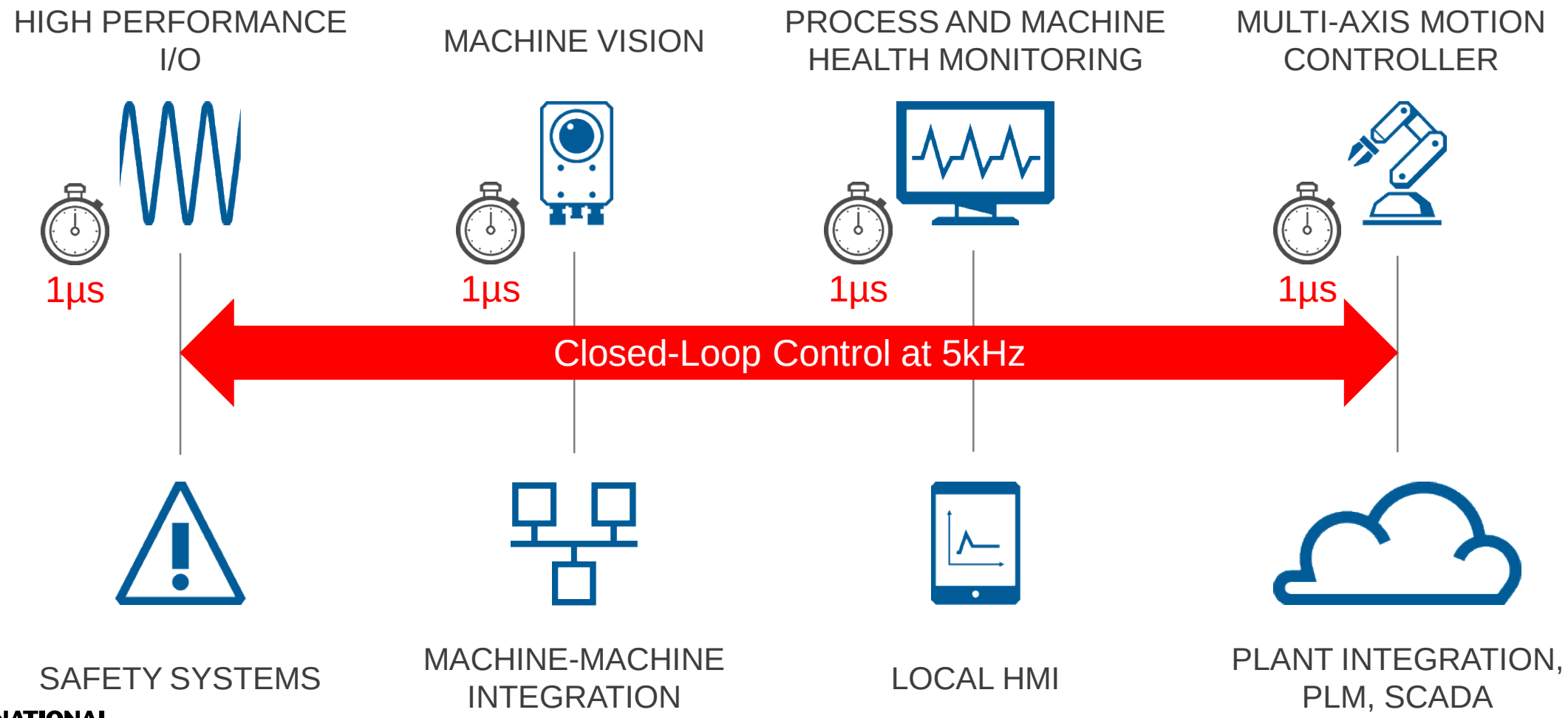

DIGITAL MULTIMETER
Test and
Measurement

Modern Machines



NATIONAL INSTRUMENTS

Modern Machines



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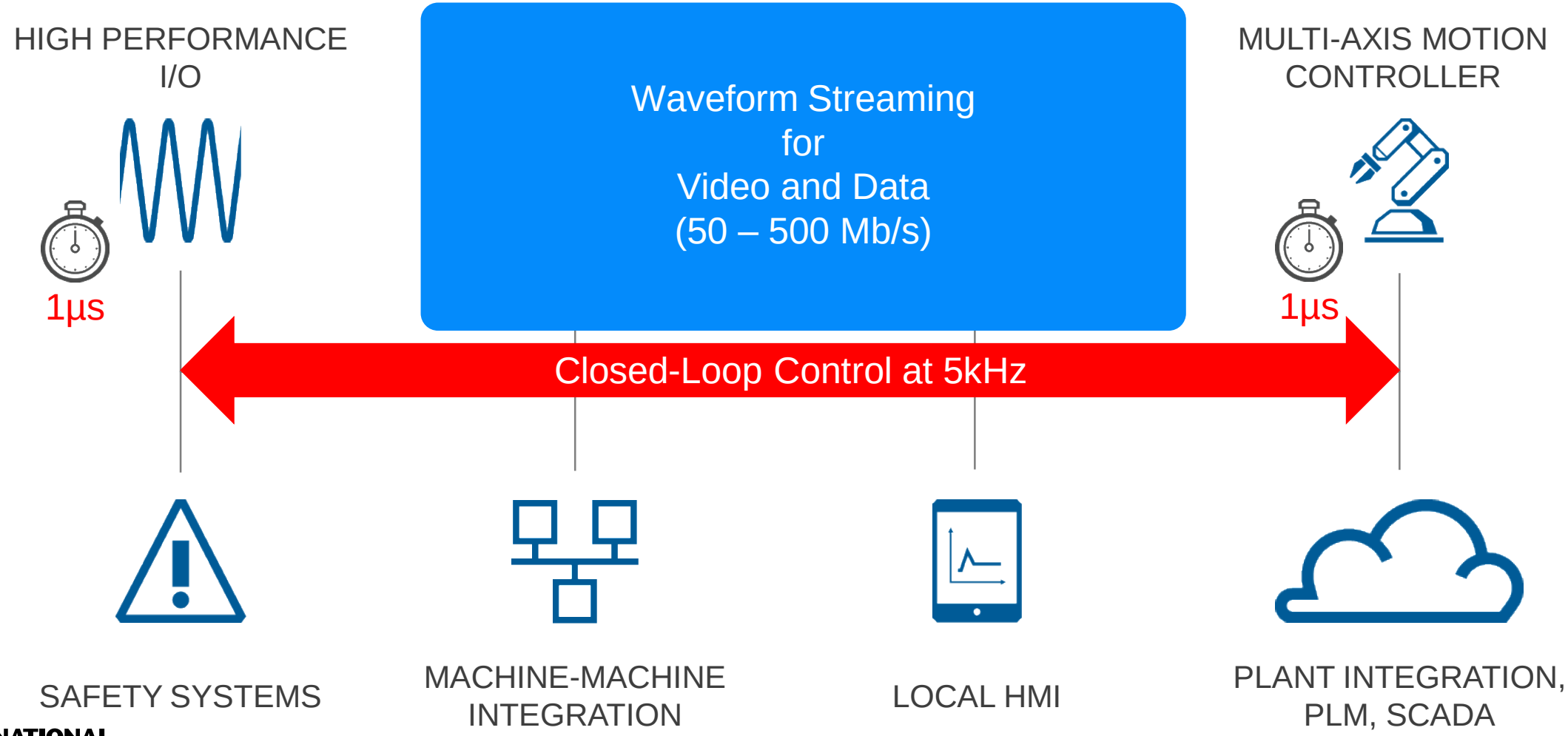
Modern Machines



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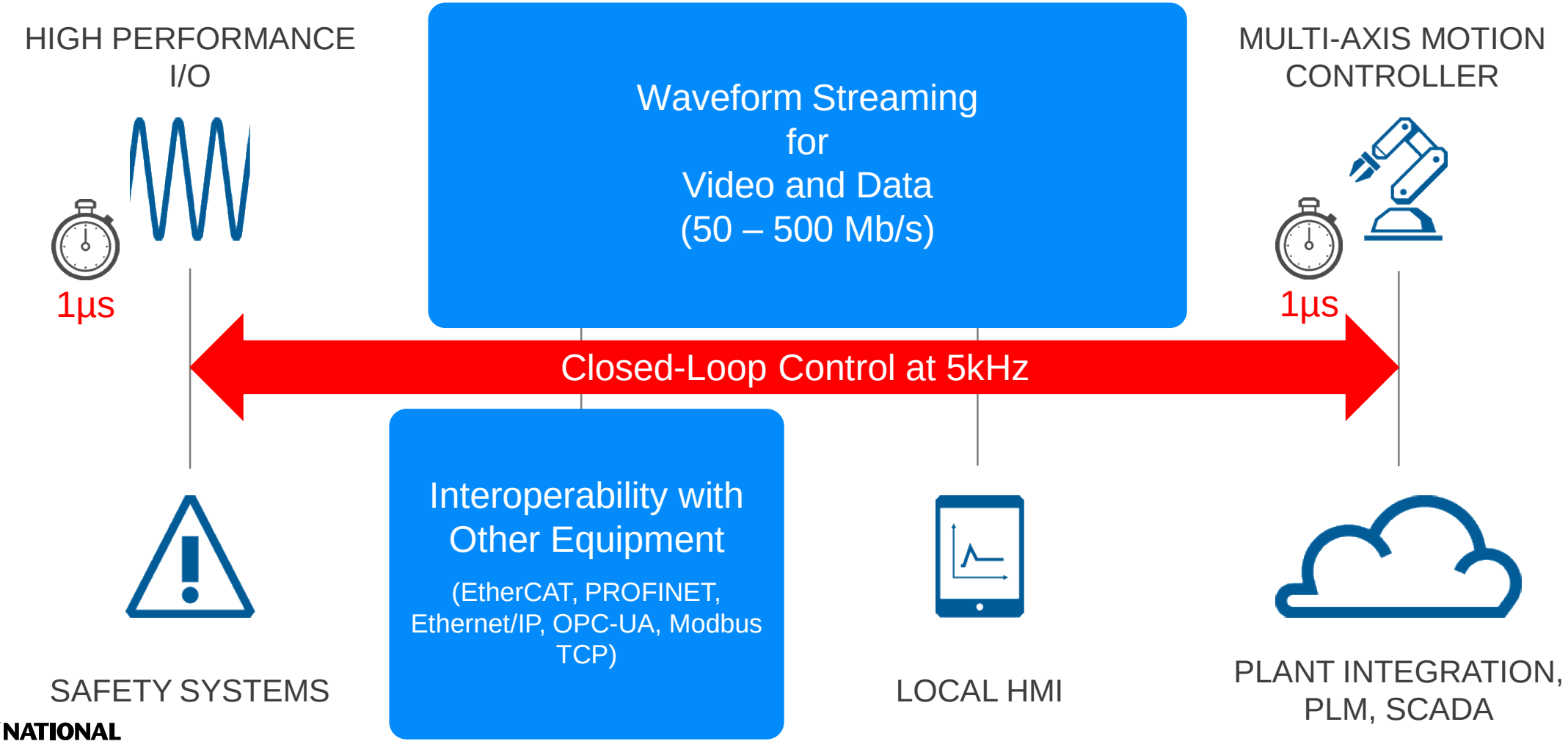
Modern Machines



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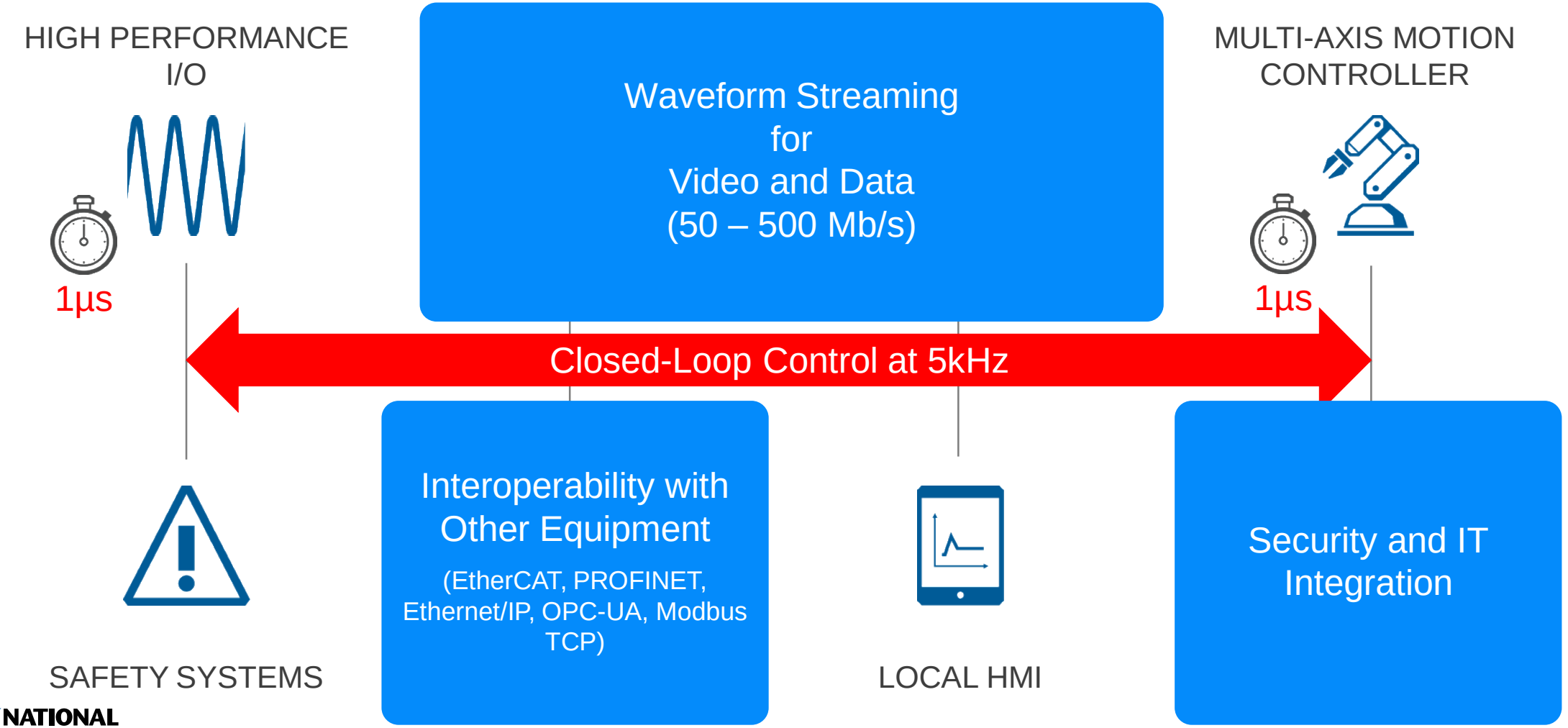
Modern Machines



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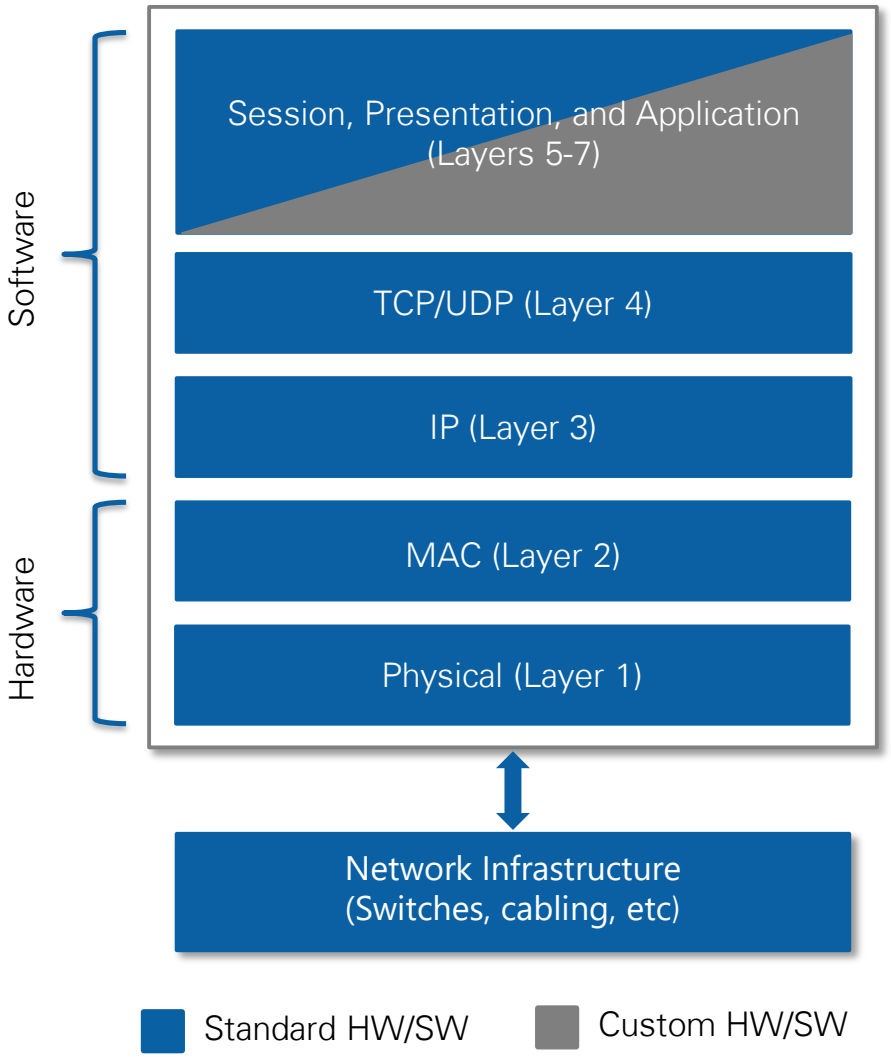
Standard Ethernet



"Standard" Ethernet

- Best-in-class approach for **openness and interoperability**
- Cannot bound latency (needed for control applications)
- Cannot guarantee bandwidth (needed for reliability)

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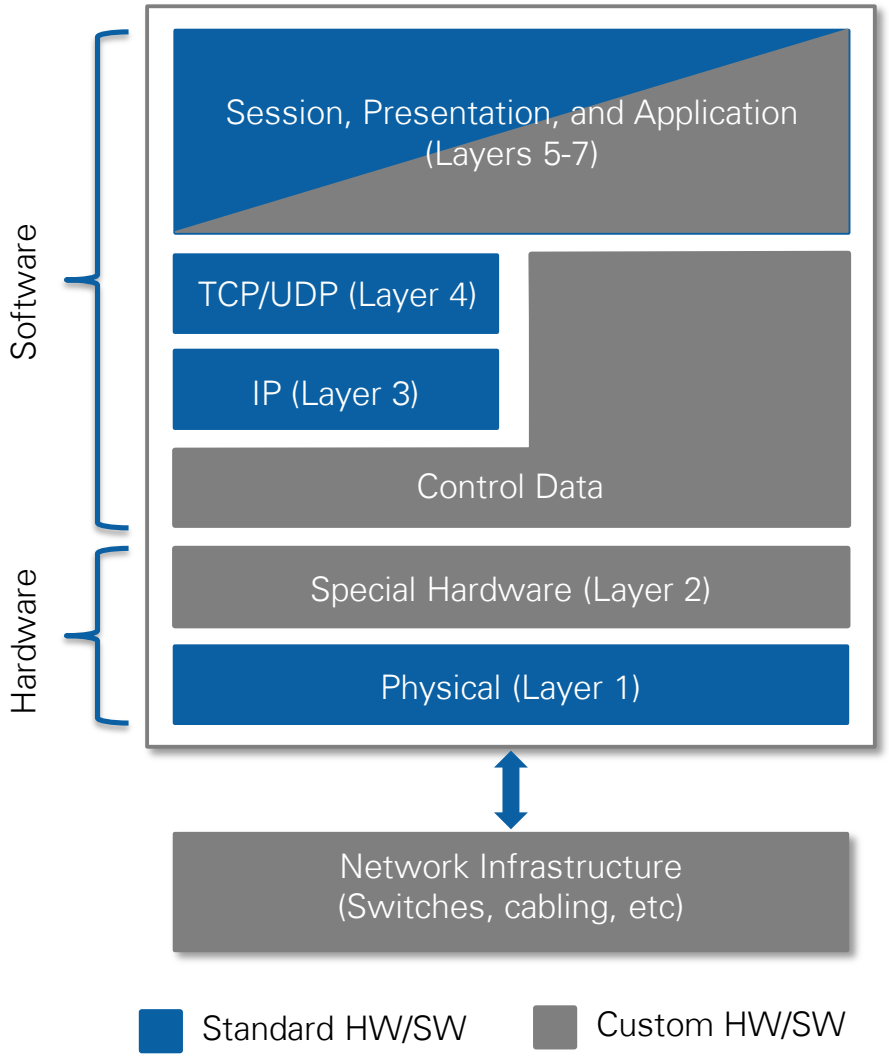
Hard Real-Time Ethernet



"Hard Real-Time" Ethernet

- Best-in-class approach for latency and control
- Cannot "share the wire" (no third party devices)
- Cannot scale with Ethernet (e.g. limited to 100 Mb/s)
- Proprietary HW/SW increases costs

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Technical Needs of Communications

Feature	Need	Needed For
Guaranteed Bandwidth	Enable validation & analysis of system ability at design time	Reliable Operations
High Bandwidth	Enable high channel data and high speed streaming	Streaming of Data
Bounded Latency (and low)	Prioritize isochronous data over best effort on the same interconnect to maintain specified latency	Control Applications
Clock Synchronization	Allowing producers and consumers of isochronous data to be phase coordinated Allow Application synchronization	Synchronized IO and Distributed Control
Distance	Enable separation of IO from controller or measurements of physically large systems	Application Dependent
Topology	Provide physical options for wiring	Application Dependent
Ecosystem	Enable the inclusion of third party devices such as drives	Application Dependent

Time Sensitive Networking

TSN is not an industrial communication protocol

TSN is an evolution of Ethernet

IEEE Time Sensitive Networks Overview

Standard	Area	Title
IEEE 802.1ASrev, IEEE 1588	Timing & Synchronization	Enhancements and Performance Improvements
IEEE 802.1Qbu & IEEE 802.3br	Forwarding and Queuing	Frame Preemption
IEEE 802.1Qbv	Forwarding and Queuing	Enhancements for Scheduled Traffic
IEEE 802.1Qca	Path Control and Reservation	Path Control and Reservation
IEEE 802.1Qcc	System Configuration	Enhancements and Performance Improvements
IEEE 802.1Qci	Time Based Ingress Policing	Per-Stream Filtering and Policing
IEEE 802.1CB	Seamless Redundancy	Frame Replication & Elimination for Reliability

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…

Additional Enhancements to Come

IEEE Time Sensitive Networks Overview

Standard	Area	Title
IEEE 802.1ASrev, IEEE 1588	Timing & Synchronization	Enhancements and Performance Improvements
IEEE 802.1Qbv	Forwarding and Queuing	Enhancements for Scheduled Traffic
IEEE 802.1Qcc	System Configuration	Enhancements and Performance Improvements

Time Sensitive Networking: Key Elements

Time Synchronization

Traffic Scheduling

System Configuration

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Time Sensitive Networking: Key Elements

Time Synchronization

Traffic Scheduling

System Configuration

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802.1AS Network Configuration

Time Synchronization

- 802.1AS devices are automatically synchronized when connected
  - < 1uS synchronization
  - Can be much lower when optimized
- Sync unaffected by cable length
  - 802.1AS uses packets, not signals to synchronize
  - Ethernet/Fiber length specifications
- NI has tested up to 15 hops/line

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Synchronizing FPGA and NI-DAQmx

Hardware Components

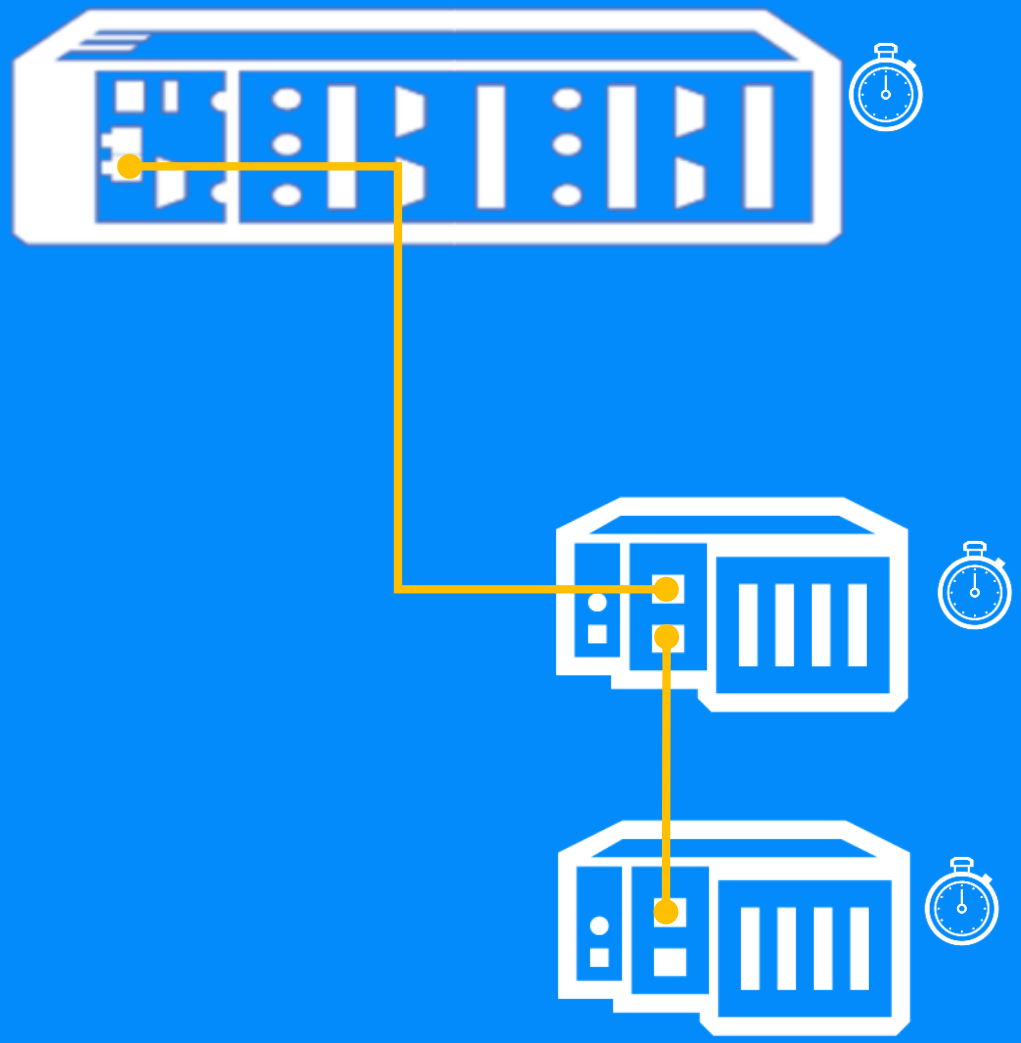
- CompactRIO Controller
- CompactDAQ Chassis
- Industrial Controller
- Cisco Switch

Symbols

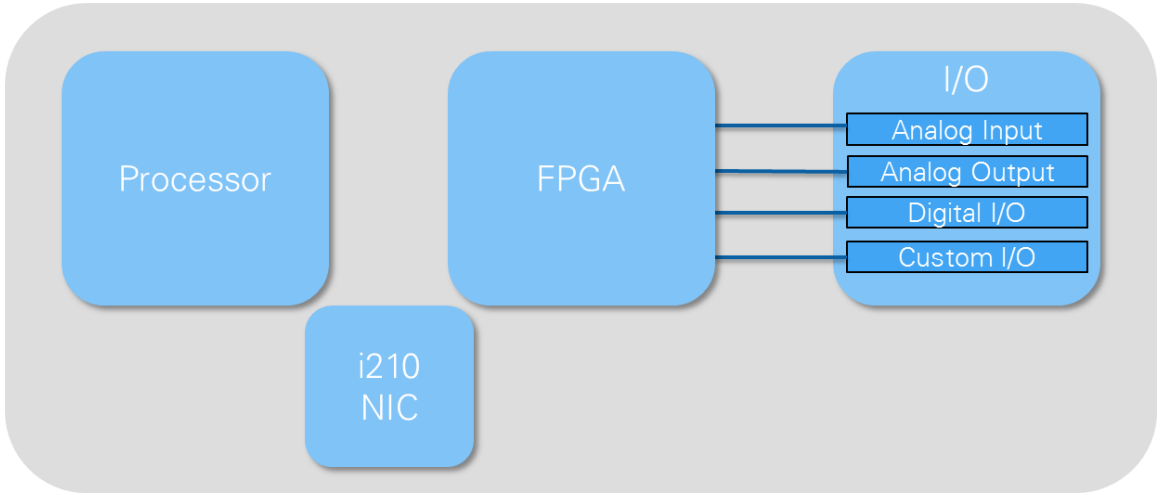
- Time Synchronization
- Scheduled Traffic

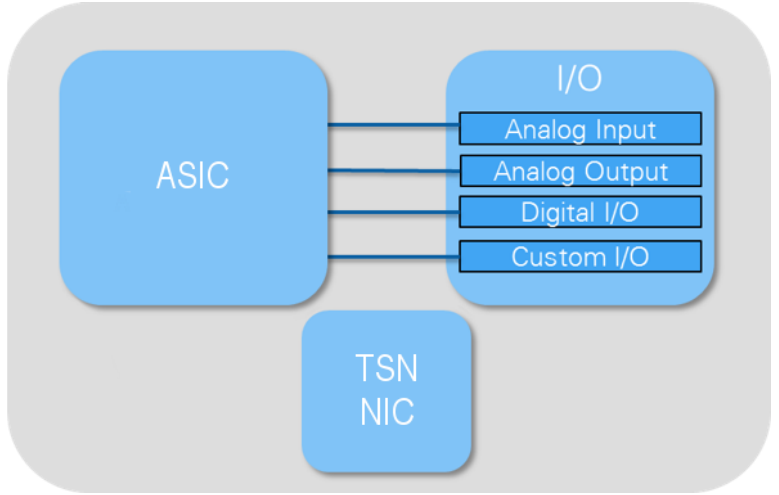
Network

- TSN
- Non-TSN



Network Time Synchronization with 802.1AS





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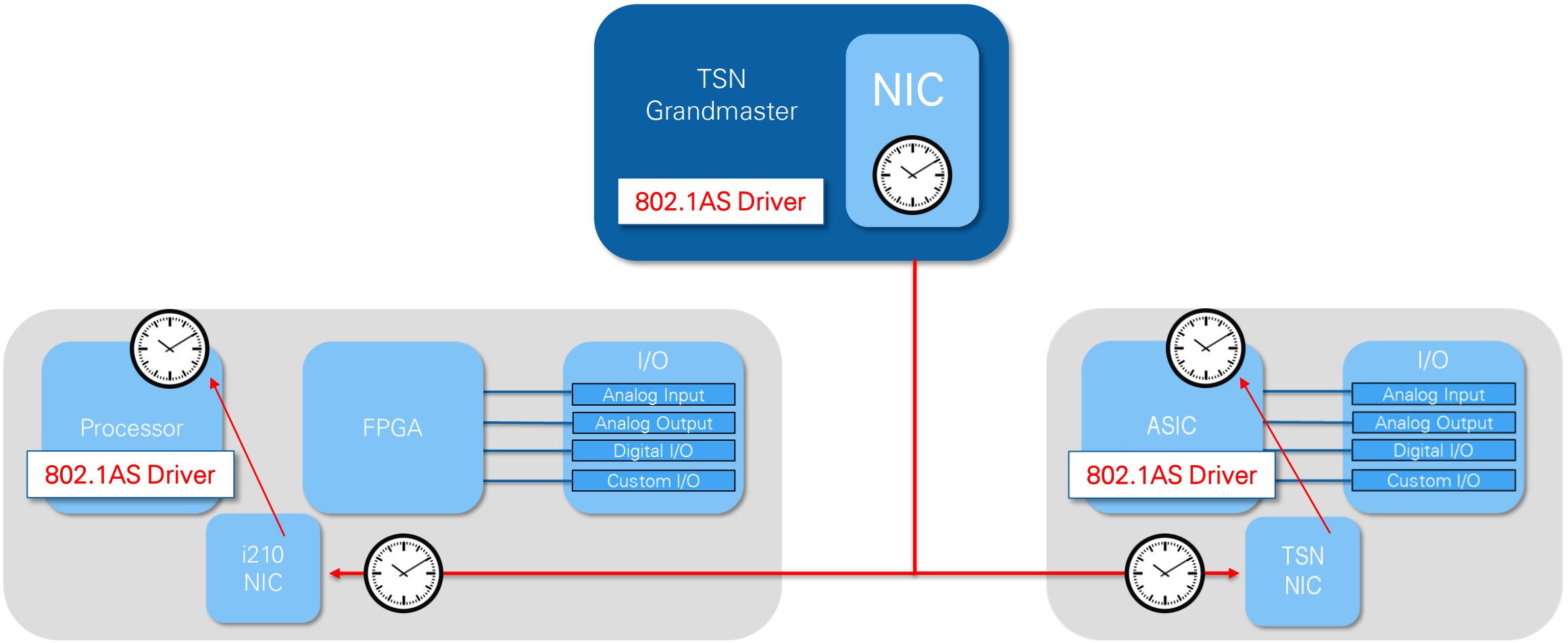
Network Time Synchronization with 802.1AS



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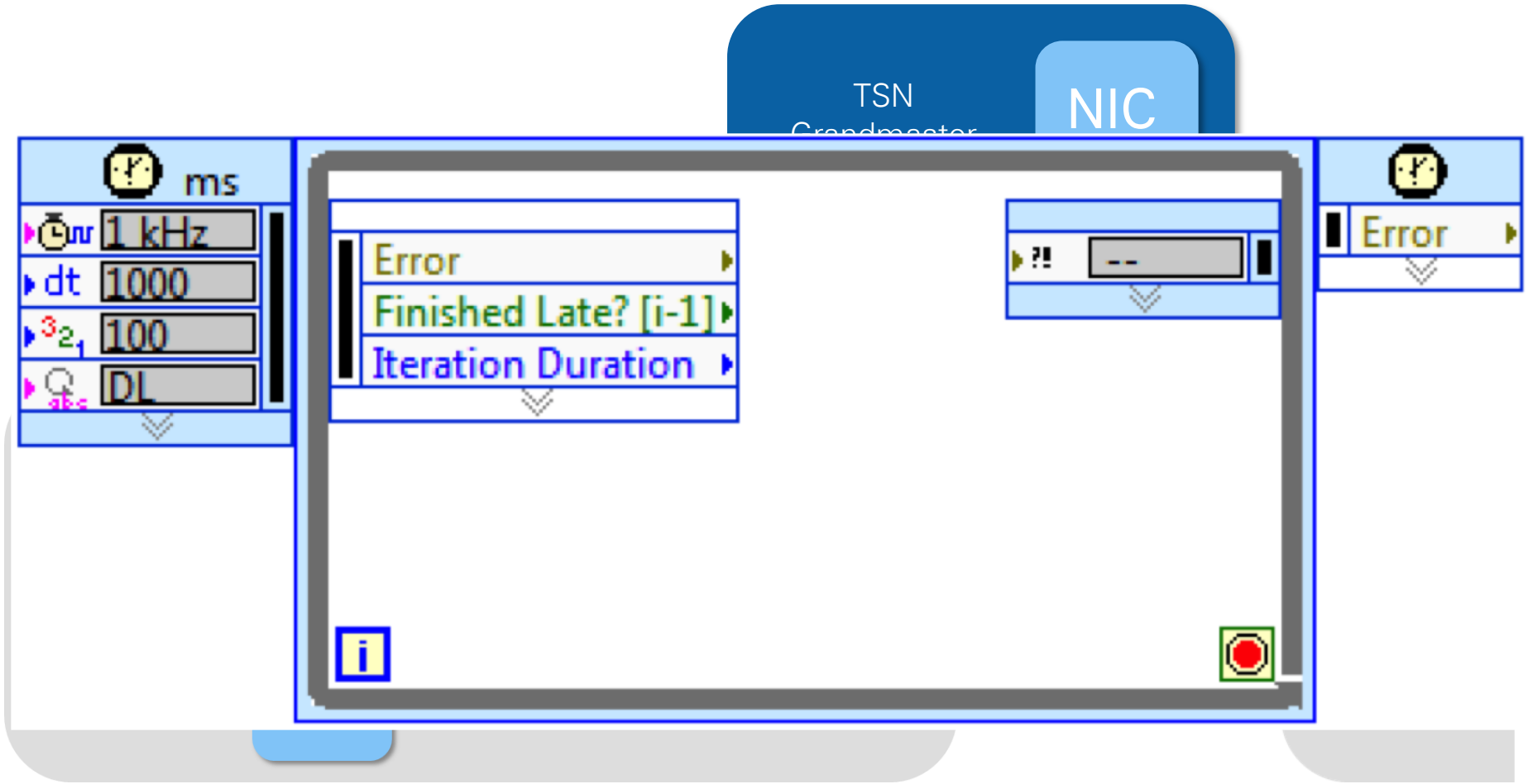
System Time Synchronization



Get Date/Time in Seconds.vi

RT Get Timestamp.vi

DAQmx
Start Time

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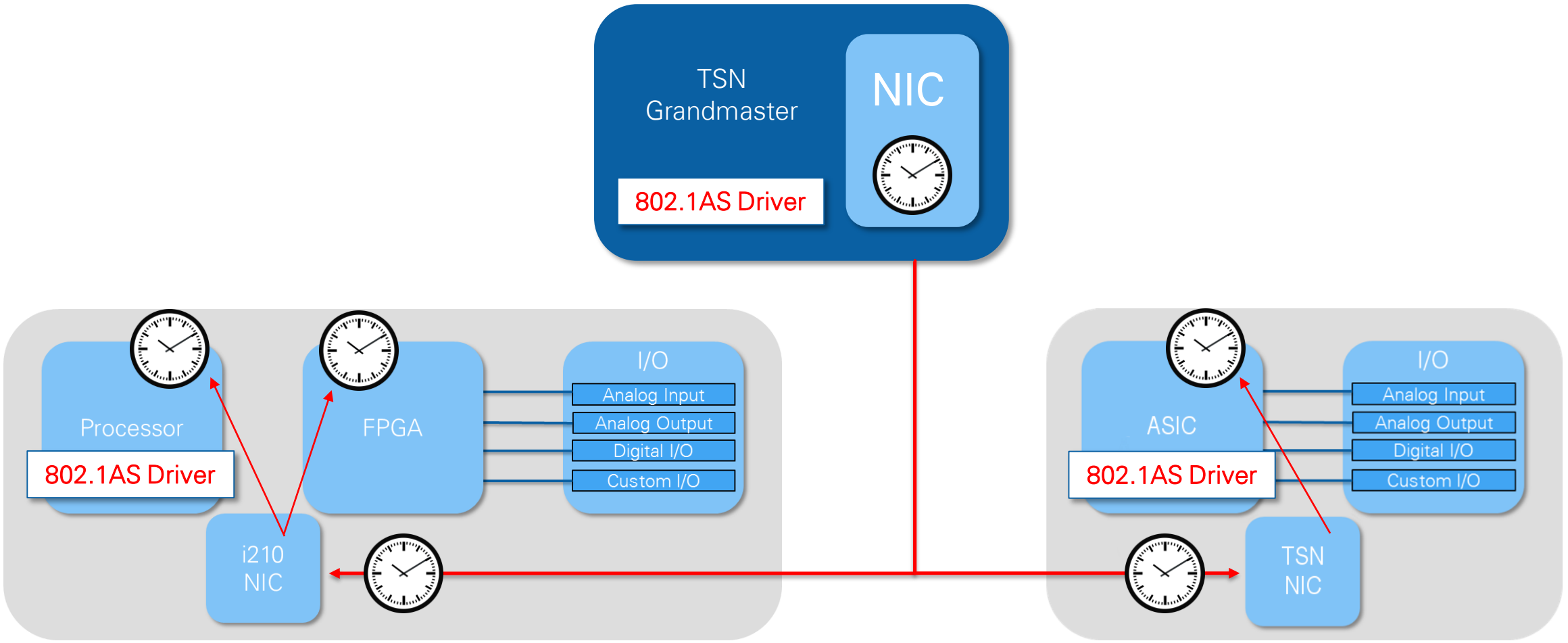
FPGA Synchronization



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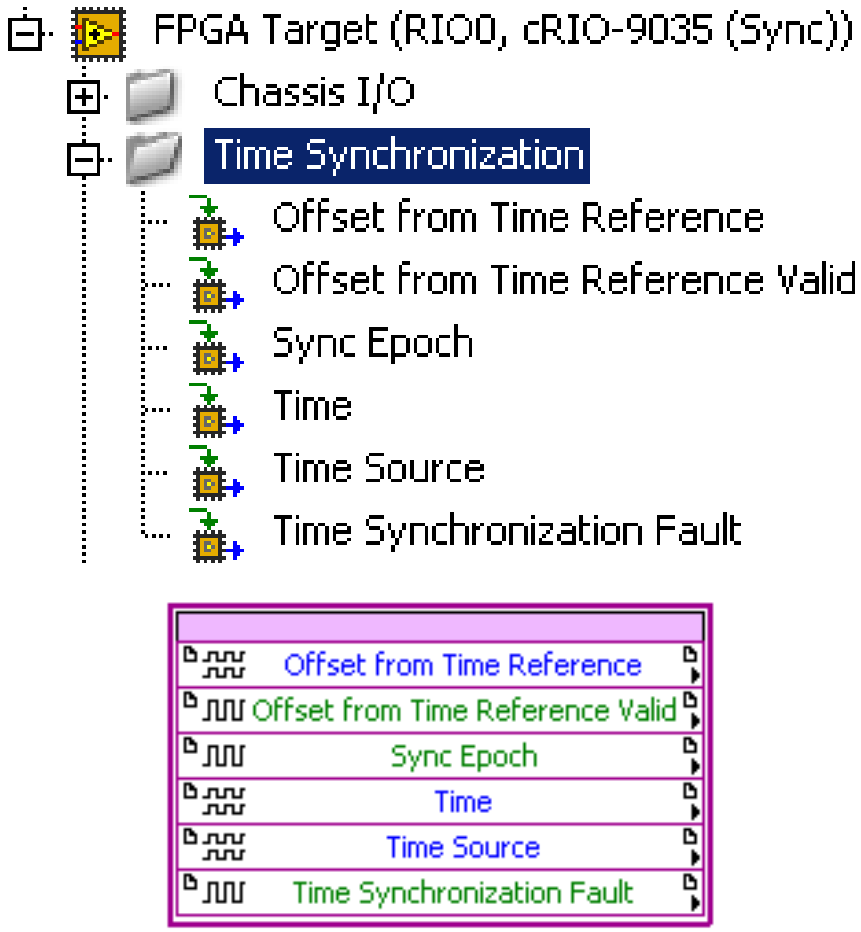
I/O Synchronization on FPGA

- 40 MHz FPGA Clock disciplined to Network Time
- New Time Synchronization registers
  - Current Network Time
  - Sync Source
  - Sync Error
  - Fault
- FPGA has concept of absolute time



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Time Sensitive Networking: Key Elements

Time Synchronization

Traffic Scheduling

System Configuration

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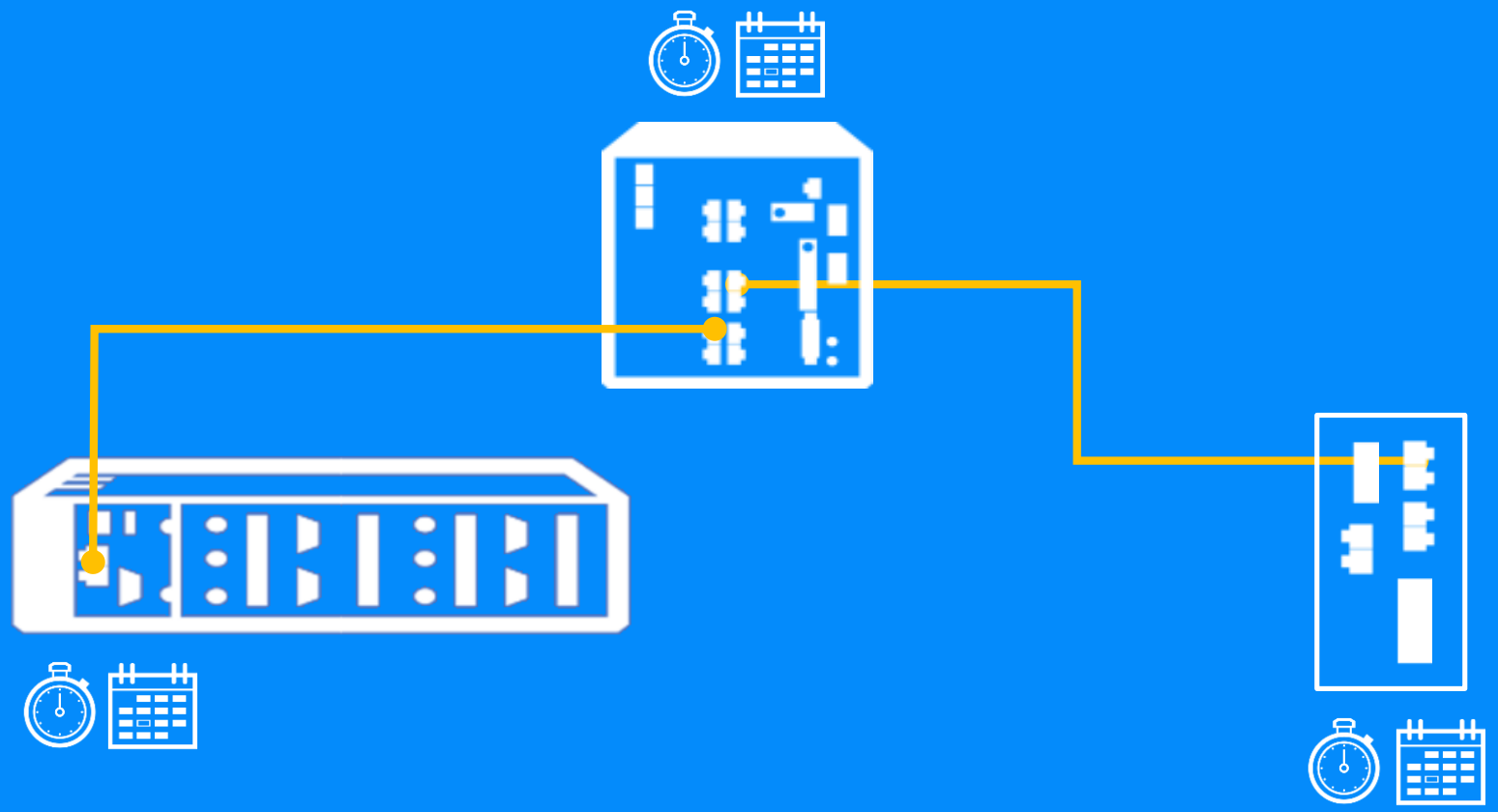
Distributed Deterministic Control



Hardware Components

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- Industrial Controller
- Cisco Switch

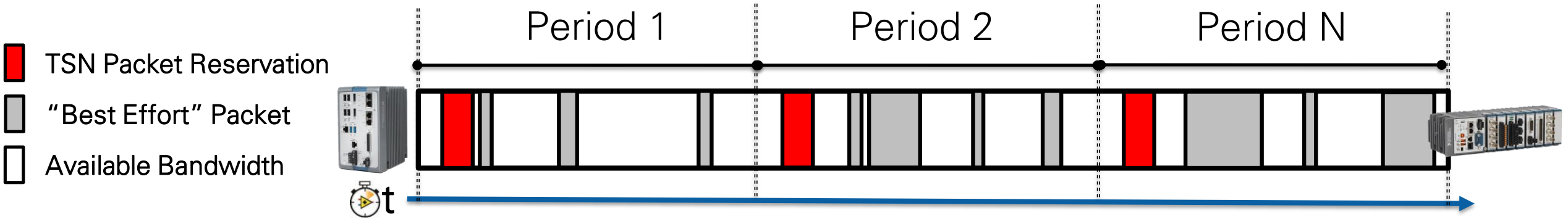
Symbols

- Time Synchronization
- Scheduled Traffic

Network

- TSN
- Non-TSN

Schedule Priority Traffic



- End devices and switches have a shared notion of time
- Time windows in each network period are reserved for TSN traffic

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The Evolution of Ethernet

Time Sensitive Networking

Convergence

Provides standardized management tools which can 'see' everything on an Ethernet network

Synchronization

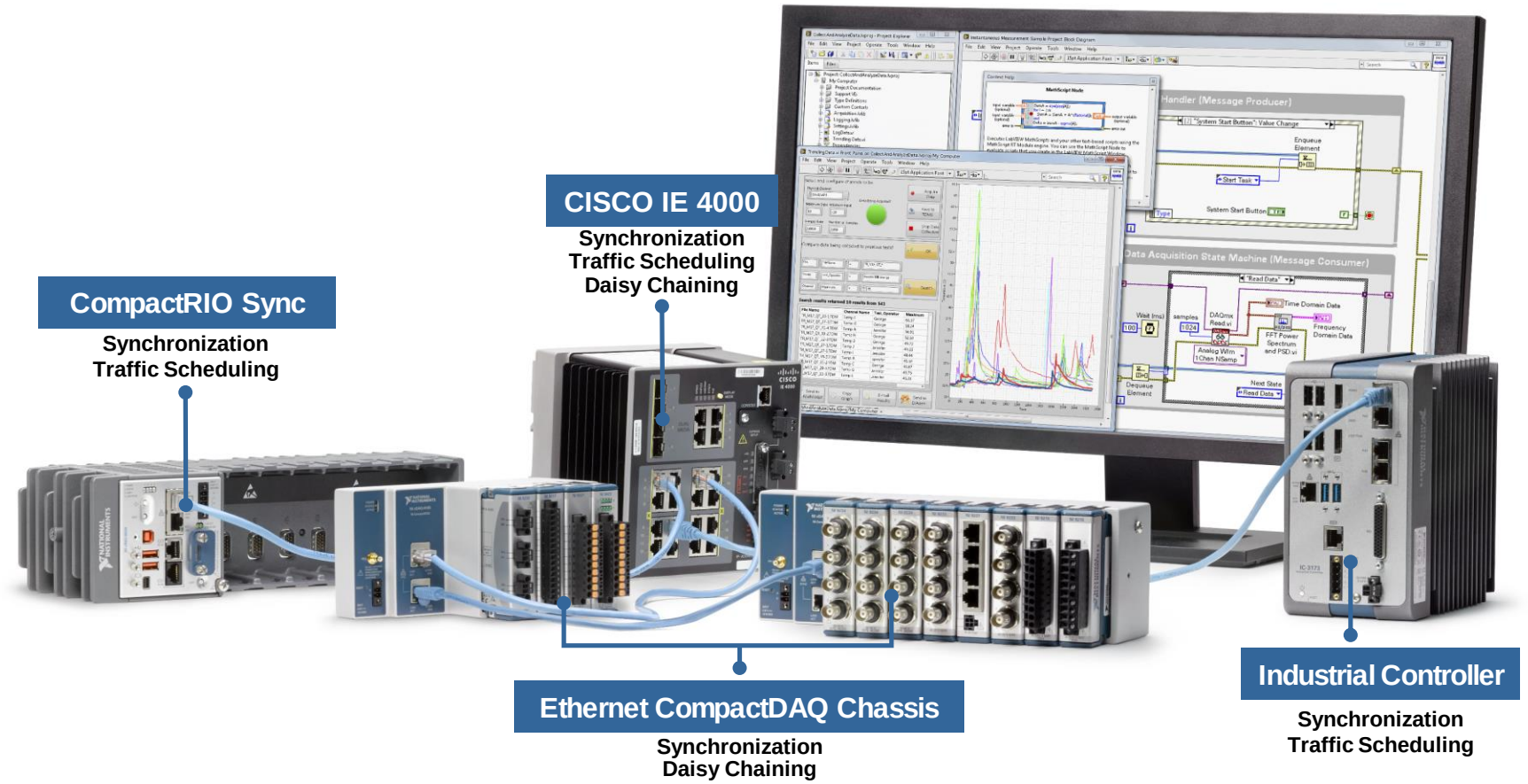
Correlated analytics across subsystems and distributed networks

Interoperability

Choose best in class equipment for your application

NI's Approach

Take advantage of NI leadership in standard's bodies and 30 years of **investment in industry technology**




Flexible Manufacturing Testbed (TSN)
SCHNEIDER ELECTRIC
NATIONAL INSTRUMENTS
NATIONAL INSTRUMENTS

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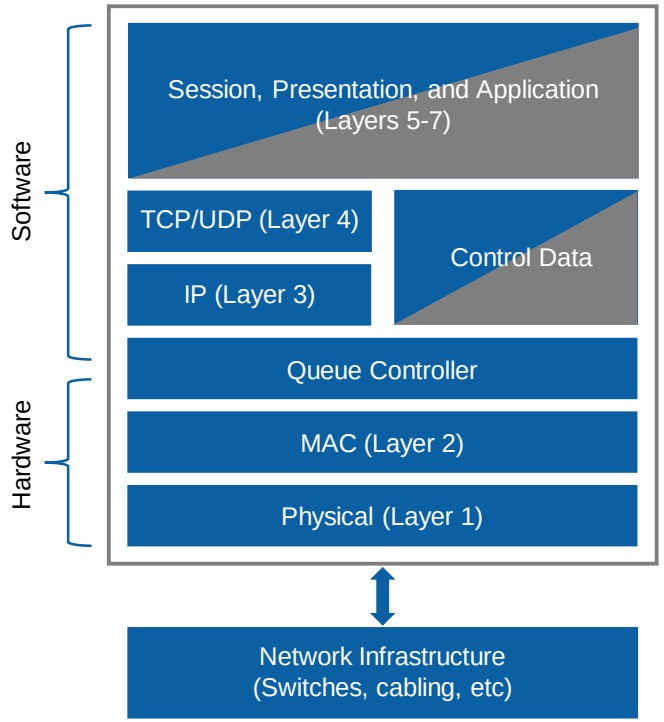
IEEE writes standards for OSI model



OPC FOUNDATION
IEC 61850
ODVA

industrial internet CONSORTIUM

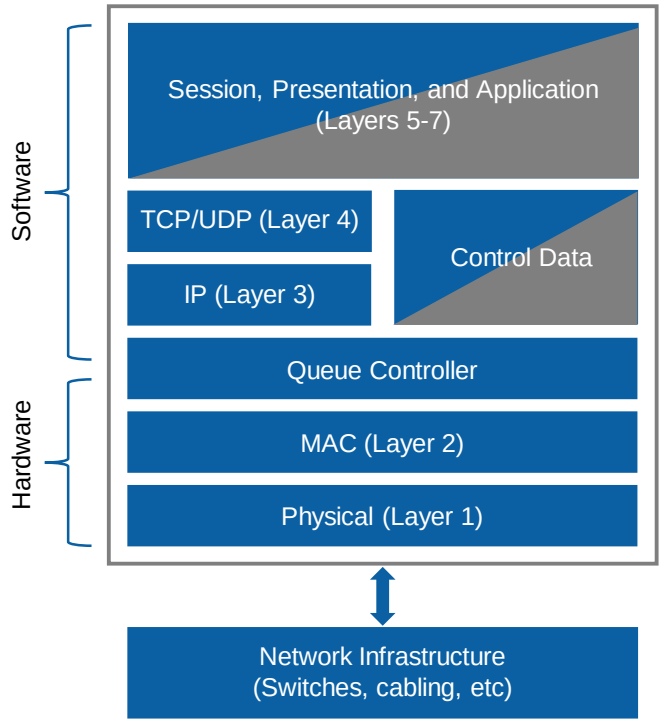
AVNU

IEEE
IETF

NATIONAL INSTRUMENTS

NATIONAL INSTRUMENTS

IEEE writes standards for OSI model



AVNU analogous to WiFi alliance

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TSN Testbed
(Flexible Manufacturing Testbed)

OPC FOUNDATION
IEC 61850
ODVA

industrial internet CONSORTIUM

AVNU

IEEE
IETF

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TRENDING TECHNOLOGY

Time Sensitive Networking

TSN is a deterministic enhancement to Ethernet, a foundational piece of the IIoT. This enhancement is key for industrial applications, such as process and machine control, where low communication latency and minimal jitter are critical to meeting closed-loop control requirements. Together with several other Industrial Internet Consortium (IIC) members, NI has been hard at work to bring TSN to life as the first fully open, standard, and interoperable way to fulfill these requirements.

LEARN MORE ABOUT TSN

ni.com/iiot

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Thank you!

claudio.cupini@ni.com

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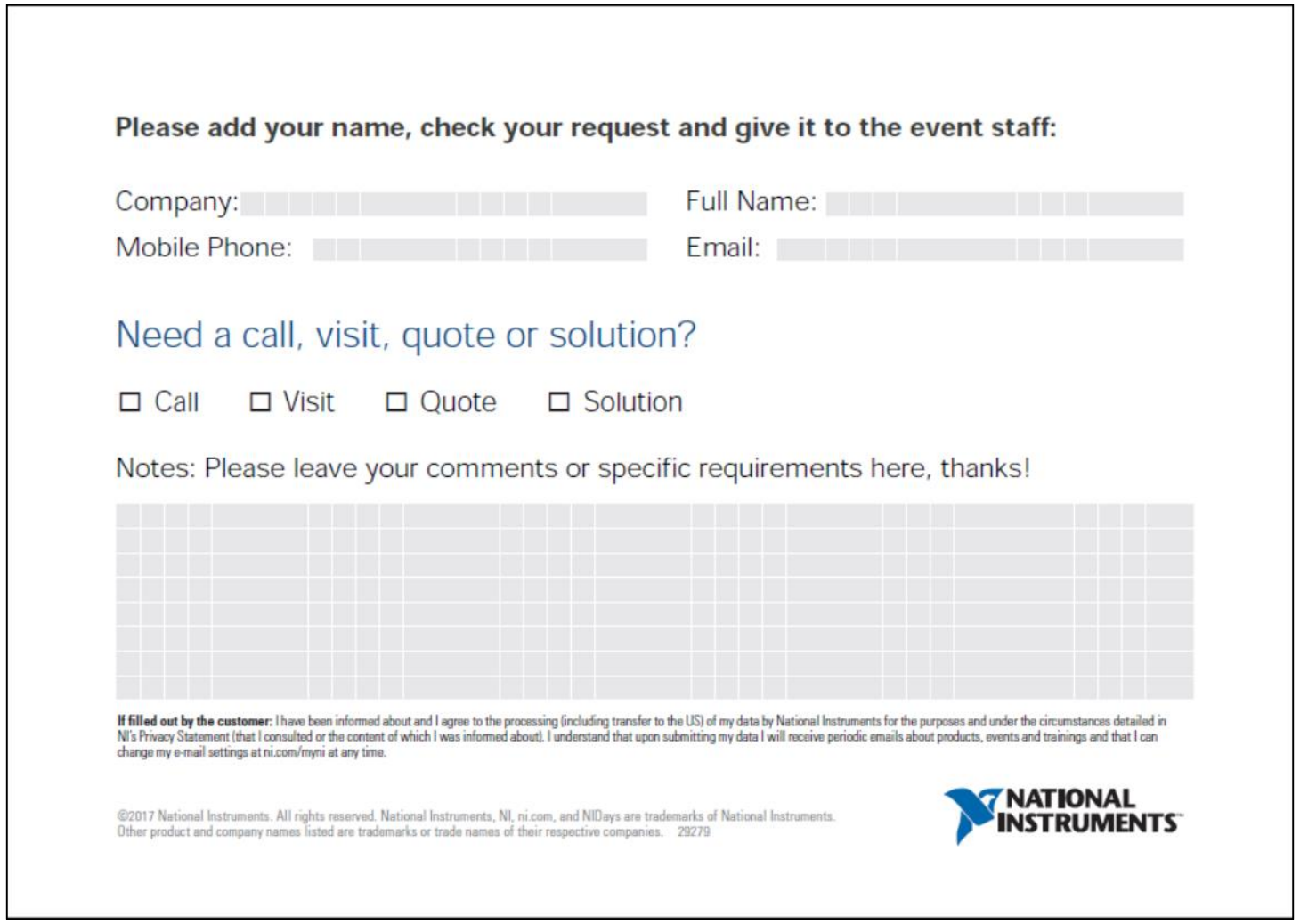
Compila la contact card e inseriscila in una delle apposite teche oppure consegnala al personale presente in reception.



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