21st Annual Meeting of Members
March 10, 2022
Agenda

- Call to Order
- Activities of the Corporation: 21st Term in Review
- Introduction to Candidates for Election by the Regular Membership
- Election and Break
- It's Not Enough to Be Smart: A User’s Perspective on Smart Process Instrumentation and Networks
- Industrial Automation 2030: A Discussion of Industry’s Next Steps
- Looking Ahead to the 22nd Term
- Adjourn
21st Term in Review

- Al Beydoun, President & Executive Director, ODVA
- Adrienne Meyer, VP of Operations and Membership, ODVA
- Joakim Wiberg, CTO and Chair of TRB, HMS Networks
21st Term in Review

- Overall Review of Activities
  - Organization and Board update
  - Key accomplishments
  - Key activities in specific regions
- Membership Review
  - Current status
  - Planned updates
- Technology Review
Board and Organization Updates
Board of Directors

Dr. Rolf Birkhofer
Endress+Hauser

Mr. Jon DeSouza
HARTING

Mr. Satoshi Kojima
OMRON

Mr. David Lagerstrom
TURCK

Mr. Samuel Pasquier
Cisco Systems

Mr. Thomas Petersen
Danfoss

Mr. Brian Reynolds
Honeywell

Mr. André Uhl
Schneider Electric

Dr. Juergen Weinhofer
Rockwell Automation
Technical Review Board

- Mr. Raj Bandekar, Honeywell
- Dr. Rudy Belliardi, Schneider Electric
- Mr. Mirko Brcic, Endress+Hauser
- Dr. Vivek Dave, HARTING
- Mr. Paul Didier, Cisco
- Mr. Gregory Majcher, Rockwell Automation
- Mr. Shinji Murayama, Omron
- Ms. Roxana Sudrijan, Molex
- Mr. Joakim Wiberg, HMS Networks
Market Advisory Committee

• ODVA’s Market Advisory Committee was established during the last term by the Board of Directors to provide additional member input on the overall direction of industry.

• The MAC’s mission is to assess the state and future of ODVA technologies, including their global and regional adoption and utilization. The MAC will provide recommendations and advice to the Board.

• A call for nominations was sent out to the Regular Membership in January 2021, and the Board of Directors appointed the initial slate of representatives in March 2021.

• The MAC has been meeting regularly since May 2021 to review and advise on ODVA technology growth.
Market Advisory Committee

- Mr. Joe Bastone, Honeywell
- Mr. Elango Ganesan, Cisco
- Dr. Vivek Hajarnavis, Rockwell Automation
- Mr. McKenzie Reed, HARTING
- Mr. Ryo Shimizu, Omron
- Mr. Tom Weingartner, Analog Devices
- Ms. Tonya Wyatt, Micro Motion
- Ms. Feiyan Zhao, Schneider Electric
21st Term in Review

• Grew membership to over 365 members and welcomed HARTING as the newest Principal Member of the association
• Continued to enhance and expand ODVA’s technologies through 13 active working groups, bringing over 80 specification enhancements in key areas like CIP Security, Ethernet-APL, and in-cabinet and resource-constrained devices
• Formed and launched the Market Advisory Committee to help advise the organization on market trends
• Promoted ODVA’s technologies at global virtual events and trade shows
• Continued to grow adoption of ODVA’s technologies by offering virtual training during the pandemic
• Focused on growth in China through the standardization and translation of EtherNet/IP to Chinese GB/T Standard
21st Term in Review

- Continued to develop support for EtherNet/IP over TSN within ODVA, with participation in the 60802 TSN Industrial Profile, by collaborating with industry organizations to develop Conformance Specification for TSN Industrial Profiles, and through a committee of the TRB to refine the path forward
- Collaborated on device integration both with the FieldComm Group in establishing support for EtherNet/IP with FDI Device Package and FDI tools and with the FDT Group in integrating EtherNet/IP with the FITS architecture
- Continued to expand the EtherNet/IP ecosystem to meet the needs of Industry 4.0 and IIOT through joint working groups to develop an OPC-UA companion specification for EtherNet/IP
- On-going progress to develop ODVA’s xDS next generation digital device descriptions
Thank you for your service to ODVA!

Congratulating on their retirement key member contributors who have been instrumental to the success of ODVA and its technologies, including:

- Kevin Knake, former chair of Roundtable
- Ray Romito, original contributor to DeviceNet and many other roles
- Steve Zuponcic, former chair of Distributed Motion SIG

We wish all ODVA Community members who retired this past term all the best on their next endeavors!
Highlights of Key Activities: Territory Alliance Groups (TAGs) and Global Outreach
Major Trade Shows in Europe – Engaging Virtually

- Hannover Messe Digital 2020 and 2021
- SPS Connect 2020
- ACHEMA Pulse 2021
Education for Members and Vendors

- EtherNet/IP Quick Start Training
- CIP Safety Quick Start Training
- Technology Update to the Membership

Special thanks to ODVA Members who have been on the training team:
- Drew Baryenbruch, Real Time Automation
- Chatrapathi, Utthunga
- Jamie Gallant, Hilscher
- Jim Grosskreuz, Rockwell Automation
- Oliver Haya, Rockwell Automation
- Vivek Hajarnavis, Rockwell Automation
- Andreas Kramer, HMS Networks
- Stefan Kraus, HMS Networks
- Rob Lodesky, HMS Networks
- Michael Schaffner, Rockwell Automation
TAG China

- CEC forum
- September, 2020
- 200+ attendees
- Interview
TAG China

- Automation seminar

Online promotion on www.gongkong.com
- Technical Blog
- Seminar Video
- Q & A
- Members’ interaction
TAG Japan

- ODVA College 2020 Online

[WEB page]

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<th>Event name</th>
<th>Date / Number of participants</th>
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<td>ODVA College 2020 Online</td>
<td>Nov 17th,2020 - Mar 16th, 2021</td>
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<th>Date / Number of participants</th>
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<td>Implementer Seminar</td>
<td>Dec 10th, 2020</td>
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<td>Network Seminar</td>
<td>Dec 4th, 2020</td>
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<tr>
<td>Implementer Seminar</td>
<td>Feb 4th, 2021</td>
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<td>Implementer Seminar</td>
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TAG Japan

- **IIFES 2022**

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<th>Date / Number of page accesses</th>
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<td>IIFES 2022 Real</td>
<td>Jan 26th - 28th, 2022</td>
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<tr>
<td>Online</td>
<td>Jan 26th - Feb 25th, 2022</td>
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[Real Exhibition]
Booth design that was planned to be exhibited

[Online Exhibition]

1. ODVA activity introduction
2. EtherNet/IP product introduction
3. CIP Safety/CIP Security
TAG Japan

- Demonstration machine renewal
  - TAG Japan members have newly created "self-supporting mobile demo machines" for each of the five categories.
  - The created demonstration machine will be used in future TAG Japan exhibitions and seminars.

- **[DLR(Device Level Ring)]**
  (W900xH800mm)
  - Introducing the redundant system configuration by DLR.
  - Introducing connectivity with IO-Link and remote maintenance.

- **[Multi Vendor]**
  (W700xH600mm)
  - Introducing the openness and abundant product lineup of EtherNet/IP.

- **[Embedded for device development]**
  (W700xH600mm)
  - Introducing embedded devices that develop EtherNet/IP devices.

- **[CIP Safety]**
  (W700xH600mm)
  - Introducing CIP Safety on EtherNet/IP.

- **[Quick Connect]**
  (W700xH600mm)
  - Introducing high-speed switching by the Quick Connect function of EtherNet/IP.
TAG Korea

• During the pandemic period (2020-2021), six Korean main magazine companies published ODVA activity status monthly

• From January 2020 to December 2021, the total number of technology magazines that printed ODVA's promotional articles was 77 total issues.
Membership Update
Growth over the 21st Term

- ODVA made progress in a virtual world
  - Membership grew by over 3.5%, and interest in membership continues to be solid
  - EtherNet/IP adoption increased over 90 new vendor IDs issued

<table>
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<tr>
<th>Membership Level on December 31, 2021</th>
<th>Number of Members</th>
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<tr>
<td>Principal</td>
<td>7</td>
</tr>
<tr>
<td>Regular</td>
<td>195</td>
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<tr>
<td>Associate</td>
<td>165</td>
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Mix of Membership by Membership Class, as of December 31, 2021
Growth over the 21st Term

Mix of Membership by Principal Place of Business, as of December 31, 2021

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Members</th>
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<tbody>
<tr>
<td>United States</td>
<td>146</td>
</tr>
<tr>
<td>UK and Ireland</td>
<td>14</td>
</tr>
<tr>
<td>Germany</td>
<td>62</td>
</tr>
<tr>
<td>Europe Other</td>
<td>43</td>
</tr>
<tr>
<td>Japan</td>
<td>50</td>
</tr>
<tr>
<td>Korea</td>
<td>14</td>
</tr>
<tr>
<td>China</td>
<td>14</td>
</tr>
<tr>
<td>Canada</td>
<td>11</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
</tr>
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</table>
Growth over the 21st Term

• ODVA made progress in a virtual world
  – First ever ODVA Member Survey was launched, and responses from members have helped shape activities, including:
    • Market Advisory Committee was developed, approved, and launched
    • Vendor training events were offered for free and expanded
    • A virtual technology development update was organized to allow the TRB and SIG to keep members informed and engaged
    • Members now receive the ODVA ToolBox for EtherNet/IP integrated learning environment free with membership
    • Members received additional free listings on marketplace.odva.org to promote their products
    • EtherNet/IP and CIP Safety vendor education was expanded, and development of a CIP Security course has begun
    • Test policy issues and solutions under review to ensure clear, consistent, and equitable applications of tests
    • Expanded marketing reach to end users via new videos, advertising, and social media posts
Looking to the Future

Our focus for the 22nd term

– Expand information and education for members
  • Continue work to develop an online knowledgebase for vendors
  • Continue development of additional training and educational tools, including a focus on hands-on training and deep technology dives
  • Expand language access of www.odva.org

– Streamline processes for easier and better access by members
  • Select and integrate new customer management systems to ensure that members receive accurate and prompt information with ease of access
  • Finalize review and create clear actions on test policies and procedures

– Continue to expand ODVA Community opportunities and input
  • Investigate how ODVA can further support product development
  • Expand co-education, marketing, and member participation roles
Technology Review
SIG Work Summary

- A total of 80 SEs and TDEs
- Two publication cycles in 2020
- Three publication cycles in 2021 – extra to incorporate Ethernet-APL content

- A total of 27 volume revisions
  - Vol 1 – 4
  - Vol 2 – 4
  - Vol 3 – 1
  - Vol 4 – 1
  - Vol 5 – 3
  - Vol 6 – 1
  - Vol 7A – 1
  - Vol 7B – 1
  - Vol 7C – 2
  - Vol 8 – 4
  - Vol 9 – 3
Key Accomplishments since last Annual Meeting

- Constrained EtherNet/IP devices
  - Protocol definitions for EtherNet/IP and CIP Security
  - Drives down the cost for end nodes
  - Foundation for the in-cabinet use case
  - EtherNet/IP down to the smallest devices
    - Profiles for push button and pilot light devices
  - Core technology for IIoT infrastructure
    - With CIP Routers the smallest sensors may be modeled
    - Together with the OPC UA Companion Specification for CIP an ideal vertical data transport
Key Accomplishments since last Annual Meeting

• OPC UA
  – Supporting the OPC Foundation Joint Workgroup for OPC Companion Specification to the Common Industrial Protocol
  – Identity Object Alignment with OPC
    • Adds additional attributes to support additional properties of OPC Part 100: Devices
Key Accomplishments since last Annual Meeting

• EtherNet/IP in Process Automation
  – Ethernet-APL support added to Volume 2, Chapter 8 specification
  – Device Type Revision
    • Provides a common way to report a revision for a Device Type/Profile definition
Key Accomplishments since last Annual Meeting

• Project xDS
  – Requirements analysis and proposals for key components
    • Conformance Information
    • Parameter Dependencies
    • Cybersecurity
    • Artifact Packaging
  – AutomationML Investigation
    • Sample AML models of xDS reference devices created
Key Accomplishments since last Annual Meeting

• CIP Safety
  – Recertification of CIP Safety Volume 5 Edition 2.22 for Compliance with IEC 61784-3 Edition 4 by TÜV was completed
Key Accomplishments since last Annual Meeting

- **Time Sensitive Networking**
  - High level approach for EtherNet/IP + TSN completed
    - Document major technical aspects and decision points
    - Define work packages for SIGs
  - Early draft for 802.1AS-2020 as an optional Time Profile for CIP Sync Object
Key Accomplishments since last Annual Meeting

• Conformance
  – Developed detailed test plan for originator interoperability
  – Conformance Testware is up-to-date with 2021 PC2 CIP Networks Library
Key Planned Activities for Next Term

- **EtherNet/IP**
  - Start looking at IPv6 - again
  - General purpose use of SPE
  - Gigabit Ethernet Physical Layer
  - Time Sensitive Networking
    - Synchronize with IEC/IEEE 60802 TSN Profile for Industrial Automation
    - Start developing specification material
Key Planned Activities for Next Term

• Project xDS
  – Begin develop material for the formal specification
  – Continue development of an EZ-xDS prototype
Key Planned Activities for Next Term

• OPC UA
  – Continue assist OPC Foundation JWG developing the OPC Companion Specification for CIP
  – Seamless mapping of CIP data
It’s Not Enough to be Smart
A User’s Perspective on Smart Process Instrumentation and Networks

Paul R. Maurath
The Procter & Gamble Company
Brief Resume

• B.S. / Ph.D. in Chemical Engineering
• 36 years with Procter & Gamble
• Focus areas
  – Process automation and control
  – Control loop performance and tuning
  – Process instrumentation
  – Community manager of the internal P&G automation and control global community.
Today’s Process Instrumentation “Network”

• Conventional I/O dominates
  – Highly distributed
  – Ethernet backbone

• Discrete devices are simple ON/Off

• HART is broadly available for analog devices but not highly leveraged

• Ethernet is becoming more important
  – Backbone of Remote I/O
  – Drives of all kinds
  – Complex / multivariable instruments
    • Coriolis flowmeters
    • pH transmitters

• Typically on an isolated private network (192.168.1.xxx)
Business and Technical Drivers

- “Smarter” devices with more data to share
- More systems want that data
  - Maintenance
  - Data Analytics
- Continued penetration of Ethernet farther down in the architecture

- Key process industry needs have not been met by mainstream IT Ethernet technologies.
  - Multi-conductor fragile wiring
  - Long distance wiring (not fiber)
  - Loop powered devices
  - Electrically classified areas

- New networking technologies
  - Advanced Physical Layer (APL)
  - IO Link
Advanced Physical Layer (Ethernet-APL)

Emerging Single Pair Ethernet / 2-Wire Intrinsically Safe Ethernet Standard for Process Automation Protocols

Process Industry Requirements for Ethernet field devices

- Twisted pair cabling
- Deployable in electrically classified / hazardous areas
- Reaching long distances
- Easy to handle technology
- Connectors for harsh conditions
- Loop-powered devices

Ethernet-APL is a 2-wire Ethernet (Physical Layer) for process automation, based on

- IEEE 802.3cg-2019, 10BASE-T1L
- IEC standards (IEC60079, IEC61158)
- Communication protocol independent
Advanced Physical Layer (Ethernet-APL)

Possible Architecture
P&G APL Demonstration Learning Objectives

1. **Gain an understanding of the knowledge and skills required to implement and maintain APL**

2. **Assess the potential benefits of APL for P&G**

   - Basic installation and wiring of switches and instruments.
   - Instrument configuration and replacement
   - Network and switch configuration and management
   - Interoperability between switches and instruments from multiple vendors
   - Instrument update rates and impact of faster communications vs. HART
   - Access to multiple variables and diagnostic information
   - Potential impact of higher power availability – conversion of 4-wire devices to 2-wire
   - Functional comparison of APL vs. other communications such as 4-20 mA HART, IO-Link
Smart Process Cell – “SPC”

- Located at P&G Corporate Engineering Technology Lab (CETL) in West Chester, OH
- Process Equipment
  - Four tank (500 kg and 375 kg)
  - Six pumps with flowmeters
  - Continuous and batch operations (3 units)
- Process Fluid – water
- Fully self-contained and remotely operated
Our APL Results – APL Works!
Initial Benchtop Tests

Using EtherNet/IP

Largest barrier was assigning IP addresses

Three devices were “bricked” and had to be returned to their suppliers

Communications established with our controller after importing EDS files
Field Tests on the SPC

Straightforward wiring

Replaced existing 4-20 mA / HART instruments

APL was completely “invisible” to the controller

Devices looked like any other EtherNet/IP device

Parallel testing of multiple IO Link devices.
The SPC Today

[Diagram showing a network of devices and connections, including HMI, Controller, IO Link Masters, Remote I/O, Variable Frequency Drives, and various types of I/O such as FIT, FV, LIT, PIT, TIT, LSL, LSLL, and FCV.]

HMI

Controller

Conventional I/O

FIT

FV

IO Link Masters

FIT

PIT

TIT

Remote I/O

FIT

VIT

Variable Frequency Drives

APL Switch

LIT

PIT

TIT

FIT

LSLL

FV

FIT

TIT

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P&G APL Demonstration Learning Objectives

1. *Gain an understanding of the knowledge and skills required to implement and maintain APL*
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- Basic installation and wiring of switches and instruments.
- Instrument configuration and replacement
  - Network and switch configuration and management
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- Access to multiple variables and diagnostic information
  - Potential impact of higher power availability – conversion of 4-wire devices to 2-wire
  - Functional comparison of APL vs. other communications such as 4-20 mA HART, IO-Link
What Do Users Need?

Help Us Manage Complexity

Hand tools
- DVM
- HART Communicator

BootP
- DHCP
- EDS
- Profiles
- Firmware Rev
- IODD
- Data Model

General Session & Annual Meeting © 2022 ODVA, Inc.
2022 Industry Conference & 21st Annual Meeting www.odva.org
The World of Logitech Mice for Windows
Replacing a Mouse

The user . . .

- Removes old mouse
- Connects new mouse
- Wait
- Uses new mouse

Windows . . .

- Loses connection to old device
- Sees a new “pointing device”
  - Finds an appropriate driver, using the network connection if it needs to.
- Installs the new driver
- Tells you it’s done.
Replacing a Mouse

**The user . . .**

- Removes old mouse
- Connects new mouse
- Wait
- Uses new mouse, but no emojis.

**Windows . . .**

- loses connection to old device
- Sees a new “pointing device”
  - Finds an appropriate driver, using the network connection if it needs to.
- Installs the new driver
- Tells you it’s done.
Replacing a Gaming Mouse

**The user . . .**

- Removes old mouse
- Connects new mouse
- Wait
- Uses new mouse, but lost 15 button configurations

**Windows . . .**

- Loses connection to old device
- Sees a new “pointing device”
  - Finds an appropriate driver, using the network connection if it needs to.
- Installs the new driver
- Tells you it’s done.
Replacing a 4-20mA HART Pressure Transmitter

**In the field**

- **PIT** Remove old transmitter
- **PIT** Connect new transmitter
- Configure the range in the new transmitter
- It probably works.

**In the application / controller . . .**

- Loses connection to old device
- Valid connection to a new device
- Check scaling
- Valid signal
Replacing A Smart Device (EtherNet/IP, IO Link, etc)

In the field

- PIT: Remove old transmitter
- PIT: Connect new transmitter
- Configure communications
- Does it work?

In the application / controller . . .

- Loses connection to old device
- Does the new device communicate?
  - New configuration file?
  - Do I have to restart/reload the controller?
- Is the data structure the same?
  - Do I have to change application code?
- How long will it take to get back up?
Where Do Users Need Help With Smart Devices

Communications

• IP Address Assignment
  – DHCP, BootP
  – Local displays
  – Dip switches
  – Selector wheels
• Switch port based DHCP ?
• Watch out for assumptions
  – 192.168.1.x
  – 10.10.x.x
  – ????
Where Do Users Need Help With Smart Devices

Integration and Compatibility

• Configuration Files / Drivers
  – EDS files
  – IODD files

• Easy replacement of “like for like” devices
  – Temperature
  – Pressure
  – Switches

What skills will be needed to troubleshoot and repair our smart systems?
Where Do Users Need Help With Smart Devices

Configuration Confusion

How many ways are there to change the configuration of a smart process transmitter?

- Local display
- Field communicator
- Controller programming software
- Asset management system
- Web interface

Do they all show the same information?

Who has the “Master Copy”? 
Future Networks and Architectures?

- Cloud
- Less controller-centric?
- Different protocols
- Users will need standards
Conclusions

- Standards are great!
- Please put the end users front and center when creating and managing standards.
- New technologies need to deliver functionality and simplicity.
Thank you for your attention
Industrial Automation 2030

A Discussion of Industry’s Next Steps
March 10, 2022

Harry Forbes
Research Director
ARC Advisory Group
HForbes@ARCweb.com
Agenda

• Why so slow?

• The view of one leading, large (and pesky) manufacturer

• What is it that the automation industry not seeing?

• The shape of (automation) things to come

• “Would you like TSN with that?”
Agenda

• Why so slow?

• The view of one leading, large (and pesky) manufacturer

• What is it that the automation industry not seeing?

• The shape of (automation) things to come

• “Would you like TSN with that?”
Innovation Cycles in Automation

Automation Architecture ca. 1995...

- Robust IPC and operator panel hardware on machines (harsh environment)
- Distributed throughout the plant – high maintenance costs, many dissimilar systems
- Each IPC and panel uses its own database – "multiple versions of the truth"
Innovation Cycles in Automation

Automation architecture today...

- Robust IPC and operator panel hardware on machines (harsh environment)
- Distributed throughout the plant – high maintenance costs, many dissimilar systems
- Each IPC and panel uses its own database – “multiple versions of the truth”
Speed of Innovation in Industry
• Why so slow?
  ▪ Cost of downtime and failure are high
  ▪ Reluctant players
  ▪ Long equipment lifecycles
  ▪ Certifications
  ▪ Lack of global standards
  ▪ ...

Why so slow?

• Cost of downtime and failures
  ▪ Cost of unplanned downtime can be $millions/hour
  ▪ Equipment failure can harm people, environment and equipment

• Reluctant players
  ▪ Automation companies: protective strategies (“proprietary-open”), need to cater all clients
  ▪ Machine builders: Small R&D teams, typical innovation cycles ~10 years, cost of equipment is critical
  ▪ EPCs: competence and pressure in projects, but little involvement in plant operations
  ▪ End users: care about costs over lifecycle, “need to run”

• Long Equipment Lifecycles
  ▪ Equipment is installed for 2 to 40 years
  ▪ During this period end users need:
    - support/maintenance
    - spare parts
    - compatibility

• Certifications
  ▪ Necessary, but...
  ▪ Barrier to entry/protection of status quo
  ▪ Markets are highly competitive
  ▪ Certification processes are long, specialized, and expensive

• Lack of global standards
  ▪ Promotes “walled garden” product and business strategies
  ▪ Lack of scale and market fragmentation hampers innovation
Innovation Cycles in Automation

1995
- Windows 95 introduced
- PCs used in production environment

2000
- Big Boom in automation
- PLCs become PACs
- IPCs increasingly used

2010
- Governments push manufacturing (Industrie 4.0)
- Cloud platforms introduced
- Predix, Mindsphere, AWS, Azure
- Network infrastructure based on Ethernet

2020
- Data models from plant to office
- Containerized deployment of industry software
- New automation architectures challenge Old Guard

IT / OT Convergence: use of technologies and concepts from IT in OT
Some End User Comments

• “We are afraid that any new technology will just add complexity to our production.”

• “We need to have a clear business case when we want to implement something new, in order to get the approval from management.”

• “We need clear and measurable KPIs for any new technology we introduce.”

• “I buy only proven technology from market leaders, so I do nothing wrong.”

• “We test for years to know how they behave in our industry.”

• “We have the capabilities to just set up our own data center and do everything ourselves; we have the economies of scale.”

• “Once installed, we do everything to keep the system running.”
Agenda

• Why so slow?

• The view of one leading, large (and pesky) manufacturer

• What is it that the automation industry not seeing?

• The shape of (automation) things to come

• “Would you like TSN with that?”
A Different End User Comment

If I need a specific function...

**Today:**
I buy a box that provides it.

![Diagram showing current setup with Control PC, Switch Layer 2, Switch Layer 3, PLC, Process device, Firewall, Switch, Plant PC, and firewall.]

**Future:**
I buy software that provides it.
(I already have the box because it is a standard part.)

![Diagram showing future setup with Industrial PC, Process device.]

AUDI AG
ARC Industry Forum, 2020
“Why do we need a virtualized/containerized software environment? Because of the maintenance costs we have now in our factories.

As I said, [we have] 45,000 IPCs. Now imagine you want to do to an operating system upgrade on 45,000 IPCs, which you cannot do remotely because every single one of them has very specific tasks.

You must walk to each particular IPC. You have to do the upgrade. You have to pray that the drivers still work for that specific task. Then move on to the next IPC.

It’s an incredible amount of money we’re spending on doing this, and these upgrades won’t go away.”
Automation Paradigm Shift

Data Center

Shop Floor HW

Field IO

Data Center

Shop Floor Hardware

Shop Floor Function

Field IO

Audi AG
ARC Industry Forum, 2020
Here is what Audi envisions (in ARC’s opinion)

- Thin, open source orchestration layer
  - Provides for self-updates
  - Provides for virtualization
  - Has a public API for orchestration

- Supports all types of applications
  - Guest RTOS
  - VMs
  - Containerized apps
  - Lightweight Kubernetes implementations
Agenda

• Why so slow?

• The view of one leading, large (and pesky) manufacturer

• **What is it that the automation industry not seeing?**

• The shape of (automation) things to come

• “Would you like TSN with that?”
What is missing from this viewpoint? The Linux Foundation

• Software is eating the world, but...
  ▪ Open Source software is eating the software world

• Today’s enterprise IT **products** are built on a foundation of Open Source **projects**
  ▪ **Linux**
  ▪ **Docker** (containers are made usable for normal people)
  ▪ **Kubernetes** (delivers containerized, reliable, scalable, distributed systems)
  ▪ **Yocto**, and many, many others...

• The Good News
  ▪ The Linux Foundation is dominating this landscape
  ▪ The Linux Foundation is delivering huge resources to open source software developers

• The Bad News
  ▪ The Linux Foundation has so much influence that they “pick winners and losers”
  ▪ Major IT firms govern the Linux Foundation
The Linux Foundation – The Open Source Software Juggernaut

- An Open Source Software “Borg”
- $200 million/year revenue
  - 200 headcount
  - Only 2 developers on salary...
  - Software Development work is done pro bono
- Governance:
  By ALL IT leaders and Hyperscalers
- Shared expert services for OSS projects... including legal services
- “Up or Out” model for project maturity
- Far more resources/influence than any competition
  - Eclipse Foundation
  - Apache Software Foundation
Where Linux Foundation Operates

LF Open Source Component Projects for 5G
Linux Foundation Component Projects for 5G
• Maintainer human resources
  ▪ Lack of activity/support for legacy can be a major problem

• Plethora of projects

• Redundancy of projects
  ▪ Difficult to merge or terminate
  ▪ LF is not nearly as ruthless as VCs

• Governance:
  Influence of major IT firms
  ▪ vs. the traditional OSS developer culture

• and...

• Automation firms, IE consortia simply do not understand any OSS business model
  ▪ Is this a legacy of their hardware-oriented or software licensing business model?
Agenda

• Why so slow?

• The view of one leading, large (and pesky) manufacturer

• What is it that the automation industry not seeing?

• The shape of (automation) things to come

• “Would you like TSN with that?”
The Shape of the Industrial Edge to Come!
Hyper-Converged Infrastructure (HCI)

**HCI:** software-defined infrastructure that virtualizes all elements of conventional "hardware-defined" systems.

- Virtualized computing
- Software-defined storage
- Virtualized networking (software-defined network)

**This would require:**
- Virtualize real-time control (soft PLC)
- Virtualize industry software (MES, HMI, historian, analytics)
- Virtualize industrial networks

**Benefits**
- **Simplicity:** Eliminate complexity of managing different hardware components and infrastructure silos.
- **Cost:** Reduce capital hardware investments, improve cost and storage efficiency, leverage existing in-house technical expertise. Runs on commercial off-the-shelf servers.
- **Agility:** No vendor lock-in, on-demand scalability, support for legacy and modern applications
Product Examples: The Shape of the Industrial Edge to Come!

- Emerson (former GE Intelligent Platforms)
  - Among the first movers
  - Connection to GE Predix platform
  - One Hypervised CPU
- Rockwell
  - PTC investment/alliance
  - Investments in startup firm Zededa
- Siemens
  - Integrated module for S7-1500
  - Sinumerik Edge –extra module
  - Pixeom acquisition
- Phoenix Contact:
  - PLCnext - shift in portfolio strategy
- Bosch Rexroth
  - CtrlX announced @ 2019 SMS
  - New concept, new strategy
  - Deep partnership with Canonical for Ubuntu(s)
- Beckhoff:
  - Partnership with AWS
- TTTech
  - 2021 acquisition of Nebbiolo, “Nerve” platform
- IPC focused suppliers (Advantech, Kontron)
  - Leverage open HW to enable edge control
  - Push CPU power in networks and distributed HW
- Startups, startups, startups
  - Most will be acquired

Edge controllers are either a clean break with or a careful expansion of supplier portfolio.
Agenda

• Why so slow?

• The view of one leading, large (and pesky) manufacturer

• What is it that the automation industry not seeing?

• The shape of (automation) things to come

• “Would you like TSN with that?”
Do we need TSN to do this?

- It depends...
- If the real-time domain is limited to one box and one I/O network, then probably “no”
- Otherwise, probably “yes”
Dates in the Fieldbus Wars

- First Fieldbus technologies
- Fieldbus War starts
- OPC Task force creation
- OPC-UA becomes available
- AVB TG foundation
- The term “Industry 4.0” is used for the first time.
- AVB renamed in TSN
- IEC 61158-2 Last Revision
- IEC 61784-3 Last version
- IEC 61158-1 Last Release
- OPC-UA Pub/Sub release
- IEC 61784-2 Last Release
- IEC 61784-2/3/5 First Release
- IEC 61158 Revision
- IEC 61784-1 First Release
- IOT term used for the first time
- Memorandum of understanding
- Approved a proposal for an international fieldbus (IEC 61158)

Timeline:
- 1970
- 1986
- 1995
- 1999
- 2003
- 2005
- 2007
- 2008
- 2011
- 2012
- 2014
- 2018
- 2019
- 2021
Classification of Real-time Ethernet

**Class 1**
- Applications
- BE
- RT
- TCP/UDP
- IP
- Ethernet MAC
- Ethernet infrastructure

**Class 2**
- Applications
- BE
- RT
- TCP/UDP
- IP
- Scheduling/Priority
- Ethernet MAC
- Ethernet infrastructure

**Class 3**
- Applications
- BE
- RT
- TCP/UDP
- IP
- Scheduling/Priority
- Ethernet MAC
- Ethernet infrastructure with RT properties
List of TSN IEEE 802.x Standardization Projects

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.1AB</td>
<td>Station and Media Access Control Connectivity Discovery</td>
</tr>
<tr>
<td>IEEE 802.1AS</td>
<td>Timings &amp; Synchronization</td>
</tr>
<tr>
<td>IEEE 802.1AX</td>
<td>Link Aggregation</td>
</tr>
<tr>
<td>IEEE 802.1CB</td>
<td>Frame Replication &amp; Elimination</td>
</tr>
<tr>
<td>IEEE 802.1CS</td>
<td>Link Local Registration Protocol</td>
</tr>
</tbody>
</table>

**Ongoing Projects**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE P802.1CQ</td>
<td>Multicast and Local Address Assignment</td>
</tr>
<tr>
<td>IEEE P802.1DC</td>
<td>Quality of Service Provision by Network Systems</td>
</tr>
<tr>
<td>IEEE P802f</td>
<td>YANG Data Model for EtherTypes (amending IEEE 802-2014) [62]</td>
</tr>
<tr>
<td>IEEE P802.1ABcu</td>
<td>LLDP YANG Data Model (amending IEEE 802.1AB [55])</td>
</tr>
<tr>
<td>IEEE P802.1ABdb</td>
<td>Support for Multiframe PDU (amending IEEE 802.1AB [55])</td>
</tr>
<tr>
<td>IEEE P802.1ASdm</td>
<td>Hot Standby (amending IEEE 802.1AS [56])</td>
</tr>
<tr>
<td>IEEE P802.1ASdn</td>
<td>YANG Data Model (amending IEEE 802.1AS [56])</td>
</tr>
<tr>
<td>IEEE P802.1CBcv</td>
<td>FRER YANG Data Model (amending IEEE 802.1CB [58])</td>
</tr>
<tr>
<td>IEEE P802.1CBdb</td>
<td>FRER Extended Stream Identification Funs (amending IEEE 802.1CB [58])</td>
</tr>
</tbody>
</table>

Amendments to the IEEE 802.1Q standard

<table>
<thead>
<tr>
<th>Amendment</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>802.1Qat</td>
<td>Stream Reservation Protocol (SRP)</td>
</tr>
<tr>
<td>802.1Qav</td>
<td>Credit based Shaper</td>
</tr>
<tr>
<td>802.1Qaz</td>
<td>Stream Resv. Pot.</td>
</tr>
<tr>
<td>802.1Qbu</td>
<td>Frame Preemption</td>
</tr>
<tr>
<td>802.1Qbv</td>
<td>Enhancements for Scheduled Traffic</td>
</tr>
<tr>
<td>802.1Qca</td>
<td>Path Control</td>
</tr>
<tr>
<td>802.1Qcc</td>
<td>TSN Configuration</td>
</tr>
<tr>
<td>802.1Qch</td>
<td>Cyclic Queuing</td>
</tr>
<tr>
<td>802.1Qci</td>
<td>Per-stream Filtering</td>
</tr>
<tr>
<td>802.1Qcp</td>
<td>YANG Data Model</td>
</tr>
<tr>
<td>802.1Qcr</td>
<td>Asynchronous Shaping</td>
</tr>
<tr>
<td>802.1Qcc</td>
<td>YANG Data Model for Connectivity Fault Management</td>
</tr>
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**Ongoing Projects**

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<tbody>
<tr>
<td>P802.1Qcj</td>
<td>Automatic Attachment to Provider Backbone Bridging (PBB) services</td>
</tr>
<tr>
<td>P802.1Qcw</td>
<td>YANG Data Models</td>
</tr>
<tr>
<td>P802.1Qcz</td>
<td>Congestion Isolation</td>
</tr>
<tr>
<td>P802.1Qzd</td>
<td>Resource Allocation Protocol</td>
</tr>
<tr>
<td>P802.1Qadj</td>
<td>Configuration Enhancements for Time-Sensitive Networking</td>
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</table>

Amendments to the IEEE 802.3 standard

<table>
<thead>
<tr>
<th>Amendment</th>
<th>Description</th>
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<tbody>
<tr>
<td>802.3br</td>
<td>Interspersing Express Traffic</td>
</tr>
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</table>
### TSN Profiles and Classes of Industrial Network Traffic

<table>
<thead>
<tr>
<th>Description</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio Video Bridging (AVB) systems</td>
<td>IEEE Std 802.1BA</td>
</tr>
<tr>
<td>Time-Sensitive Networking for Fronthaul</td>
<td>IEEE 802.1CM</td>
</tr>
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</table>

**Ongoing Projects**

<table>
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<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Automation</td>
<td>IEEE/IEC 60802</td>
</tr>
<tr>
<td>TSN Profile for Service Provider Networks</td>
<td>IEEE P802.1DF</td>
</tr>
<tr>
<td>TSN Profile for Automotive</td>
<td>IEEE P802.1 DG</td>
</tr>
<tr>
<td>TSN for Aerospace Onboard Ethernet Communications</td>
<td>IEEE P802.1 DP</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Traffic Typology</th>
<th>Periodic</th>
<th>Sporadic</th>
<th>Deadline</th>
<th>Bandwidth</th>
<th>Bounded Latency</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isochronous cyclic real-time</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cyclic real-time</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network Control</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Audio/Video</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Brownfield</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alarms/Events</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configuration/Diagnostic</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal/pass-through</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best-Effort</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Summary

• Change in automation technology is slow for many reasons
   Some of them are good reasons

• End users want to move to a standardized and manageable hw/sw platform
   But...this will need to include Open Source software

• OSS is dominating software and the Linux Foundation is dominating OSS
   So watch out!

• The Automation industry does not have IT-like OSS business models
   ...and denial is not a long-term strategy

• TSN is very difficult
   Broad applicability across many industries
   Impact on many existing standards
   “Things take time”
Thank you!

Harry Forbes
Research Director
ARC Advisory Group
HForbes@ARCweb.com
Looking Ahead to the 22nd Term

• Al Beydoun, President & Executive Director
Leadership in the 22nd Term

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- Mr. McKenzie Reed
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- Ms. Tonya Wyatt
- Ms. Feiyan Zhao
Looking Ahead to the 22\textsuperscript{nd} Term

- Continue to expand the EtherNet/IP ecosystem and support of Industry 4.0 and IIoT initiatives
- Continue to grow our membership and adoption of CIP technologies through training, tools development, marketing initiatives, and promotions
- Continue to monitor emerging technologies in Industrial Automation working with the Market Advisory Committee for integration into ODVA technologies
- Collaborate with other organizations to expand and address the challenges of tomorrow in areas such as Security, TSN, Energy Management, Ethernet-APL maintenance, and more
- Align our marketing and communication globally working with the TAGs
- Continue adaptation of EtherNet/IP to the Process Industries: Establish conformance certification for Ethernet-APL, and collaborate with industry organizations on Device Information Models and Profiles
- Develop specifications for xDS digital device description
- Complete the translation of EtherNet/IP to GB/T Standard for China market
- Collaborate with industry organizations to develop TSN Industrial Automation Conformance specifications
- And as always, continue to engage with the membership to understand and support their needs
Be a Part of the ODVA Community!

Working Groups are Calling:

• CIP System Architecture – Configuration data, message router fragmentation service
• EtherNet/IP System Architecture – TLS 1.3 support, CIP Authorization Profile, IPv6
• EtherNet/IP Infrastructure – LLDP, TSN, SPE
• EtherNet/IP Physical Layer – Gigabit, TSN, SPE guidance, PoE, PoDL, Wireless
• CIP Safety – safety concurrent connections
• Distributed Motion and Time Synchronization – CIP Sync over DLR
• xDS Digital Device Descriptions – Create specification and prototypes
• Common Industrial Cloud Interface – OPC UA companion specification
• EtherNet/IP In Process Industries – Device profiles for process industries
• Conformance – Continued test improvement
THANK YOU!