Webinar

Revolutionizing factories with real-time communication

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System Engineering & Marketing

Agenda

- Factory real-time communication introduction
- Benefits of real-time communication
- Industrial protocols and emerging protocol trends
- Use case examples
- Future trends
- Summary and conclusion
- Live Q&A

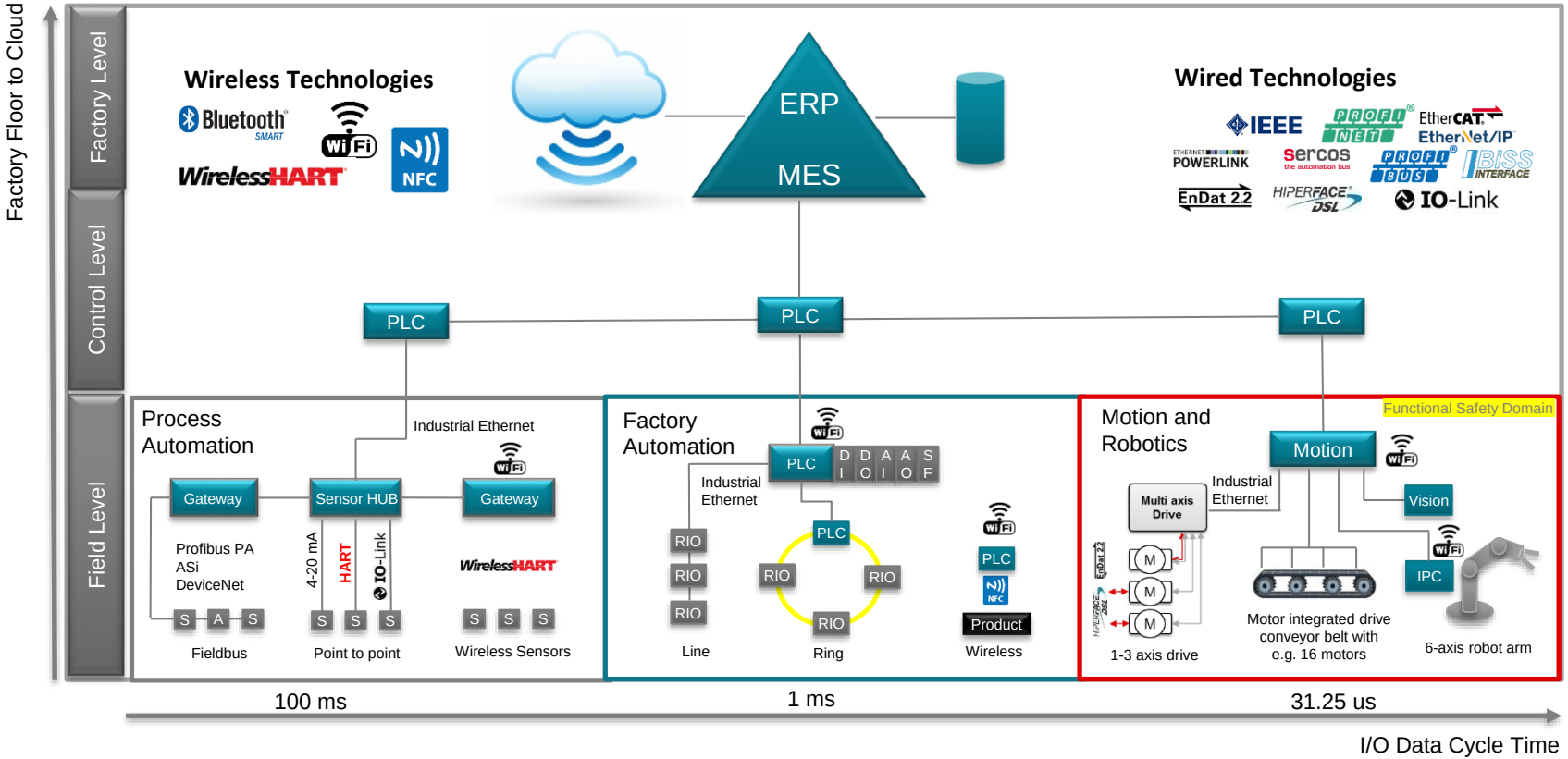
Intro | Factory real-time communications

Industrial networks found in factories include communication technology that improves data communication quality, reliability and real-time performance.

Some key challenges designers for factories face

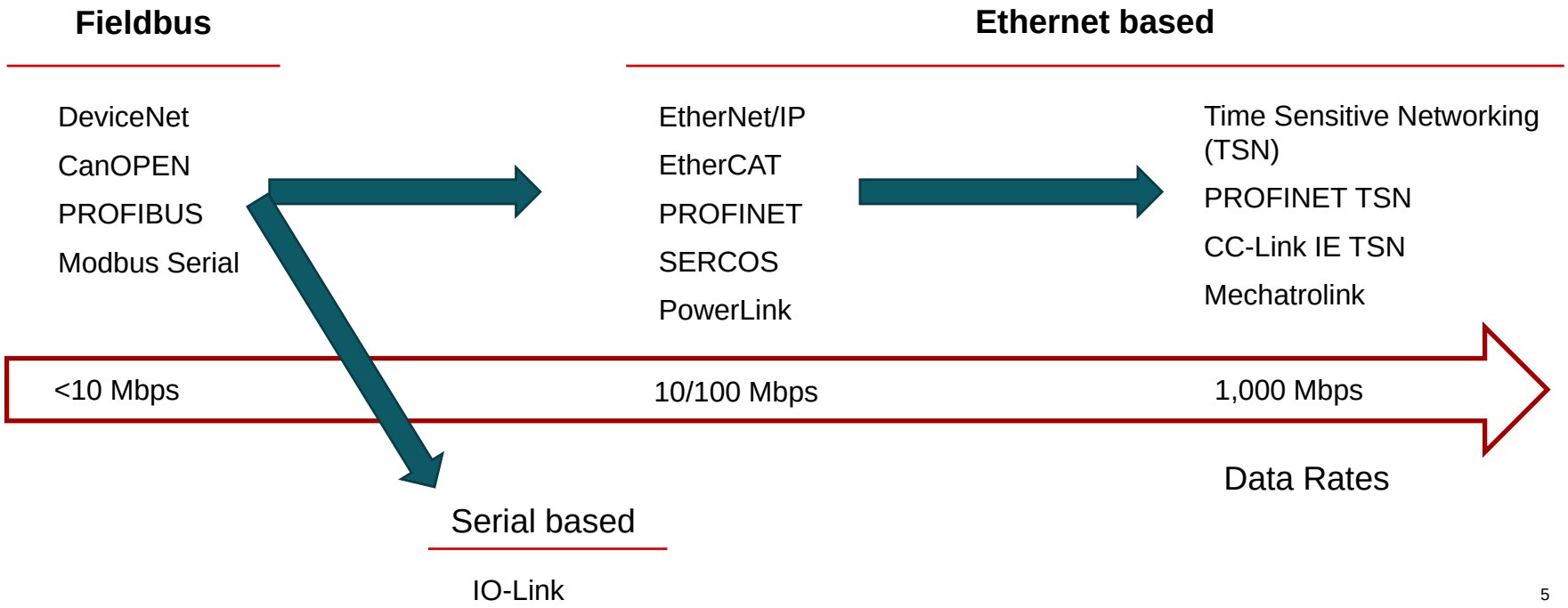
- Visibility and control of equipment to cloud/management
- Reduce IO data exchange cycle time
- Security and Reliability
- Interoperability across vendors and compliance to specifications
- Upgrade and future-proofing

Real-time communication in factory automation

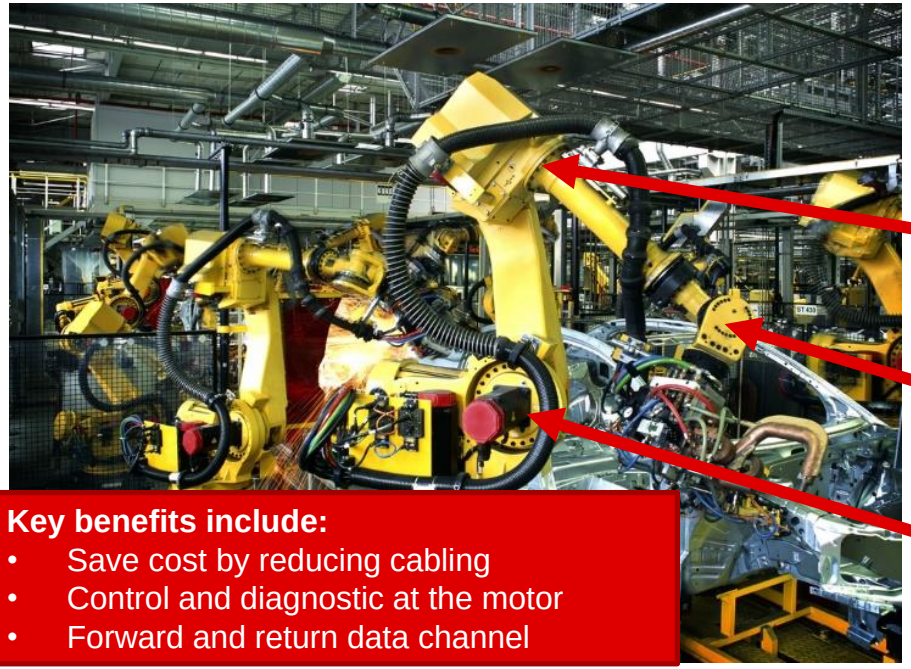


Real-time communication evolution

Over the years, there has been different versions of industrial communications.

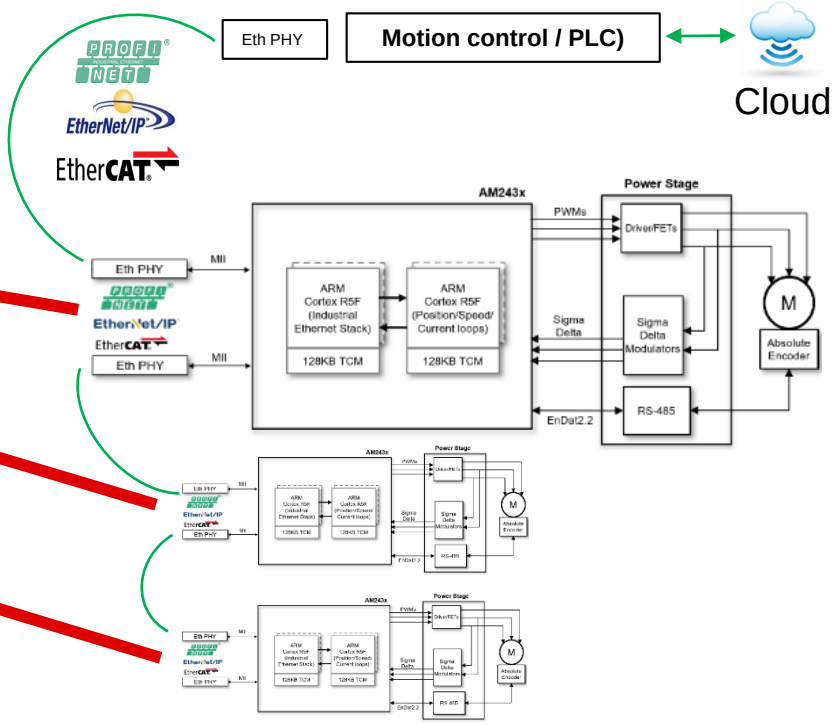


Benefits for adding real-time communication to robotics



Key benefits include:

- Save cost by reducing cabling
- Control and diagnostic at the motor
- Forward and return data channel



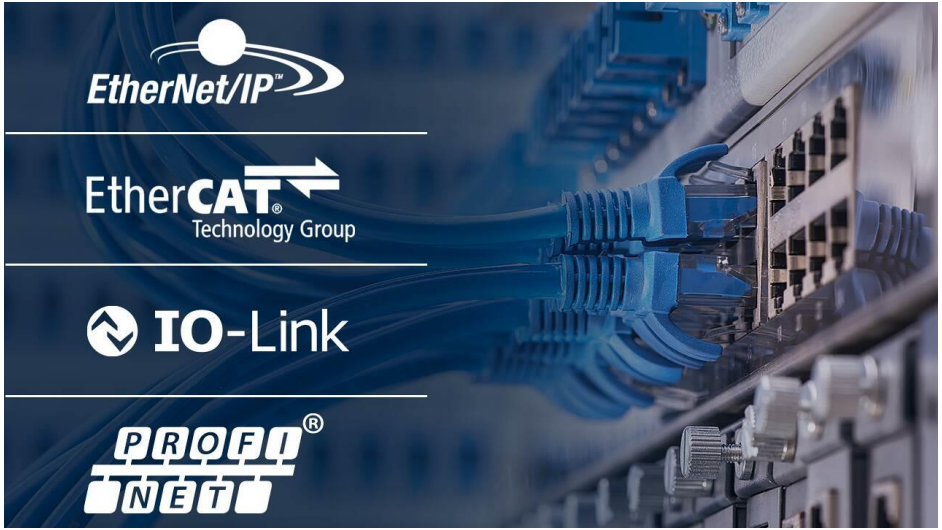
A robot arm is made of a controller controlling several (3 in this example) motors

Key protocols for factory applications

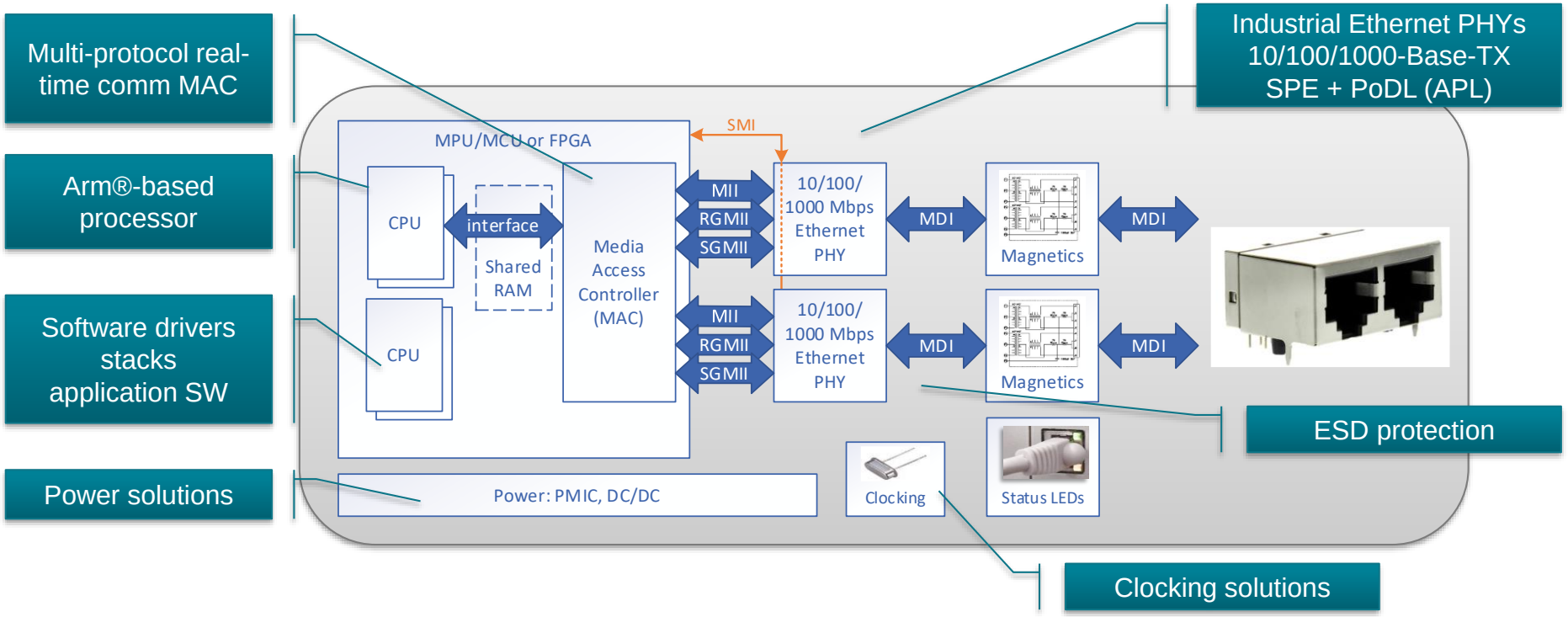
MORE PROTOCOLS | Time-sensitive network, MECHATROLINK, CC-Link IE TSN, SERCOS, POWERLINK, …

Increase efficiency and productivity in factory environments

- Connectivity technologies along with industrial protocols enable access to important factory data which allows factories to adapt process flow.
- Our large portfolio includes devices for networking and industrial communication and features diverse communication interfaces.

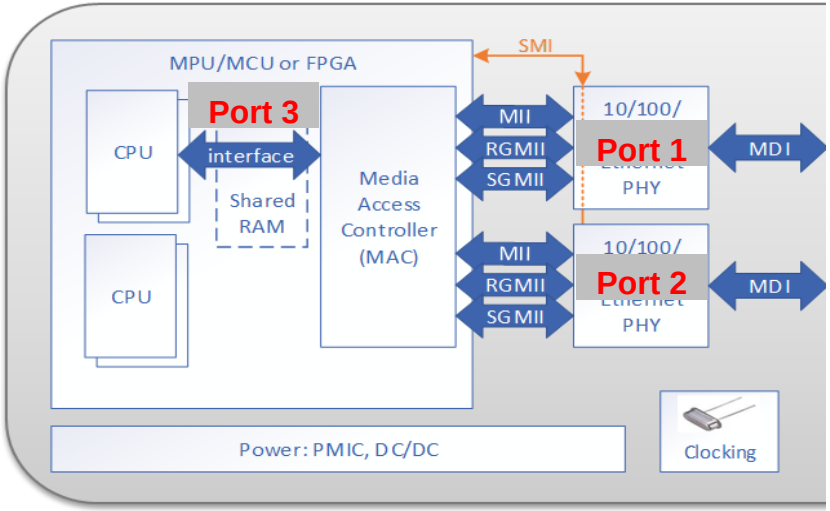


Industrial Ethernet system block diagram



Industrial Ethernet MAC and frame processing

- Media Access Controller (MAC)
  - **3-port switch (2 port + host port)**
  - **Protocol-specific MAC implementation**
- MAC frame processing methods:
  - **On-the-fly:** Frame is forwarded to second port and MAC read/write the frame.
    - Delay time: <1 µs (100Mbps)
  - **Cut-through:** MAC makes forward decision on frame header;
    - Delay time: 3-4 µs
  - **Store & Forward:** Legacy MAC; store complete frame in MAC memory before making forwarding decision;
    - 6.7 µs (64 Bytes) to 125 µs (1500 Bytes)



Applications for these methods:

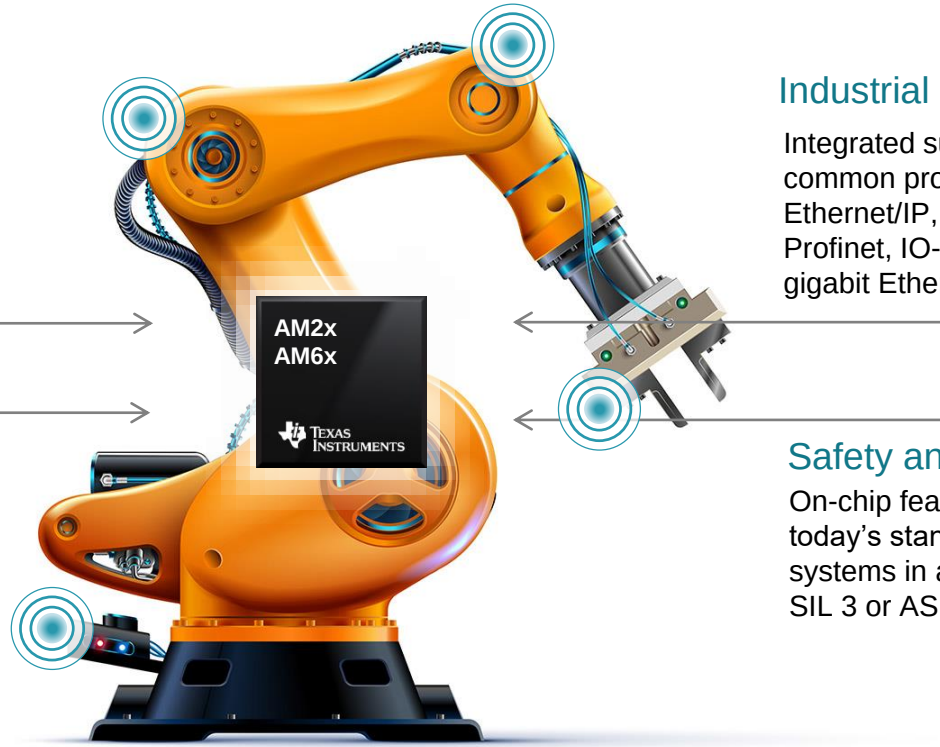
Processing, control and networking with a single chip

High-performance processing

Single and multicore devices, running up to 800 MHz per core, enable fast computations with less than 1 W of power consumption

Real-time control

Integrated sensing and actuation peripherals enable low-latency real-time control



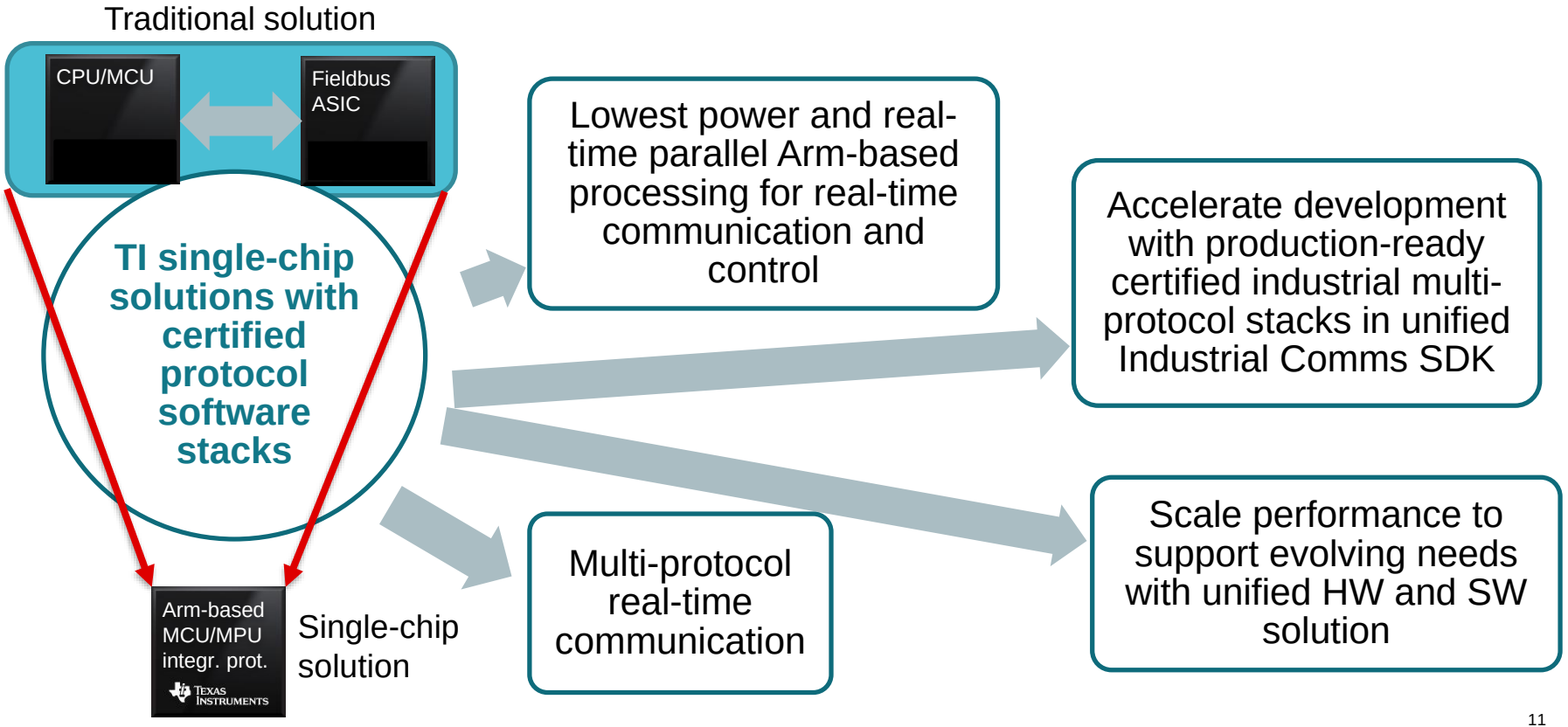
Industrial communications

Integrated support for common protocols including Ethernet/IP, EtherCAT, Profinet, IO-Link Master and gigabit Ethernet

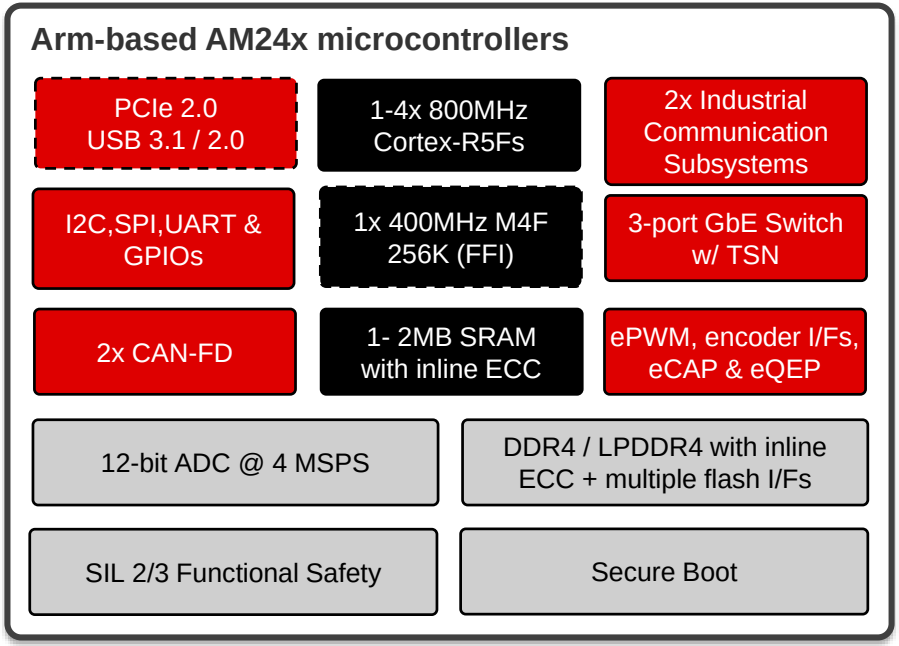
Safety and security

On-chip features help support today's standards and assist systems in achieving up to SIL 3 or ASIL D standards

Simplify industrial networking with processors



Arm-based microcontrollers for industrial networking



Safety & security

- ❑ Supports customer's system designs up **to SIL 3**. (IC targeting SIL 2)
- ❑ On chip security subsystem supports **secure boot**, firewalling of memory, key storage, crypto, security features.

Performance

- ❑ Up to 4x R5F real-time cores with up to 6.4K DMIPs

2x Industrial Communication Subsystems (ICSS)

- ❑ Programable real time peripheral I/F connectivity
- ❑ Multi-Encoder support

HIPERFACE DSL, EnDat 2.2, Tamagawa, IBiSS INTERFACE, sigma-delta, ΣΔ

- ❑ Multi-protocol industrial networking support

PROFINET, EtherNet/IP, EtherCAT, IO-Link

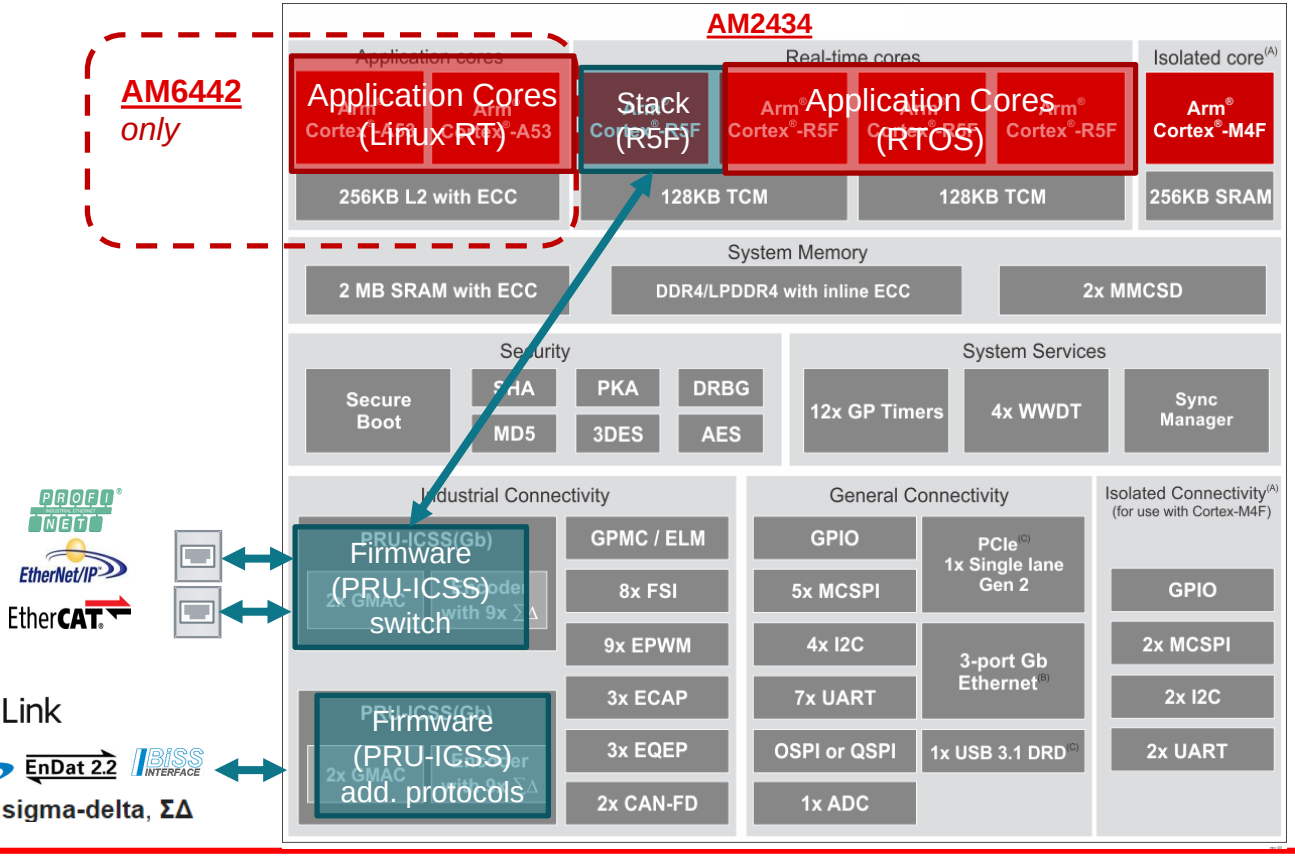
Gigabit Industrial Ethernet

- ❑ 3-port GbE TSN & cut-through switching (2-ext, 1-int port)
- ❑ Up to 5x independent GbE ports

Motor Control

- ❑ Up to 3 axis motor control (FOC, DTC)
- ❑ Multi-protocol position encoder support
- ❑ 18-bit on-chip sigma delta filters for current measurement

Arm-based processor software architecture



Software from TI

Application Software

Certified device protocol software stacks provided by TI

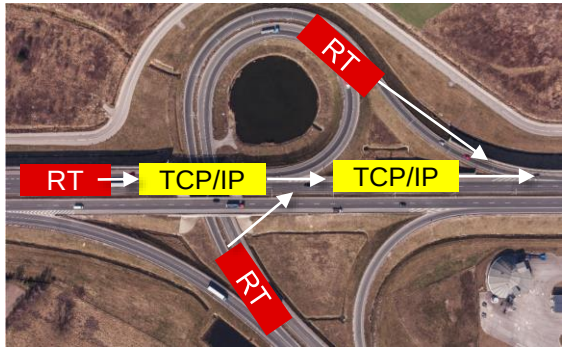
Protocol	Certified	Min. Cycle Time	Key features supported
EtherCAT	Yes	31.25 us	CiA402, CAN over EtherCAT (CoE), Servo Drive Profile (SoE), Ethernet over EtherCAT (EoE), File Access over EtherCAT (FoE),Distributed Clocks
EtherNet/IP	Yes	1 ms	Address Conflict Detection (ACD), Quality of Service (QoS), Device Level Ring (DLR), Precision Time Protocol (PTP)
PROFINET	RT/IRT: 1H24	1 ms (RT) 250 us (IRT)	Conformance Class A, B (RT), and C (IRT), Precision Time Control Protocol (PTCP), Media Redundancy Protocol (MRP)
IO-Link	Yes	All communication classes supported	Up to 8 channel IO Link Master per ICSS, IO-Link standard-compliant with Standardized Master Interface (SMI)

Detailed feature set for each protocol available in the INDUSTRIAL-COMMUNICATIONS-SDK release datasheets

** Additional real-time communication protocols are available via third-party stack provider*

Emerging protocols and trends

Protocols such as TSN and IO-Link are a few examples of emerging technologies being adopted into factory applications.



So what is TSN?

- Production systems in a modern factory are fully connected using real-time Ethernet. A time-sensitive network is a key technology with which to connect various control systems in real-time.
- Although the requirements for control systems are different in terms of scale, cycle time and accuracy, they can use the same communication interface to transfer data deterministically.

What is IO-Link?

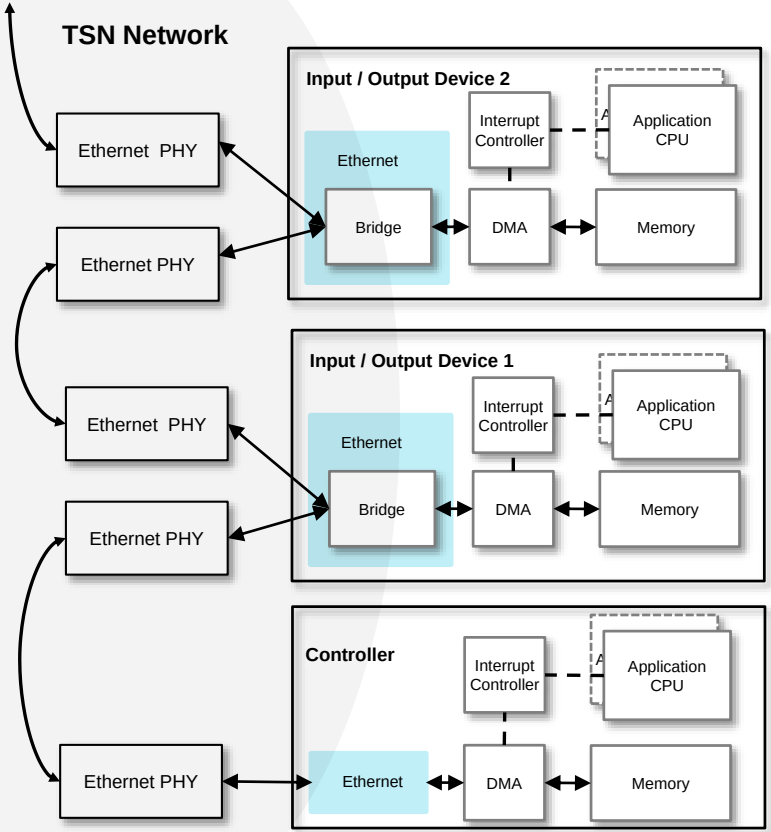
- Point-to-point communication protocol that connects sensors and actuators to industrial automation systems, enabling bidirectional data exchange and advanced device parametrization.
- Remote IO device example
  - Industrial Ethernet ports
  - Eight-port IO-Link Gateway

Source: PNO, TSN workshop

TSN standardizes real-time communication

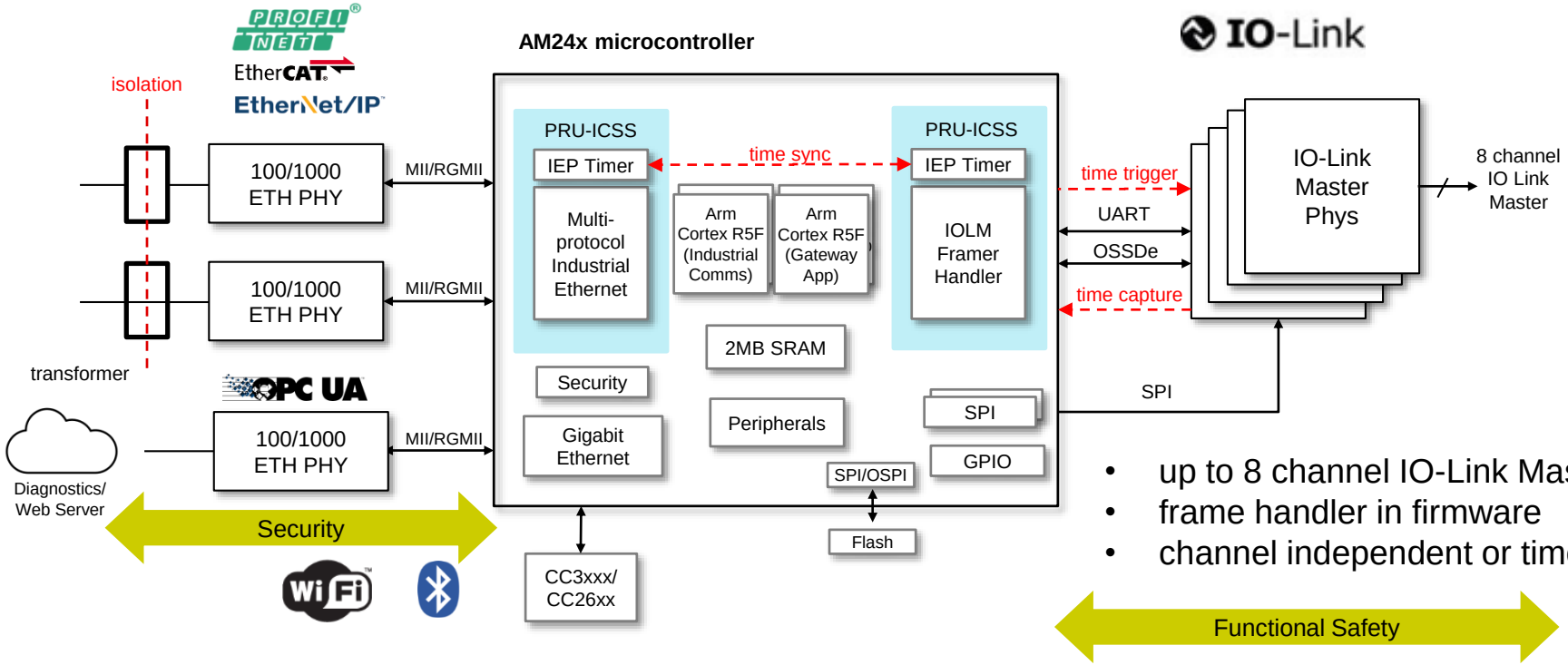
TSN is an umbrella term for several optional IEEE802.1Q Ethernet features for achieving real-time networking performance

- **Timing over packet** (802.1AS-2011, 802.1AS-2020, As-rev, IEEE1588)
- **Time aware shaper** (EST, 802.1Qbv)
- **Preemption** (IET, 802.1Qbu/802.3br)
- **Integrated switching including cut-thru** (not yet IEEE standard)
- **Credit based shaper** (AVB, FQTSS, 802.1Qav)
- **Redundancy** (FRER, 802.1CB)



*all but redundancy is supported by TIs arm-based processors and included in IEEE802.1Q-2018

Remote IO (gateway) | Industrial Ethernet to IO-Link Gateway



- up to 8 channel IO-Link Master
- frame handler in firmware
- channel independent or time sync

Long-reach Ethernet applications with single-pair Ethernet

Process automation

Field instrumentation

- Flow sensors
- Level sensors
- Pressure sensors
- Temp sensors
- Loggers
- Field switches

HART + Other field buses → **T1L Ethernet**

Building automation

- Fire alarm control
- HVAC control
- Elevators
- Security controls

RS485 → T1L Ethernet

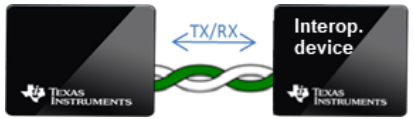
Factory automation

- Sensors
- Valves
- Encoders
- Motor starters
- Robotics

Various field buses →T1L Ethernet

New trend | Single-pair Ethernet (SPE) for reach and cabling

	Single Twisted Pair ENET		
Cable type	1 twisted pair / 2 wires		
IEEE Standard	**IEEE802.3cg**	**IEEE802.3bw**	**IEEE802.3bp**
Description	10BASE-T1L / 10BASE-T1S	100BASE-T1	1000BASE-T1
Maximum Bandwidth (Mb/s)	10	100	1000
Standard Cable Reach (m/link)	1000 / 200 25 (8)	50	15
Data Transfer	Full-duplex	Full-duplex	Full-duplex
Sample Applications	Harsh environments Diagnostics Automation	Harsh environments Domain to domain connections Robotics Replaces serial fieldbus	



Predictive maintenance

Unpredicted failure
- Costly (tools, material)
- Safety Concerns
- Affects Production

Why predictive maintenance?

"It costs approximately 50% more to repair a failed asset than if the problem had been addressed prior to failure" *

Machine breakdown can be unsafe leading to manpower loss, fines, audit, production stop…

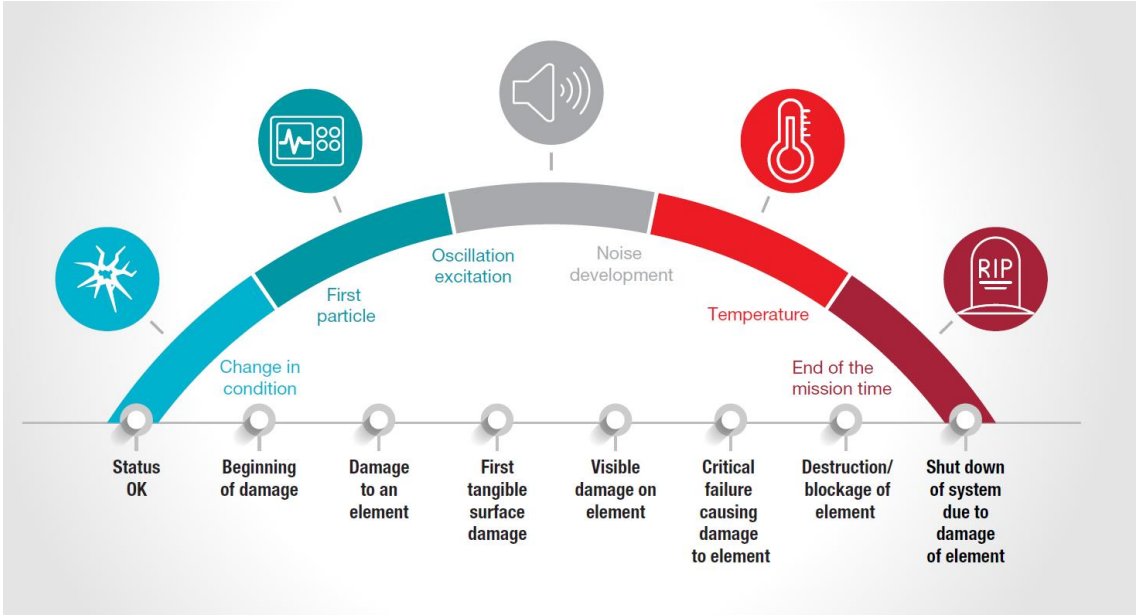
Non-invasive, retrofitting techniques reduces down time, increases availability and productivity

Maintenance	Corrective	Preventive	Predictive
	•Replace when breaks	•Replace upon schedule	•Replace when required

Industry 4.0

* Source: Emerson brief

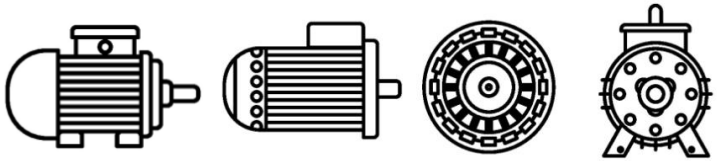
Predictive maintenance | Condition monitoring



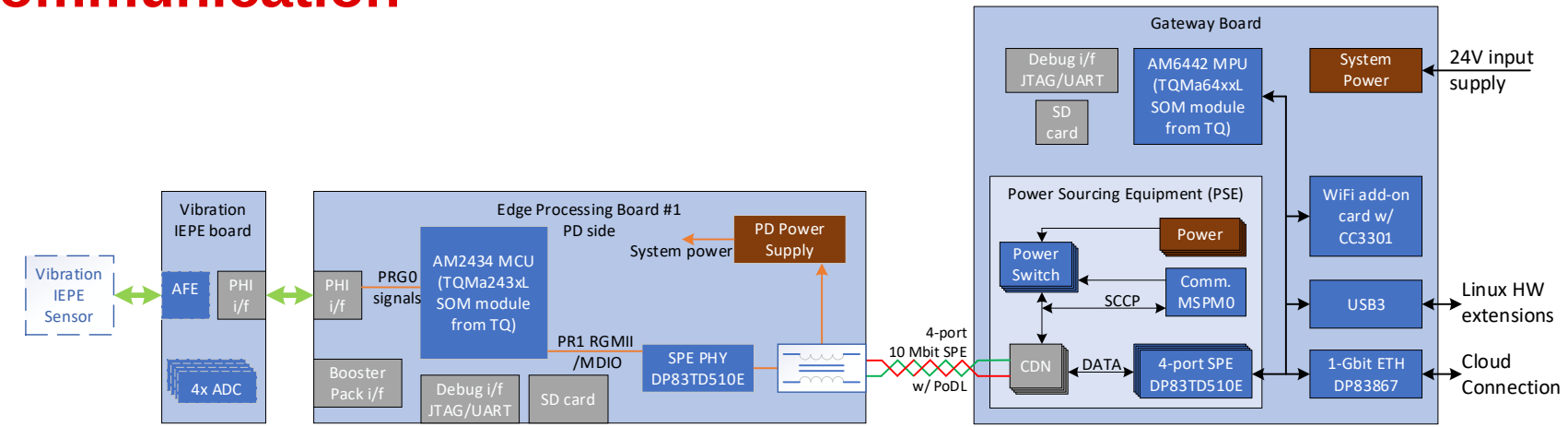
Condition monitoring

- Current
- Temperature
- Vibration

- Misalignment
- Mechanical defects
- Unbalance
- Loose fixtures



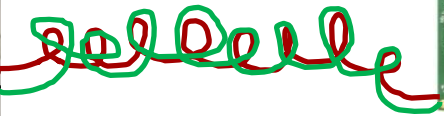
Vibration monitoring with edge processing and SPE/PoDL communication



Sensor ⟷ **AFE** ⟷ **Edge processing** ⟷ **SPE/PoDL** (**up to 2 km**) ⟷ **Gateway** ⟷ **Cloud**

TIDA-010249

TIDA-010261



SPE/PoDL

TIDA-010262

FFT

Conclusion

- Legacy protocols such as EtherCAT, PROFINET and Ethernet/IP have and continue to play a pivotal role in factory operations.
- Emerging protocols like TSN, IO-Link and single-pair Ethernet are reshaping factory connectivity by providing faster, more reliable, and more flexible communication to enhance automation.
- Real-time communication optimizes performance across many applications in the factory.
- Advanced processor solutions and interfaces are supporting these trends with specialized hardware acceleration, parallel processing, improved processing power and scalability.

Learn more about how TI is supporting the latest communication trends here: ti.com/connect

Getting started

You can start evaluating the industrial communication solutions leveraging the following:

Content type	Content title	Link to content or more details
Product folder	AM243x / AM64x DP83867 / DP83826	AM2434 DP83867IR, DP83826I
Reference design	AM243x Launchpad Eight-port IO-Link reference design	LP-AM243 TIDA-010234
Customer training series or webinar session	AM24x academy	AM24X-ACADEMY
Technical blog content or white paper	Factory automation design made simple with multiprotocol industrial Ethernet systems PoDL PD and PSE Application note	Blog post PD PSE
Selection and design tools and models	MCU-PLUS Software Dev Kit (SDK) Industrial Communications SDK	MCU-PLUS-SDK-AM243X INDUSTRIAL-COMMUNICATIONS-SDK-AM243X
Development tool or evaluation kit	Code Composer Studio	CCSTUDIO

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