TSN and EtherNet/IP Networks

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ODVA

Agenda

- EtherNet/IP Today
- TSN + EtherNet/IP
- TSN PITCH OEM / SI / EU
- TSN: Performance
- TSN: Targeted customer values
- Conclusion

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EtherNet/IP Today

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EtherNet/IP's Position Today

Ascent of EtherNet/IP

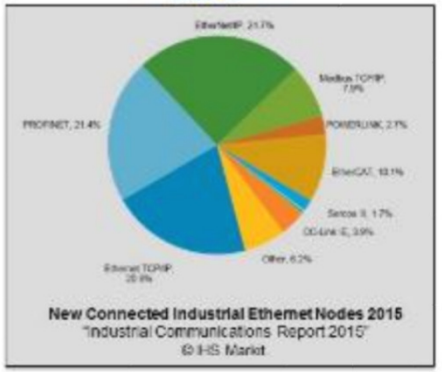
What are industry analysts saying?

IHS Markit

"Transition to industrial Ethernet is accelerating and EtherNet/IP accounted for approximately 25% of all new Ethernet nodes shipped in 2015. The growth trend for EtherNet/IP is expected to continue building on its strong installed base, the transition from fieldbus to Ethernet networks, and the fact that industrial Ethernet will provide a fundamental component of connectivity necessary to enable smart manufacturing and IIOT solutions."

Mr. Alex West, analyst for IHS Markit

EtherNet/IP ODVA



New Connected Industrial Ethernet Nodes 2015
"Industrial Communications Report 2015"
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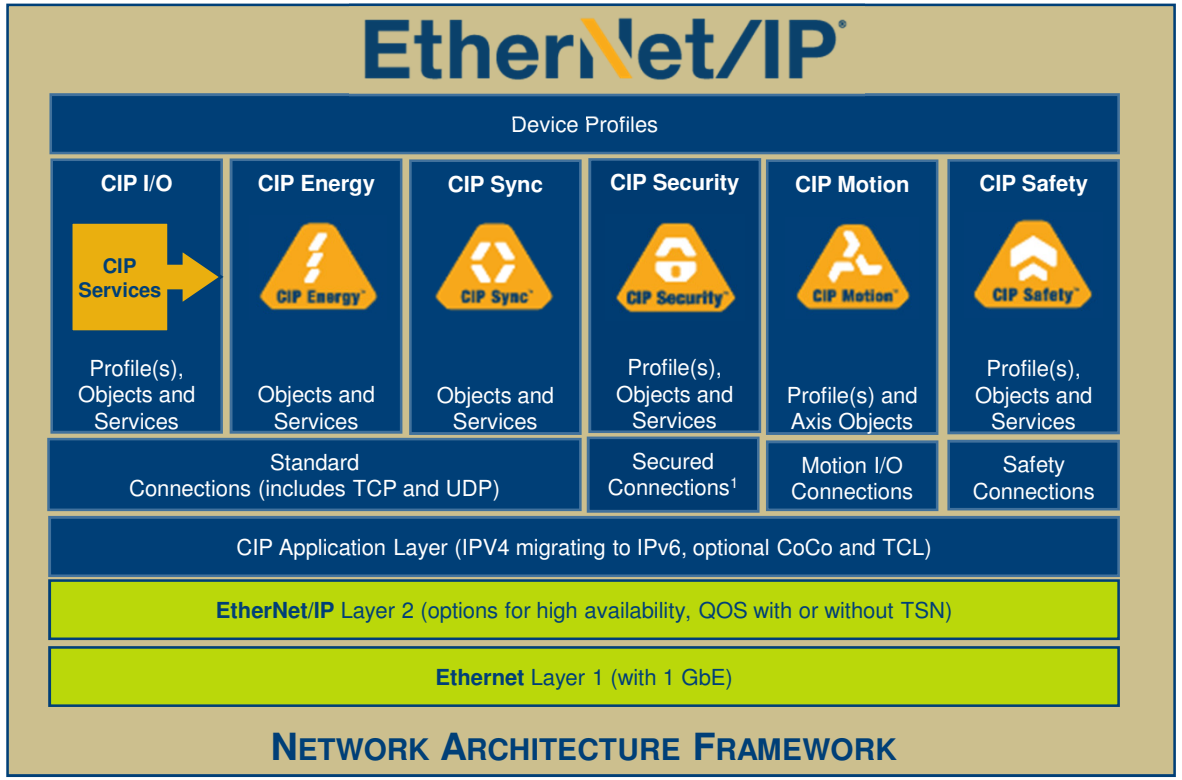
Platform for smart and secure industrial control systems



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Deterministic Ethernet in Industrial

- For over a decade, Industrial Automation has used:
  - **Cut through switching**
  - **Time synchronization**
  - **Traffic shaping techniques**
  - **Scheduling algorithms**
  - **Dynamic frame packing**
  - **Frame fragmentation**
- The results are excellent for EtherNet/IP!
- But, TSN will offer additional performance gains and extend the application coverage.

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Evolution of Time Sensitive Networking Standards

IEEE
802.3
(including SPE amendment resulting from IEEE 802.3cg Task Force)

The EtherNet/IP Specification
(including normative references to SPE amendment resulting from IEEE 802.3cg Task Force)

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Evolution of Time Sensitive Networking Standards

IEEE 802.3
(including SPE amendment resulting from IEEE 802.3cg Task Force)

IEEE 802.1
(TSN Standards)

The EtherNet/IP Specification
(including normative references to SPE amendment resulting from IEEE 802.3cg Task Force)

What is ODVA Doing

- Liaison with IEEE 802.1
- Adaption of TSN Standards to EtherNet/IP

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The IIoT represents a huge inflection point in the market

- Demands for network convergence and more data will force these standards bodies to adopt Gigabit Ethernet
- **Not all equipment and installations scale easily to Gigabit**
- While the availability of products and services is largely satisfactory, dealing with multiple solutions **generates high costs and limits IoT capability**
- The emerging Time-Sensitive Networking (TSN) standards provide another migration path
- TSN may bring further harmonization and consolidation and perhaps emerging alternatives

Deterministic Ethernet in Industrial

- Time-sensitive networking (TSN) technology can deliver the performance required to secure and protect critical traffic
- Allows the data-intensive applications of the Industrial IOT and Industrie 4.0.
- Delivers deterministic performance on an open-standard & scalable network
- Not all sub-standard have to be implemented…
- The important sub-standards for Industrial Automation are:

- 802.1AS (REV) Network Time Synchronization
- 802.1Qbv Time Aware Traffic Shaper
- 802.1Qci Ingress Policing & policing
- 802.1CB Seamless Redundancy
- 802.1Qcc Network Management. Stream reservation
- 802.1Qbu/802.3br Preemption

Customer advantages

- All nodes share the same time
- Scheduled Ethernet frames never collide
- Removes babblers from network (security)
- Zero loss switch-over
- Path provisioning according to IEEE
- Maximum bandwidth without compromising real-time behavior

TSN + EtherNet/IP

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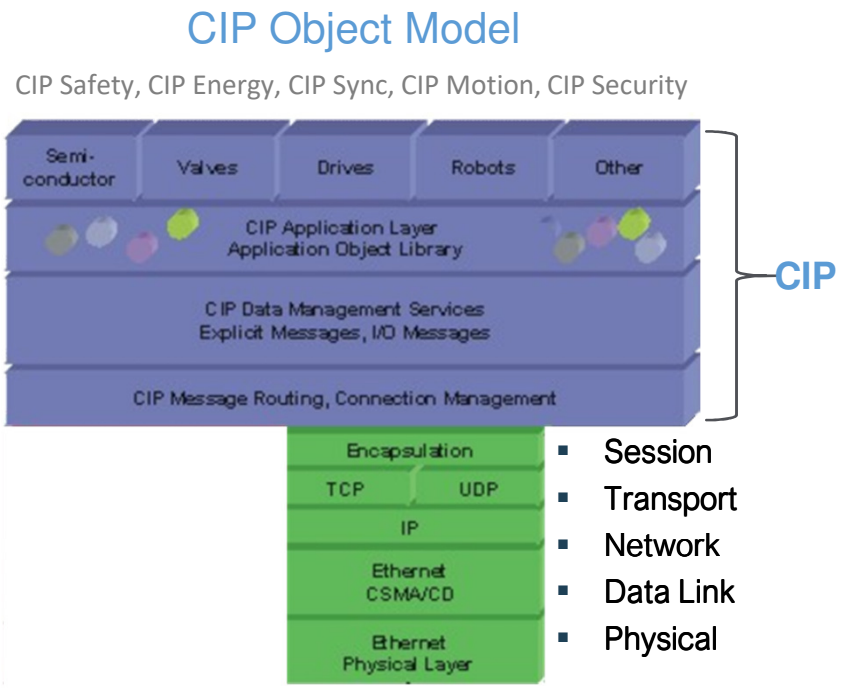
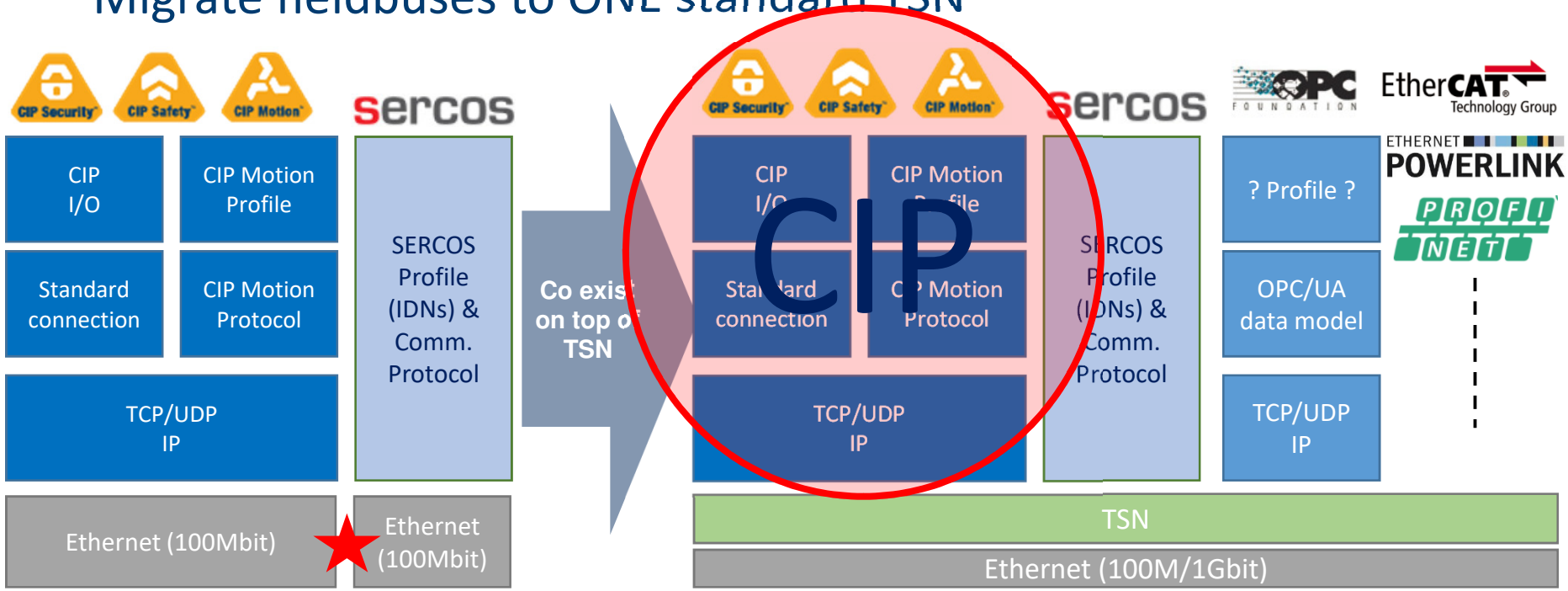
Profile interoperability

- In industrial communication systems, interoperability needs to be ensured on each OSI layer
- Saying “protocol is running over Ethernet” is not enough to avoid customer dissatisfaction
- Common implementations must address all seven OSI layers
- Standardized profiles for safety, drives, IO and controller to controller communication must be taken into consideration



Migrate fieldbuses to ONE standard TSN

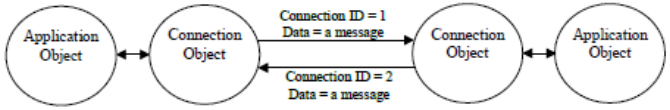


Same base technology, but cannot coexist (in same network/on same wire) because of different selection of higher level technologies (scheduling / prioritization)

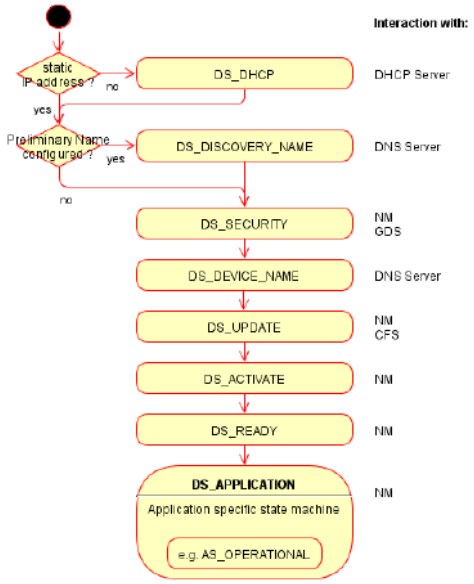
Converging to TSN with scheduling as a base technology allows coexistence in the same network / on the same wire

Network Management

- TSN as previously described, is not enough by itself for a complete scope for network management. It is needed to describe also services to establish communications relationships between devices before exchanging data. CIP™ on top is an answer for these needs.
- Interoperability is also based on mechanisms to do things like boot a network device by transitioning it through a series of states into an operational state; enable a device to detect, handle and signal errors during runtime; or implement procedures necessary to replace faulty devices
- States and state-transitions comprise functions such as network device identification (ensuring that the device can be reached on the network, matches the expected vendor/model, etc.).

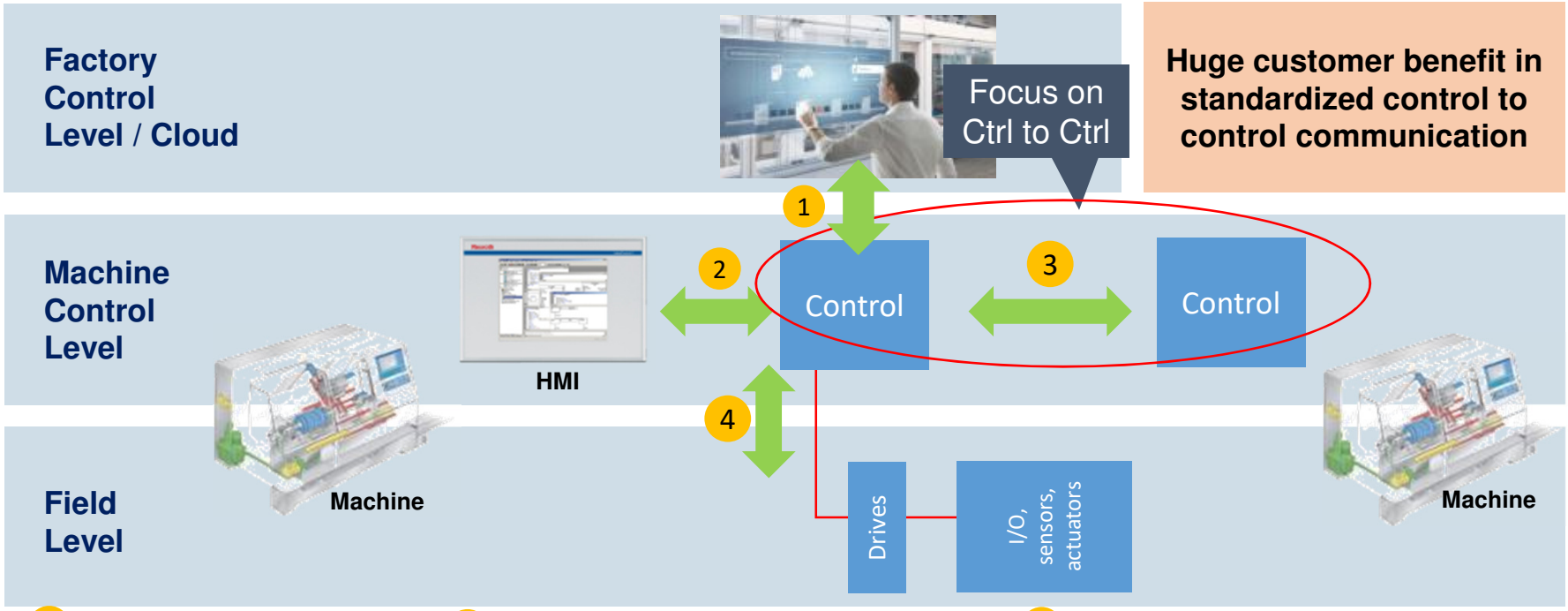


Connections and Connection IDs principle



States during boot-up of an TSN end station

Network Topology



1 HMI communication

2 Factory level communication

3 control to control communication

4 field level (Motion, Safety, and standard I/O)

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TSN PITCH FOR OEM / SI / EU

(Machine builders / System integrators / End users)

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Advantages of TSN for Machine builders

- Provide a high performance isochronous network
  - Address new generation of isochronous machine architecture
  - Support multi protocols constrained streams on same cable (ex. Video, motion, safety, …) without impacting the real time

- All fieldbuses could adopt the same lower level TSN
  - Move out gradually from current fieldbuses to the new TSN standard in alignment with the expected performance

- Converge motion bus and automation bus on the same cable
  - Use the advantage of TSN for real time capabilities and address motion applications in a vendor independent flat physical network (higher performance, less cabling, simplified horizontal integration)

Advantages of TSN for System Integrators

- Move towards a “flat” automation network architecture
  - Flat physical network construction in opposition to the segmented networks currently used in conformance with ISA 95 & ISA 88 pyramid
  - Simpler Network architecture configuration, simpler cabling, reduced engineering (ease of use)
  - Converged network enables access to sensors data from cloud
- Move from existing protocols to TSN + standardized profile
  - Standardize integration of machine components
- Ethernet with TSN as backbone for scalable network architecture
  - Full compatibility with the existing standard Ethernet technology (zero use of gateways or protocol converters is required).
  - Guaranty of bandwidth
- Converge on ONE standard automation architecture
  - Mixed reconfigurable manufacturing with robotics, multi-axis motion machines, vision, IO, and machine health/diagnostics
  - Openness to third parties
  - Reduce gateway usage and eliminate the need to configure the gateway as applicative
  - Ability to integrate brownfield through TSN switches

Advantages of TSN for End Users

- Flexible & scalable automation architecture
  - Flexible processing line with multiple integrated control systems and peer-to-peer communication
  - Lower cost for system design and integration
  - Protection of installed base through a phased roll-out
  - Third parties availability

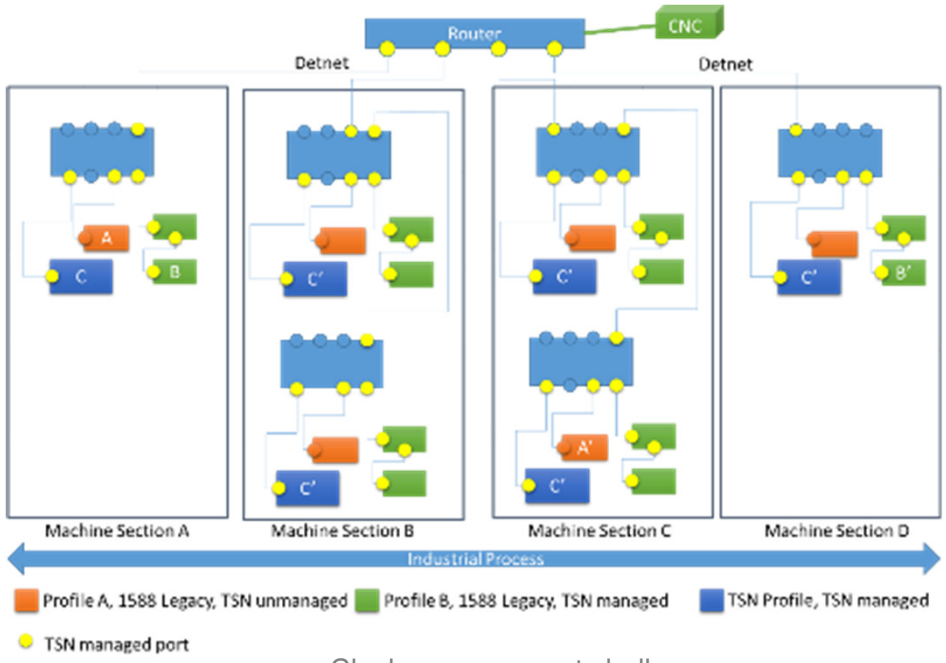
- Simplify automation maintenance
  - A single and consistent network throughout the shop floor (ideally configured and managed with a single tool).
  - Simplify the construction of the network architecture compared to segmented networks currently used.

- Cyber Security protection as native
  - Secure communication (at application and connection levels)

- Reduced downtime
  - Support for rapid manufacturing reconfiguration reduces plant downtime while enabling integration of plant diagnostics for increased uptime
  - Simplify scalability of the network (disparate life times of factory components)

Industrial Use Case

- A single machine consisting of four different sections of machinery
  - Section delivered via different OEMs
  - Each section is a subnet with a unique VLAN
- 15 machines per site
  - Common IP addressing scheme
- 7 manufacturing sites worldwide.
- All sections synchronized and coordinated to produce final product
  - Relevant events timestamped
  - Data on the manufacturing floor can be correlated against data in the MES system and data from the supply chain

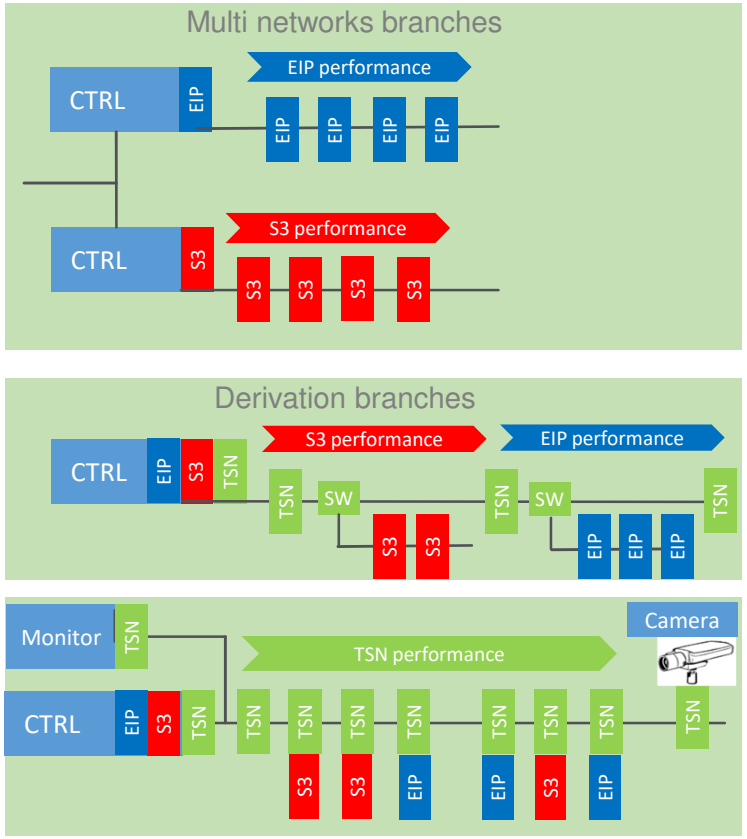


Clock management challenge

Migration path principle

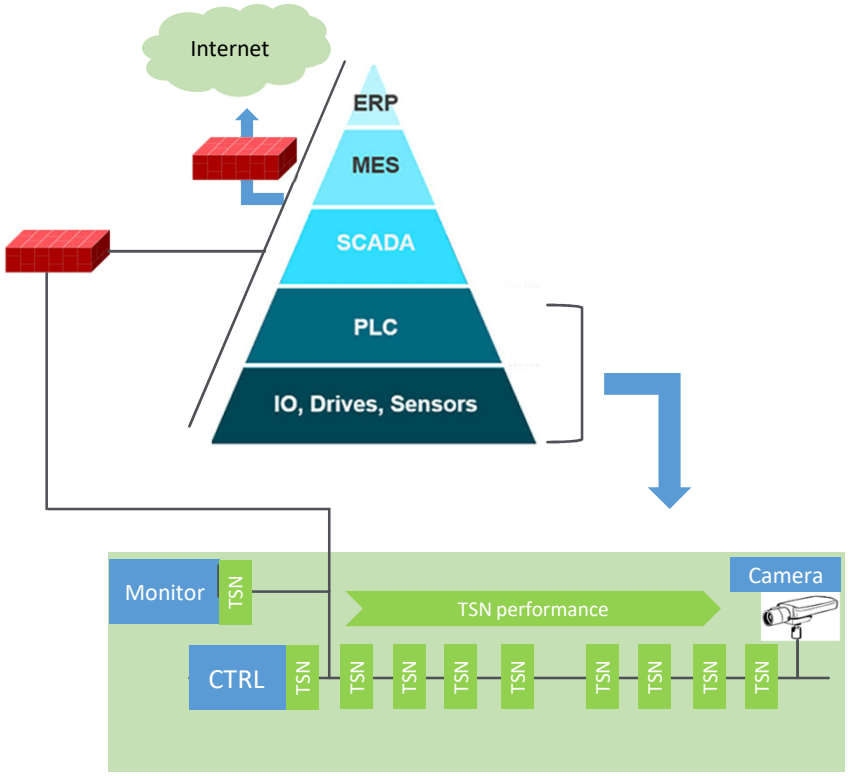
- Today even if it exists some artefacts to merge automation bus and motion bus, it is always difficult to manage both in same time by facing performances limitation…
- Improvements is to reduce network branches without impacting performances
- This can be done with TSN by sharing multiple layers in the same cable.

Migration & transition phase



Security concerns

- The current architecture for controlling Factory Automation is hierarchical and different layers in the Pyramid have different network requirements.
- Physically flat network can simplify network infrastructure creation…
- But there still needs to be a layered network for security purposes to allow separation of communications and TSN is supporting this interfacing



TSN: Performance

(Setting and ambition)

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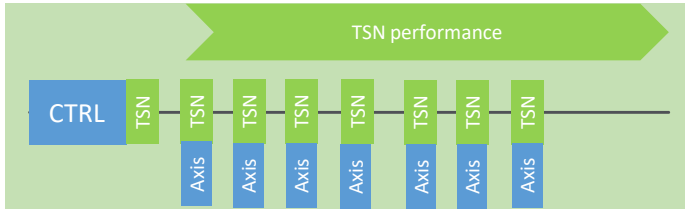
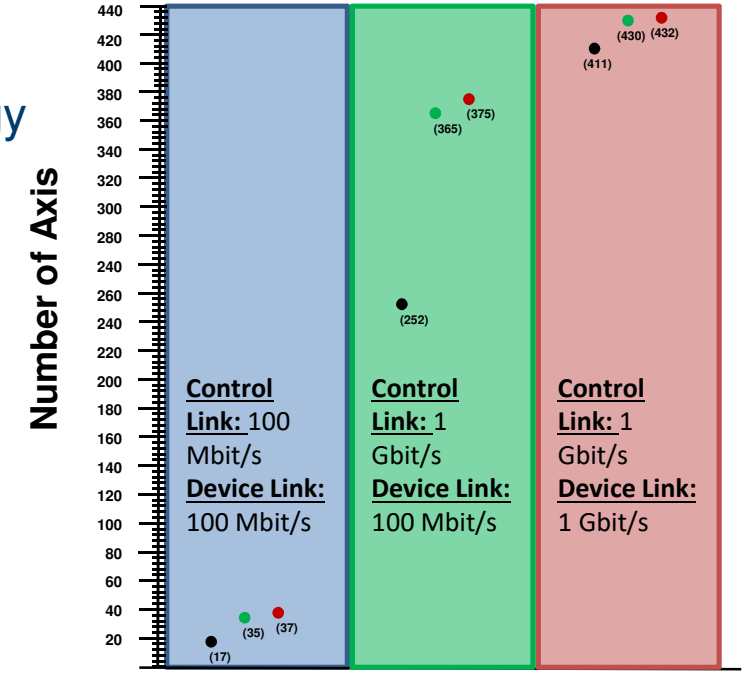
Performances estimation: Distributed Linear Segment Topology

- Wire speed contributes to the majority of throughput and performance on the wire.
  - Number or axes
  - Jitter
- TSN functions allow for better “packing” of data at any given wire speed

- There is little difference in performance benefit between preemption and scheduling
  - However, both can be used together.





Wire Speed vs. TSN Functionality

Common Configuration

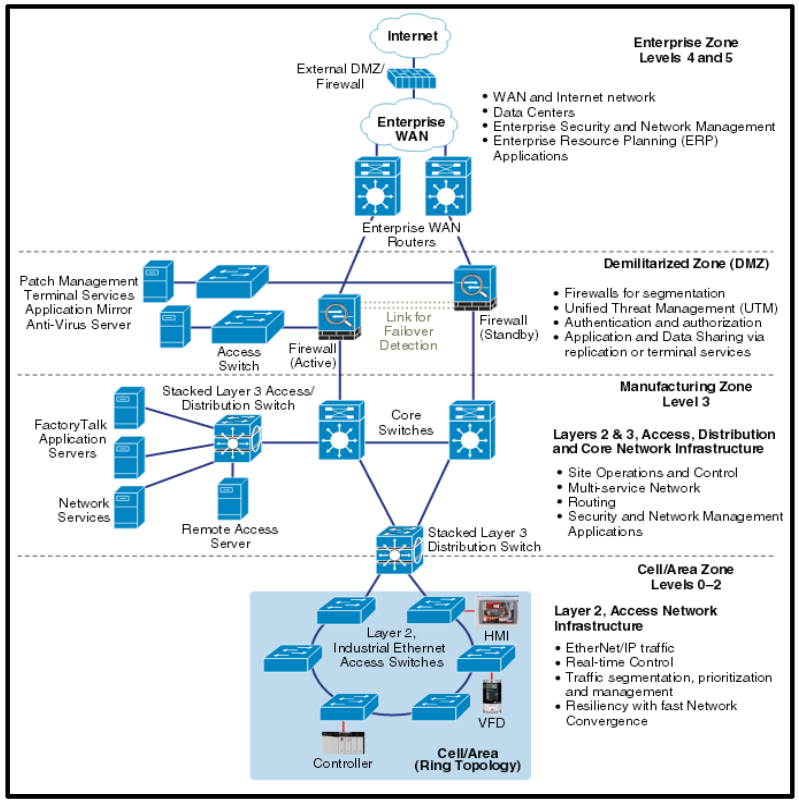
- **i7 Processor**
- **2-cycle timing**
- **1 millisecond motion planner**
- **1500 byte non-motion packet**
- **1 Switch**
- **Up to 50 nodes per linear segment**

Legend:

- ● ← **No TSN functions enabled**
- ● ← **Preemption enabled**
- ● ← **Scheduling enabled**

Industrial Use Case

- Given these results, do we need scheduled traffic?
- As deployment of Ethernet in Industrial Automation grows more data is desired. Solutions must scale
- As the Enterprise and Automation networks become more integrated, data flows from various applications must converge
- TSN provides a practical approach for achieving this vision



States during boot-up of an OPC UA TSN end station

TSN: Targeted customer values

(Setting and ambition)

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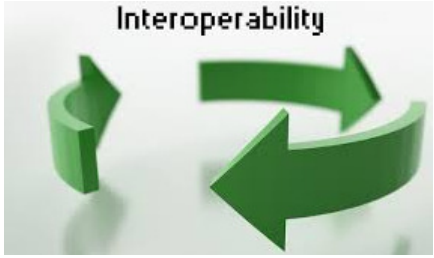
Ambition for TSN

- Reduce by 2 the network configuration time
  - Network configuration and deployment across the system
- Reduce by 4 the device configuration time
  - Devices configuration deployment
- ONE cable
  - Support Multi networks and real-time guaranty
- Improve industrial grade network capacity by 4 or more
  - Merging OT bus & IT bus keeping latency, determinism, …
- Divide by 3 current high performance machines infrastructure cost compared to future TSN infrastructure
- 1 profile by device type across manufacturers
  - Interoperability on semantic & operating mode
- Reduce by 2 the diagnostic time
  - Transparency and sustainability of install based



Conclusion

(Next steps)

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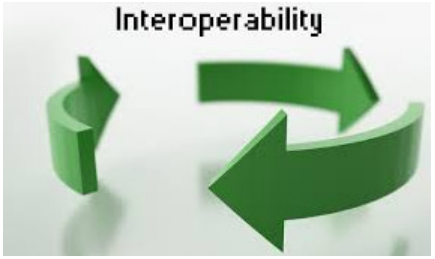
Conclusion

- TSN technologies offer a scalable, predictable approach to deterministic networking.
- Because EtherNet/IP products have always relied upon standardized technologies, ODVA is in an excellent position to leverage these emerging standards.
- However, significant challenges remain.
- The integration of various PTP profile and the convergence of EtherNet/IP traffic with a scheduled TSN network are chief among these challenges.

Major customer value to guaranty success of TSN adoption as the next generation Industrial Automation Network

is

"Interoperability"



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Thank you!

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