Testing The Limits: TSN and SPE Updates

Presented by Bob Noseworthy and Griffin Leclerc
February 9, 2021
UNH-IOL at a Glance

The UNH-IOL as founded in 1988. Main UNH campus is located in Durham, New Hampshire, USA

The UNH-IOL is a non-profit neutral, third-party laboratory dedicated to testing data networking technologies through industry collaboration.

The UNH-IOL has been involved with TSN since the days of Residential Ethernet (’05) and in Ethernet Physical layer test since 1988.

- Principal developer of Avnu Automotive Certification Test Plans & Tools
- Principal developer of OPEN Alliance Physical layer, PCS, Phy Control and Sleep/Wake Test Plans
Overview of 802.1 Time Sensitive Networking and 802.3 Single Pair Ethernet activities {20 Min}
- Digital Factory Updates
- APL & 1588 Updates

Timing Security Updates {10 Mins}
- 1588/PTP Security TLV
- NTP NTS Update

Q/A and Open Discussion {30 Mins}
- Put questions in Zoom Q&A Box
- Those asking a question will be given permission to speak
Today’s Speakers

Bob Noseworthy
Principal Engineer, TSN, SPE, 1588 Technologies

Involved with:
APL Group Certification,
Avnu Alliance’s Certification,
IEEE PTP Certification,
Open Alliance Certification,
End-user TSN Profile development &
IEEE 802.1 TSN Working Group

Griffin Leclerc
Graduate Researcher
UNH-IOL &
Department of Computer Science

Actively involved in TSN and
IEEE 1588 compliance validation and leading NTS performance study
SPE Summary Updates

10BASE-T1L and APL (Advanced Physical Layer)

APL Certification testing online and expanding to the APL Group membership and organization labs

10BASE-T1L PMA, PCS, PHY-Control and Auto-Negotiation In development
- PMA fully available and PCS partially available

Tooling available:
- PCB Test Fixtures
  - Bias Tees for Spur/ Trunk Source/Load
  - Line taps + more

https://license.unh.edu/products/iol/APL

Test Software expected this month

Service offering migrating to a 10BASE-T1 Service group
- APL Testing available as Pay-per-test
- Silicon conformance testing moving out of “Low-speed SPE” group
SPE Summary Updates (2)

100BASE-T1 to MultiGig, OPEN Alliance and Ethernet Alliance + Plugfests!

- Contributing to Open Alliance Errata and ISO process for 100BASE-T1 test plans.
- Continuing to develop MultiGig PMA test capability launch and work with industry leaders for MultiGig PCS/PhyC compliance testing.
- Participating in discussions with the Ethernet Alliance SPE group on potential activities for further EA driven validation.
- Anticipating Summer 2022 plugfests for SPE interests (potential for 10BASE-T1L through MultiGig SPE – possibly include 1000BASE-T1 Type B and 40Meter reach).

UNH-IOL Hosting EA High Speed Networking Plugfest April 25-29 & IBTA May 2-6.
• .1Qbu/.3br: UNH-IOL Pre-emption conformance testing, including negative test cases, available since 2017
• .1Qbv: Time aware scheduling (TAS) testing performed for some IP & silicon providers
• .1Qci: Ingress Policing (Per-Stream Filtering and Policing) in development
• Test plans currently available or expected in ‘22
AVB was ~5 IEEE standards, TSN has >42 & climbing

Most standards have multiple options, some orthogonal

TSN Profiles must exist to define interoperable solutions for a given use case
- Example: IEEE 802.1BA (AVB Profile)

Several profiles are in-flight, none complete:
- IEEE 802.1DG (Automotive)
- IEC/IEEE 60802, (Industrial Automation)
- IEEE 802.1DF, (Telecom Service Provider)
- IEEE 802.1DP (Aerospace)

Currently authored 2 profiles for large end-user needs (not yet publicly available, expected to be in 2022)

TSN Standards → TSN Profiles
Industry Updates

- Supporting needs of the APL Group
  - PNO, FieldComm Group, ODVA, OPC Foundation
  - In discussions with several member organizations and member companies to offer further services
- Tracking APL further specification definitions
- Tracking IEEE 802.3 100BASE-T1L
- Developing full Silicon Validation for 10BASE-T1L
- Tracking IEC/IEEE 60802 and related CA discussion
- Supporting Research interests in Industry 4.0 / Digital Factory
NSF - U.S. National Science Foundation

I/UCRC - Industry / University Collaborative Research Center

CDFI - Center for Digital Factory Innovations
Center for Digital Factory Innovations (CDFI)

To drive innovative research with our industrial partners that enables the future digital factory by allowing the synchronization of processes—cyber, physical and human—and creating a manufacturing system endowed with efficiency, resilience, and intelligence.

Nicholas Kirsch
University of New Hampshire

Noel Greis
NC State University

Christopher Saldana
Georgia Institute of Technology
**Vision**: We envision interconnected, self-aware factories and processes that manufacture products through automation and the marriage of intelligent human-machine interactions.

**Objective**: To catalyze Internet-of-Things for Manufacturing (IoTfM) advancement and adoption for the purposes of improved product performance, enhanced productivity, workforce development, and economic growth.

**Importance**: To benefit US industry by generating new knowledge/methods to accelerate innovation, reduce waste, increase productivity, bring transparency to the value chain, and provide unique training opportunities for the critical, future workforce.

**Technical insights**: AI/ML integration, future workforce, future factory computing, self-optimizing systems.
Areas of CDFI Industry-Motivated Research

**Self-Aware Processes**

*Dynamic and self-aware manufacturing processes* which contribute integrated sensors and accompanying adaptive, cloud-based optimization and control systems for processes, such as machining, forming, and robotics.

**Self-Organizing Systems**

*Self-organization and control of production systems* which feature autonomy and reconfigurability within a distributed environment to allow local intelligence to the edge, enabled by machine learning and 5G networking for real-time control of the factory environment.

**Augmented AI**

*AI-Enabled Human-in-the-Loop in the Digital Factory* which assures human-machine cooperation in a cyber-physical system environment through artificial intelligence (AI) algorithms and machine learning for applications such as discrete processes and cobots.

**Deterministic protocols, interoperability, and cybersecurity** which focuses on communication platforms from time sensitive networks to wireless connectivity to the secure transfer of data for a given manufacturing process or entire factory environment.

**Collaborative Secure Intelligent**

**Protocol & Interoperability**

**Digital Factory of Tomorrow**
Where Are We In The Process?

We are here

- **Preliminary Planning Grant Proposal Submitted**
  - June 2020

- **Preliminary Planning Grant Awarded**
  - Sept 2020

- **Planning Grant Proposal Submitted**
  - Dec 2020

- **Planning Grant Awarded**
  - June 2021

- **NSF IUCRC BOOTCAMP**
  - July-Aug 2021

- **INDUSTRY PLANNING MEETING**
  - Jun-Sep 2022

- **Final CDFI Proposal Submitted**
  - Dec 2022

- **Final CDFI Funds Awarded**
  - Early 2023

- **CDFI LAUNCHED**
  - Mid 2023

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**University of New Hampshire InterOperability Laboratory**

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University of New Hampshire
Advanced manufacturing processes with next generation communication systems focused on time-sensitive networking, interoperability and cybersecurity.
• John Olson Advanced Manufacturing Center
• InterOperability Laboratory
• Connectivity Research Center

North Carolina State University
Digital technologies that transform data collected across the digital factory into actionable intelligence and self-managing capabilities.
• Digital Solutions Laboratory
• NCSU High Performance Computing Center
• ReasonSmart Data Analytics Platform

Georgia Tech
Advanced manufacturing and computing with a focus on additive/hybrid manufacturing, digital.smart manufacturing and manufacturing robotics.
• Advanced Manufacturing Pilot Facility
• CODA Computing Complex
• Factory Information Systems Laboratory

CDFI University Sites

CDFI Leadership

Dr. Nicholas Kirsch (Center Director, UNH Site Director)
• Associate Professor, Electrical & Computer Engineering
• Expertise: wireless communication networks, MIMO communications systems, cognitive radio, transparent antennas, and spectrum sensing

Dr. Noel P. Greis (NCSU Site Director)
• Research Professor, Operations and Supply Chain Management
• Expertise: Industry 4.0, machine learning, and intelligent technologies for digital manufacturing

Dr. Christopher Saldana (GT Site Director)
• Ring Family Professor and Associate Professor, Mechanical Engineering
• Expertise in digital manufacturing and hybrid manufacturing process development
Industry Updates

IEEE Conformity Assessment Advancing toward approved Test Specification

• Continuing to support
  o Launch of IEEE 1588 Power Profile Certification
    ▪ OCs, BCs, and TCs
    o PTP Violett for in-house pre-testing
  o Test Suite Specification in review prior to ballot
  o NIST and UNH-IOL collaboration and correlation effort
  o Join the program and pass testing to become certified and listed in the IEEE Registry
Industry Updates

• Officially Members (finally!) as of late Jan’22
• Exploring potential to further assist with:
  o Leveraging existing UNH-IOL draft ITU-T 8275.1 and 8275.2 test plans
  o Leveraging existing UNH-IOL expertise with IPv6, service provider networks, plugfest and test bed hosting
Time Sensitive Networks depend on secure & reliable time

In 2018: UNH-IOL & CS Department supported Dragos Maftei’s thesis:
  - IMPLEMENTING PROPOSED IEEE 1588 INTEGRATED SECURITY MECHANISM
  - Open source update to PTPd available to implement Security TLV

GAP: The IEEE 1588-2019 Security TLV does not define key exchange mechanisms
NTP Network Time Security (NTS)

• With support form the Internet Society, UNH-IOL is supporting graduate researchers pursuing compliance, interoperability and performance study of NTP’s NTS

• NTS is of interest to NTP and 1588 worlds alike
  ○ Likely path to be taken by future 1588 Security update

• Note, UNH supports the International IEEE Symposium on Precision Clock Synchronization (ISPCS), including its plugfest activities.
RFC 8915

Ensures time originates from a trusted source
Protocol Conformance Testing
Ensures NTS implementations conform to the RFC

Interoperability Testing
Ensures NTS implementations provide well formed timing information

Performance and Scalability Study
Quantify resource impact introduced by using NTS over NTP
Augment Cloudflare’s open source NTS implementation with Cargo Bench

Isolate NTS operation from NTP for a baseline comparison

Deploy the Clients and Servers to gather measurements using a variety of topologies
Quantify any additional resource requirements introduced by NTS

- Additional CPU cycles consumed
- System memory usage
- Timing protocol performance
Experiment Topologies

One to One

Many to One

Emulated Network Interference
With sufficient interest:

- 10BASE-T1S (OPEN Alliance TC14) support
- 100/1000BASE-T1 Interoperability testing (per OPEN definition)
  - Extending our TC1/TC12 service offering
- Full coverage of OPEN TC8 ECU & TC11 Silicon validation
  - Could be provided via Violett® and supported hardware solutions
  - Potential partnership with T&M equipment provider
- Accelerate & expand Timing Security / Quality of Time testing
- Accelerate & expand custom FPGA TSN NIC development
- Accelerate coverage of TSN Profiles In I.A., Telecom, Automotive, etc.

Questions and Requests?
Contact us on how to ‘kickstart’ such efforts.

We want to hear from you!

Thoughts?
Q&A

Input from the discussion in Dec’22:

Interest expressed / updates given on:

- 1000BASE-T1 Type B and 40Meter reach, as benefits the Agricultural industry (aef-online.org)
- Multiple inquiries around plugfest activities and organization, MultiGig SPE, TSN, Management, Security all potential topics of focus/event.
- Research efforts for Digital Factories, through efforts UNH, Georgia Tech, and NCSU are pursuing to form an NSF I/UCRC (Industry/University Cooperative Research Center), with a planning meeting at Georgia Tech in March 22-23 {postponed to June-Sept'22 due to Covid concerns - contact us for details as they settle} with a research scope including AI, ML, self-organizing systems, Wireless & TSN technology- contact us for more information!

Thanks for your Questions! Contact us (see next slide) for options on how to ‘kickstart’ such efforts.

We want to hear from you!
Contact Information

Single Pair Ethernet and Time Sensitive Networking Testing Services

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