TSN - Report on the IIC Testbed

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Session Abstract

This paper will give a report from the Industrial Internet Consortium's TSN Manufacturing testbed. The goal of this test bed is to display the value of new Ethernet (IEEE 802) standards referred to as Time-Sensitive Networks in a Manufacturing ecosystem of applications. 4 ODVA members are participating in the testbed: BoschRexroth, Cisco, Innovasic (recently acquired by Analog Devices, Inc.) and Schneider Electric.

The testbed will display the following:

- Combine different critical (e.g. OPC Pub/Sub and ODVA CIP) and best-effort traffic flows on a single network based on IEEE 802.1 Time Sensitive Networking (TSN)
- Demonstrate the real-time capability and vendor interoperability using standard, converged Ethernet
- Evaluate security value of TSN and provide feedback on the secure-ability of initial TSN functions
- Show ability for IIoT to incorporate high performance and latency sensitive applications
- Provide integration points for smart edge-cloud control systems into IIoT infrastructure & application

By the time of the report, the testbed will have conducted at least 2 plugfests where a variety of vendors have demonstrated varying levels of integration with TSN-based networking technology. This paper will report on the applications used, the level of integration and readiness of TSN based standard technology and report some of the value of TSN to the ODVA community.

Agenda

- Testbed Overview
  - Testbed Objectives
  - Current Testbed Topology
  - Plugfest Results
- Next Steps
  - Testing Status
  - SDN-inspired Network Configuration
- The Future
  - TSN Testbed of the Future
  - Conclusions

Testbed Overview

TSN Organization and Roles

Testbed and Reference Architectures

- Testbeds to evaluate “full stack” and provide feedback to members and liaison organizations
- Application specific architectures to aid in market adoption
- Outbound marketing to create awareness

Application Layers

- Define data models for end-device communication
- Integration of TSN communications and configuration models into application tools
- Application flow for end-node configuration
- Conformance for data models and end node configuration

TSN Transport Interoperability and Conformance

- Define network services needed by market
- Fill gaps in standards to provide interoperable network configuration services
- Conformance of transport and network services
- Establish certification services

Network standards

- Define standard features to provide data plane and configuration plane providing TSN capabilities
- Assure proper operations and backwards compatibility with IT and OT

Testbed Objectives

Time Sensitive Networks - Flexible Manufacturing for Robotics and Automation Cells

Testbed Objective and Overview

Market Segment

- Flexible Manufacturing providing tight coordination of multiple machines and Industrial-IoT (IIoT) integration

Goal

- Real-time control & synchronization of high performance machines over standard Ethernet

Features

- Combine different critical and best-effort traffic flows on a single network based on IEEE 802.1 Time Sensitive Networking (TSN)
- Demonstrate the real-time capability and vendor interoperability using standard, converged Ethernet
- Show ability for IIoT to incorporate highly performance and latency sensitive applications
- Provide integration points for smart edge-cloud control systems into IIoT infrastructure & application
- Standards Feedback – report depicting standards used, not used and gaps/improvements for relevant standards groups (IEEE, AVNU, OPC …)

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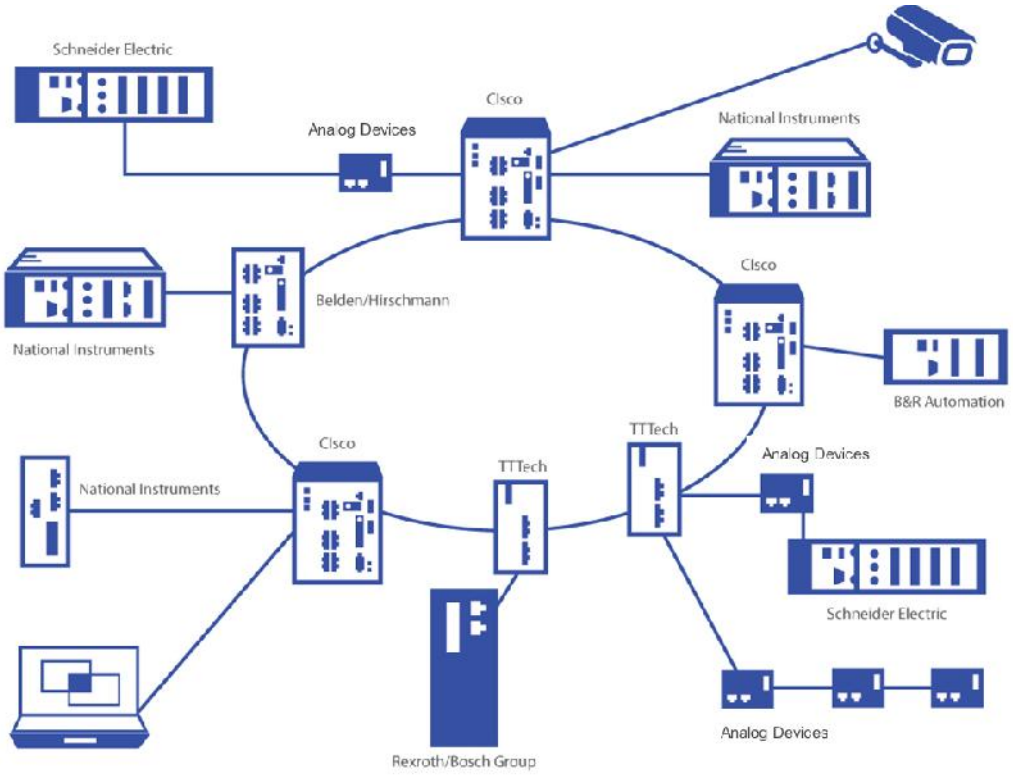
Current Testbed Topology



IIC TSN Testbed – Plugfest #1

On June 20 – 23 we conducted the first TSN plugfest in Austin TX at NI Headquarters. Testbed is officially open and available.

Participants include: NI, Cisco, TTTech, GE, Schneider Electric, Kuka, Intel, Analog Devices, Inc. and Ixia

Dependent on Participant readiness, the objectives included

1. Establish end-device synchronization via 802.1AS network based time services
2. Define TSN flows in Central Network Controller and distribute schedule to network infrastructure
3. Communicate I/O traffic via TSN flows
4. Measure and verify TSN performance with Ixia testing tools

All participants with end-devices achieved synchronization and a subset of participants achieved all 4 objectives.

IIC TSN Testbed – Plugfest #2

On Oct. 3-5 2016 we conducted the second TSN plugfest in Austin TX at NI Headquarters.

Participants include: NI, Cisco, TTTech, Belden Hirschmann, BoschRexroth, B&R, Schneider Electric, Intel, Analog Devices, Inc. and Ixia. Dependent on Participant readiness, the objectives included:

1. Establish end-device synchronization via 802.1AS network based time services
2. Communicate I/O traffic via TSN flows
3. TSN Gateway traffic from one vendor
4. Measure and verify TSN performance with Ixia testing tools
5. Built a demonstration displayed at IOT SWC (Oct. Barcelona) and SPS Drives (Nov. Nuremberg)

All of these objectives were achieved and successful demonstrations of the testbed were held at the IOT SWC and SPS drives.

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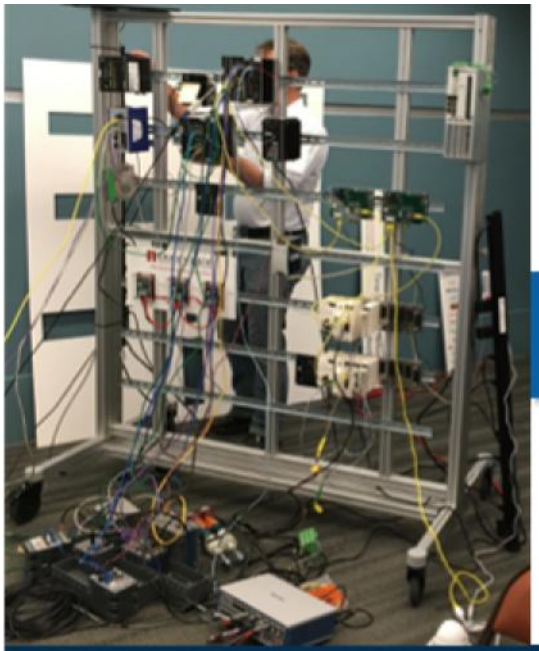
IIC TSN Demo



Plugfest to Demonstration

Serve as showcase:
"Road-show" at *IoT Solutions World Congress* and *SPS*

Next Steps

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Testing Status

Time Synchronization

Traffic Scheduling

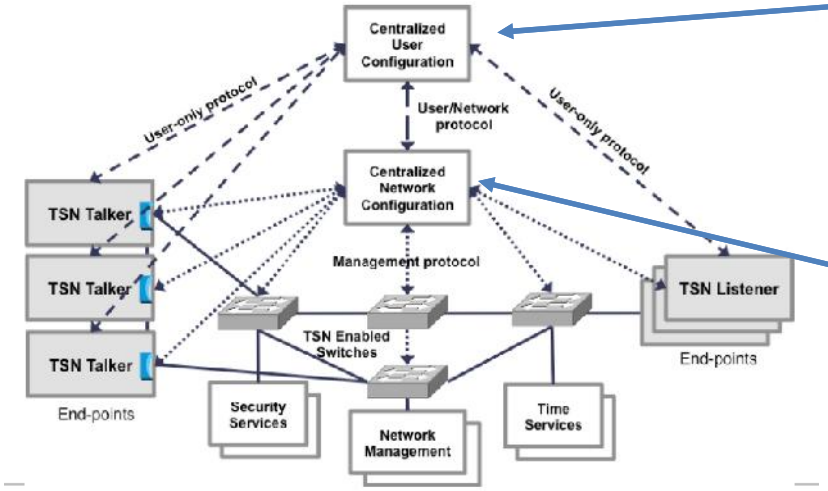
System Configuration

SDN-inspired Network Configuration

Core TSN Network Services

To manage traffic schedules and paths (including redundant paths) for data and time-sync, a **centralized configuration** approach is beneficial

- Can be supported with existing protocol standards, can lower costs for end nodes and bridges, can scale to support future network capabilities (new shapers, etc.)



Centralized User Configuration (CUC)

- Receives requirements from users of TSN network services (Talkers/Listeners)
- Sends requirements to manager of TSN network services (CNC)

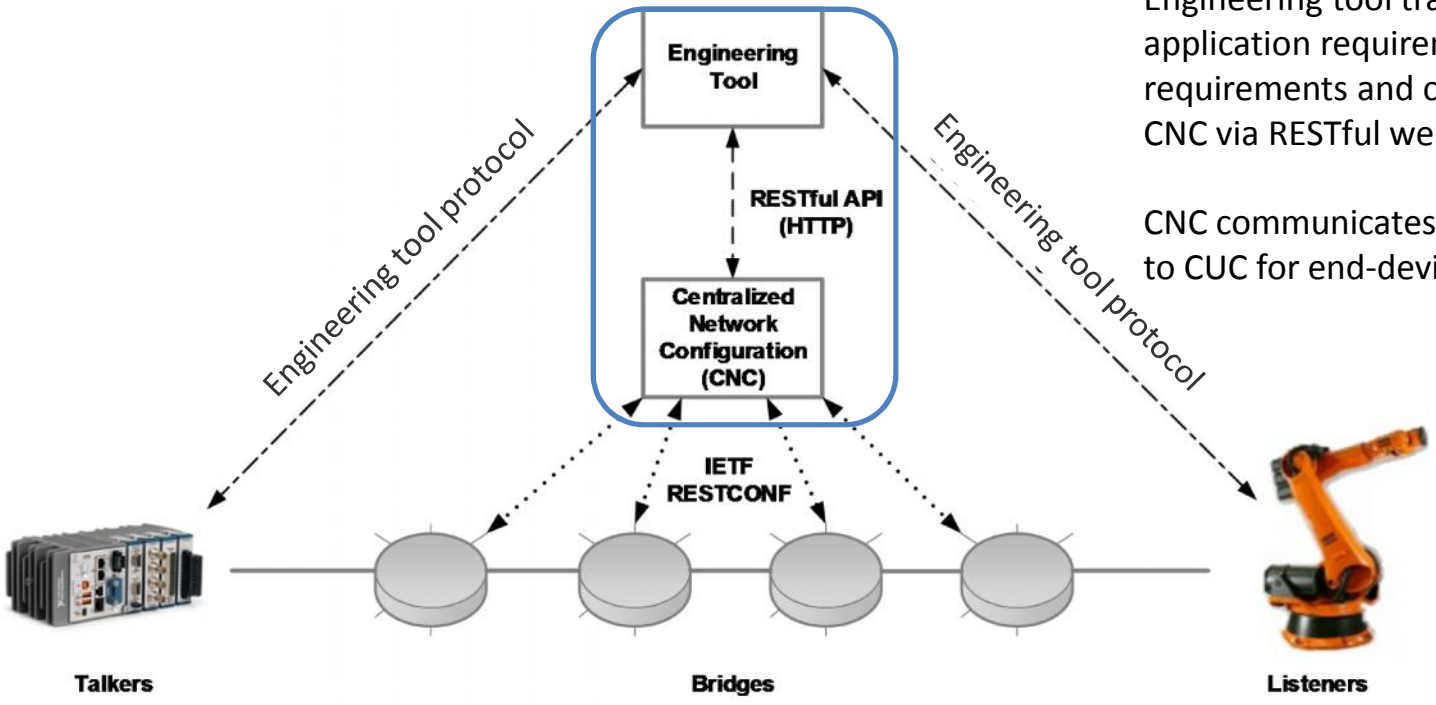
Centralized Network Configuration (CNC)

- Receives *consolidated* requirements from users of TSN network services (CUC)
- Sends requirements to enablers of TSN network services (TSN-enabled switches)

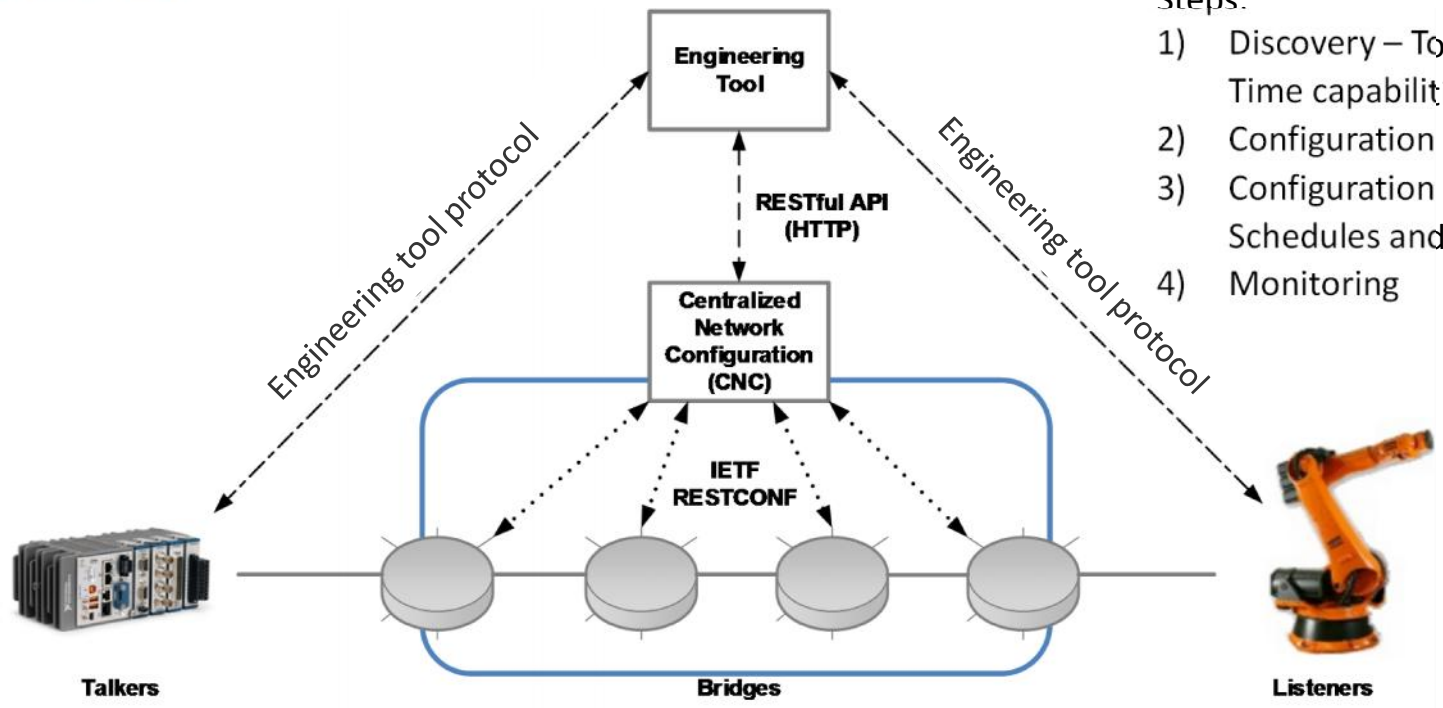
CNC - Northbound

Engineering tool translates application requirements to network requirements and communicates to CNC via RESTful web API

CNC communicates flow parameters to CUC for end-device configuration



CNC - Southbound



Steps:

1) Discovery – Topology (LLDP) and TSN & Time capabilities (Yang and/or MIBs),
2) Configuration of .1AS (Time)
3) Configuration of TSN-Quality of Service, Schedules and Streams, .1Qbv and more
4) Monitoring

The Future

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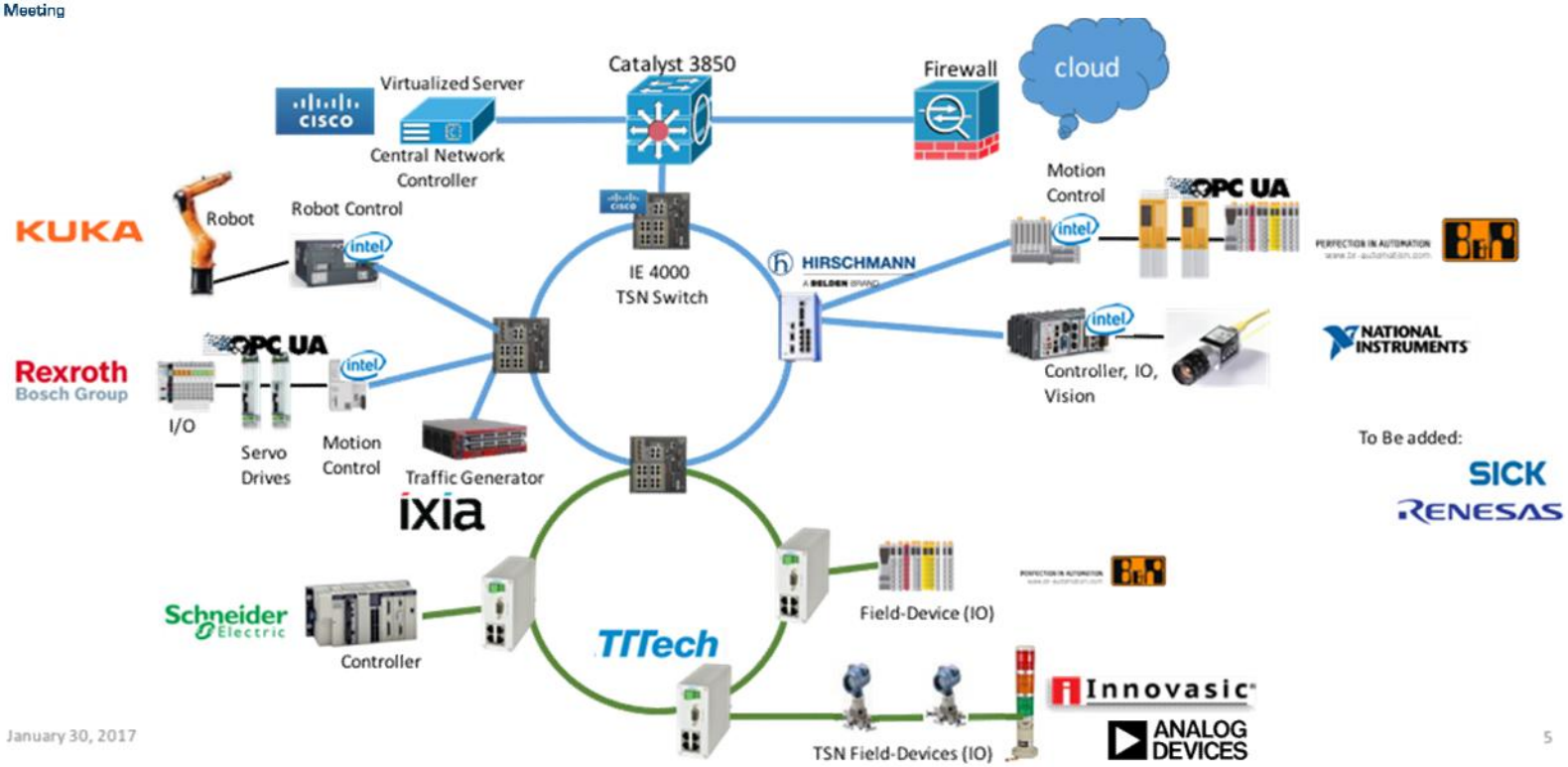
TSN Testbed of the Future



Conclusions

- In the near future, centralized configuration of the time-sensitive features will be achieved, making it possible to coordinate:
  - motion control,
  - I/O,
  - controller-to-controller and
  - machine-to-machine communications
- Seamlessly across the same network backbone.
- Further, data from any or all of these applications can be made seamlessly available to the user via the network or through the cloud.
- We invite all those interested in shaping that vision to join our efforts to achieve a truly converged network.

Thank You!