



# Networking Architectures for Industrial Internet

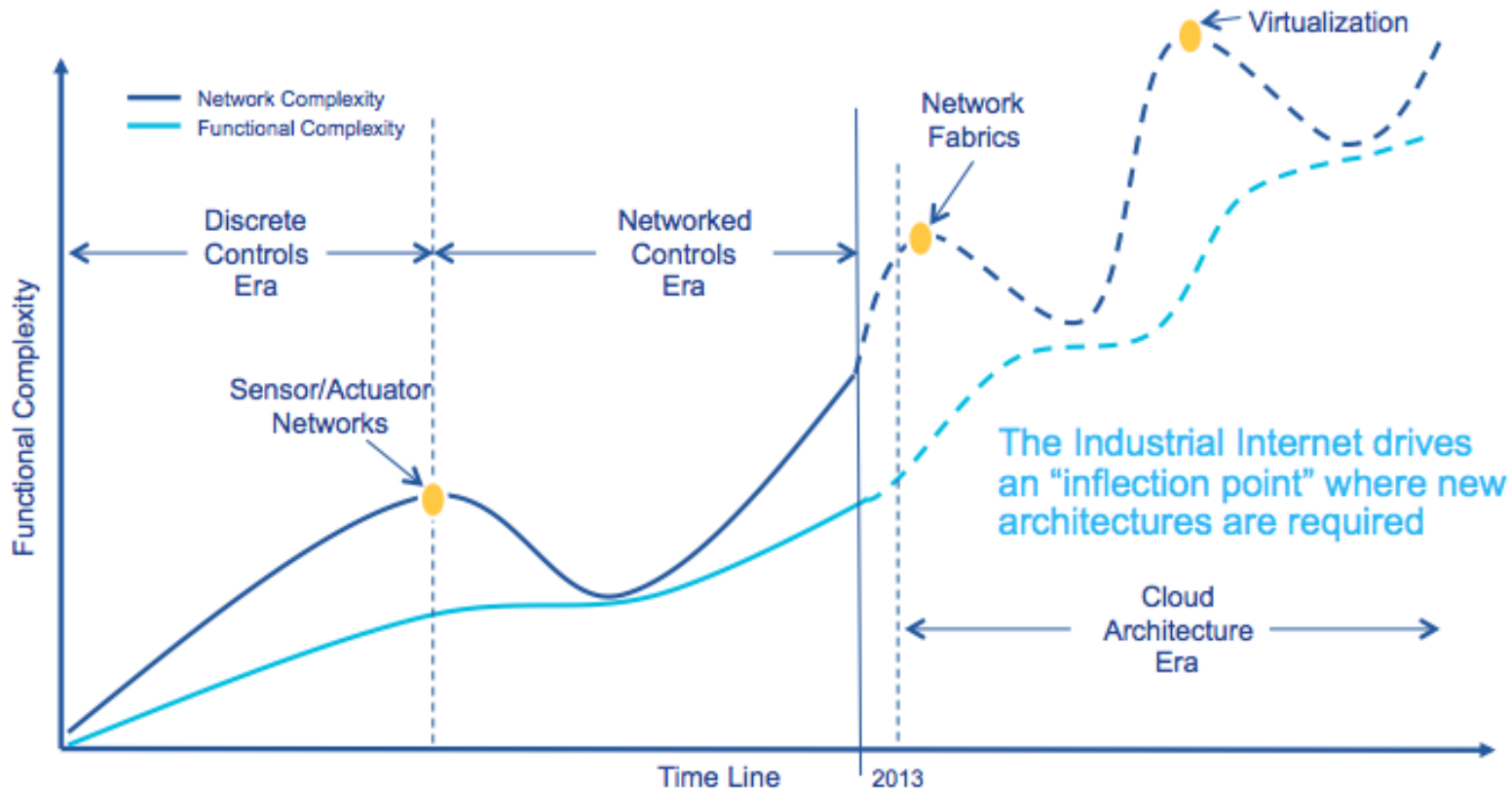
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# Network complexity as a major challenge - limits functional capability of system

Development of functional (minimum) complexity vs. network (actual) complexity over time

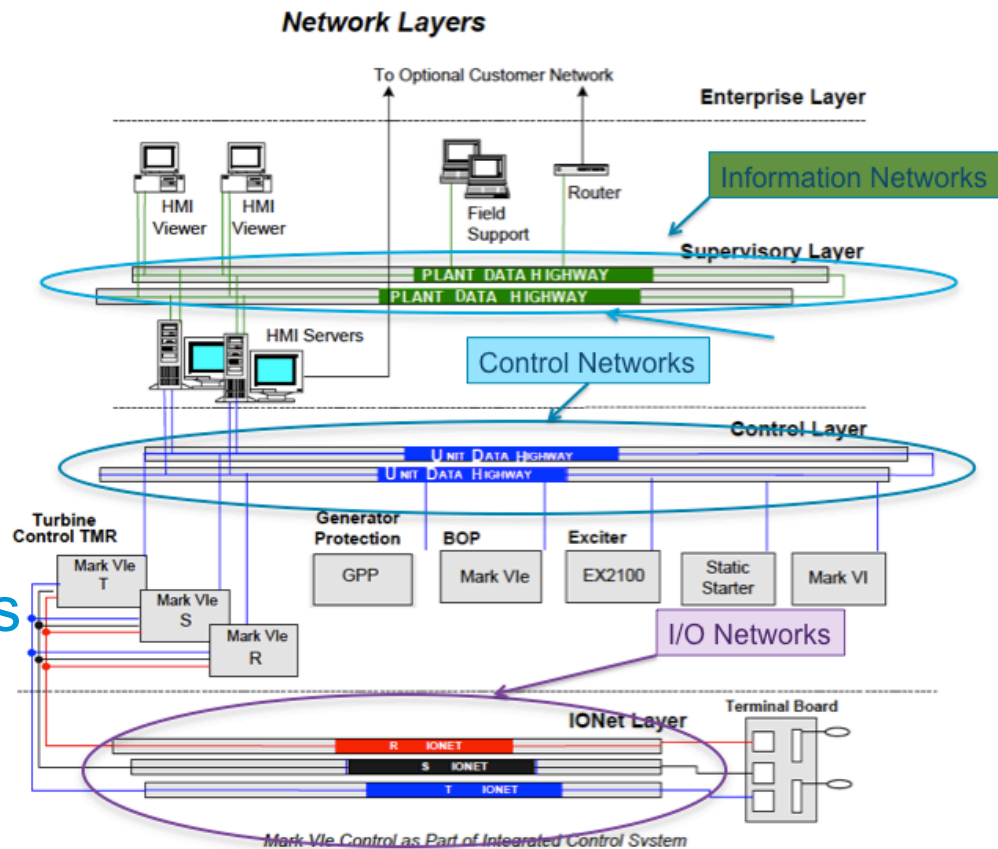


- Control Systems across sectors perpetually increase in functional complexity
- Incremental development makes the actual complexity outgrow the functional complexity
- This actual communications complexity limits functional capability and growth
- New advanced communications architectures enable advances in controls

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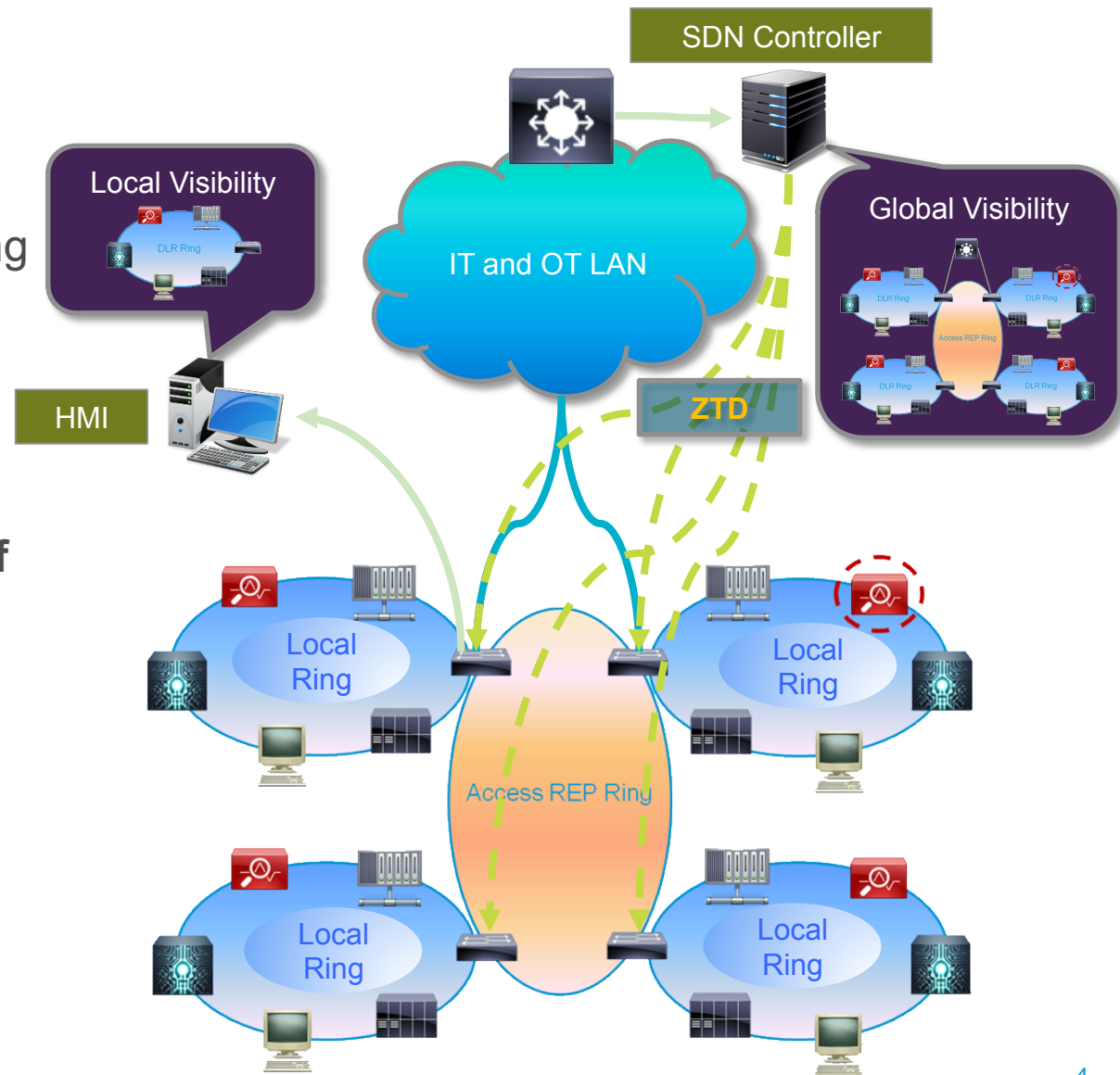
# The Current

- Small, Segmented networks
- Hard to deploy & manage
- Security via obscurity
- Lots of gateways and cables
- Reliable thru physical segmentation



# The Future

- Automatic Network Discovery and Provisioning via **Zero-Touch Deployment**
- I/O PAC, HMI, PLC, sensor, switch, etc.
- **Deterministic delivery of information.**
- Embedded Security
- Remote Monitoring and Management



# Network Developments

## Characteristics of Industrial Network

- Converged
- Easy to use
- Secure, Private
- Guaranteed Deterministic
- Scalability

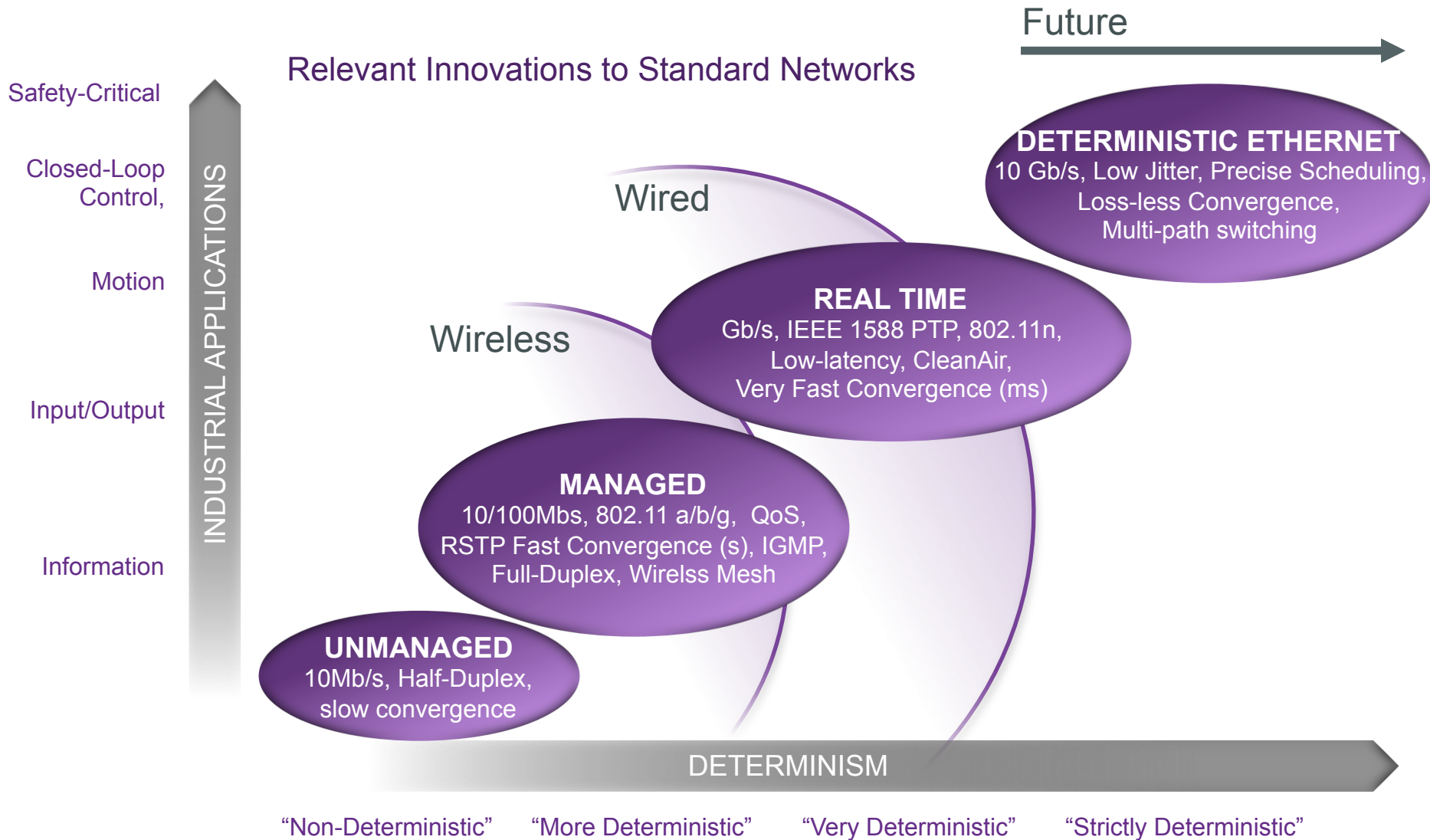


# Network Developments

## Characteristics of Deterministic Ethernet

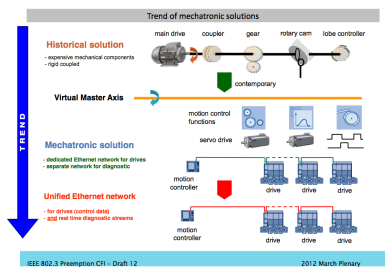
- Converged Single Wired/Wireless Network
- Easy to use Software Defined Network
- Security, Privacy, Identity, Policy, Access, Zone, Application
- Guaranteed Deterministic Time Sensitive Networks
- Scalability IPv6, RPL, PCE

# Industrial Intelligence Requires Evolution



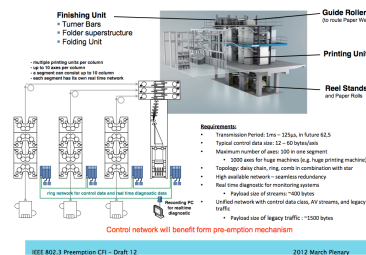
# Deterministic Ethernet Standards

Use Case 1 - Motion Control



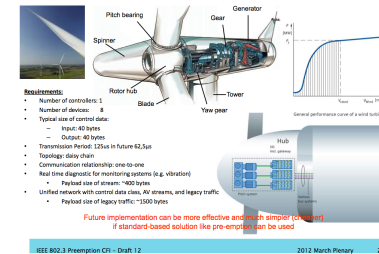
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Use Case 2 - Printing Machine



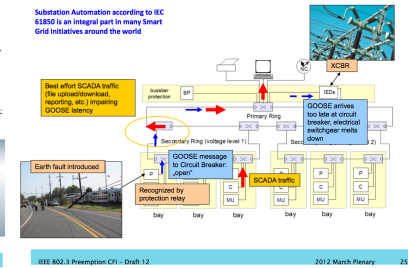
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Use Case 3 - Pitch Control for Wind Turbines



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Use Case 4 - IEC 61850 Substation Automation System



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IEEE 802.1 & 802.3 is undertaking efforts to make Ethernet deterministic including:

- Guaranteed Delivery over a variety of multi-path topologies
- Scheduled Delivery; Low-latency ( $< x \mu\text{s}$ ), low-jitter
- Time synchronization across end-devices and the network ( $< 100\text{ns}$  drift)
- Converge critical application, Audio-Visual and best-effort data traffic

Deterministic Ethernet has been proven for highly critical applications (Aviation, SIL, etc.)

Additionally, work has started on efficient, light-weight cabling for data/energy as cable weight is also a significant issue



# Evolution of Ethernet

## Initial 10b2 Ethernet: CSMA/CD Collisions

The reason Ethernet got a bad rep with determinism...



# Evolution of Ethernet

## Full Duplex Switched

Major Improvement – but still not converged or (necessarily) deterministic...



# Cisco Deterministic Ethernet: Safe, Secure, Scalable, Converged

Time Triggered Ethernet – Converged BE + Critical



# The Promise of TSN

## IEEE TSN

- Truly RAND Standard
- Industrial Grade
- Scalable
- Converged
- Deterministic Networking

## Cisco add-on

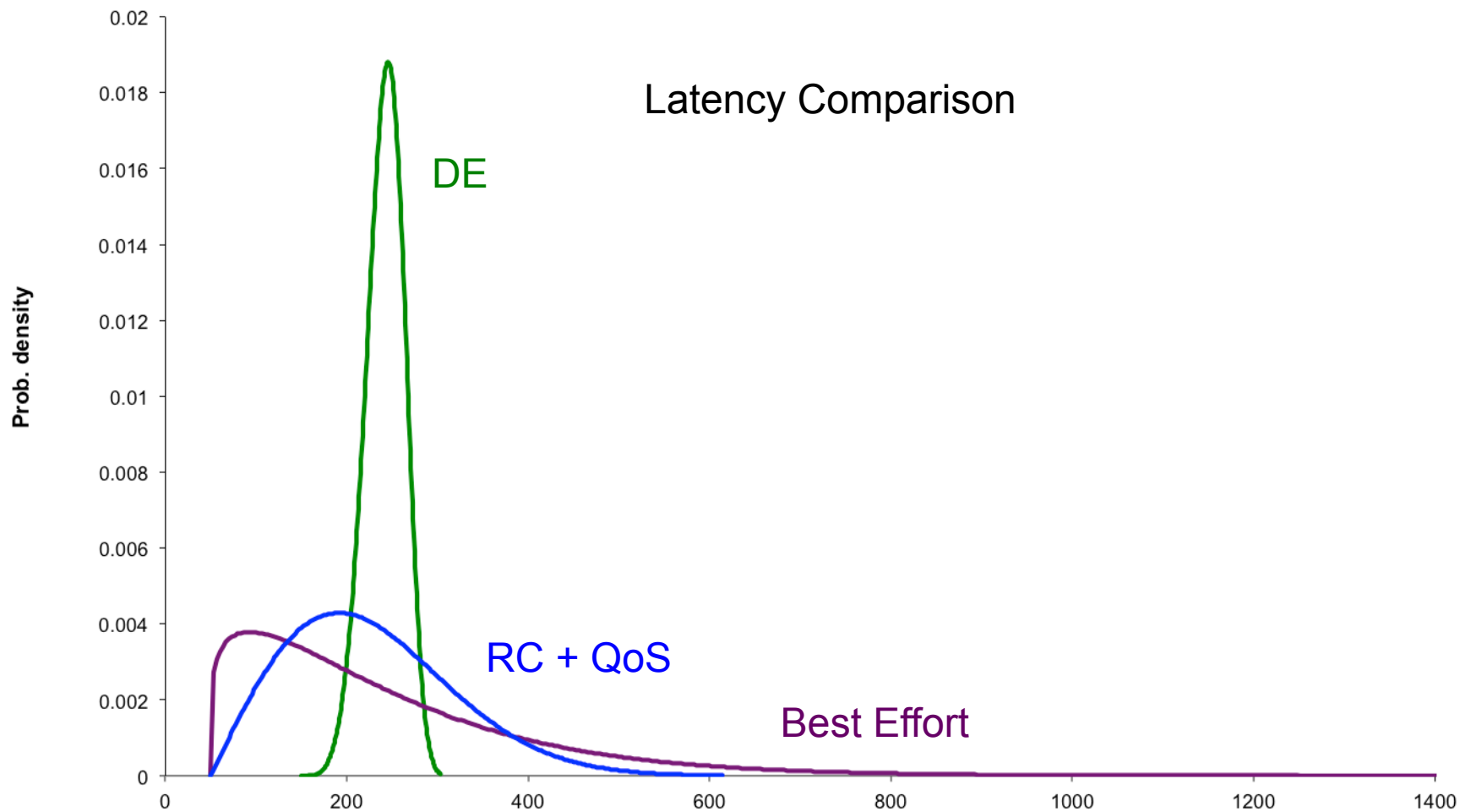
- **Easy to Use** TSN
- Additional Features...
- Replacing all existing forms...

“...Profinet IRT, EtherCat and Powerlink ... will become obsolete... when IEEE's TSN Task Group has completed its work.”

**TSN is a Superset**



# Latency Comparison



Thank you.

