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Innovasic®

Time Sensitive Networks For Industrial Automation Systems

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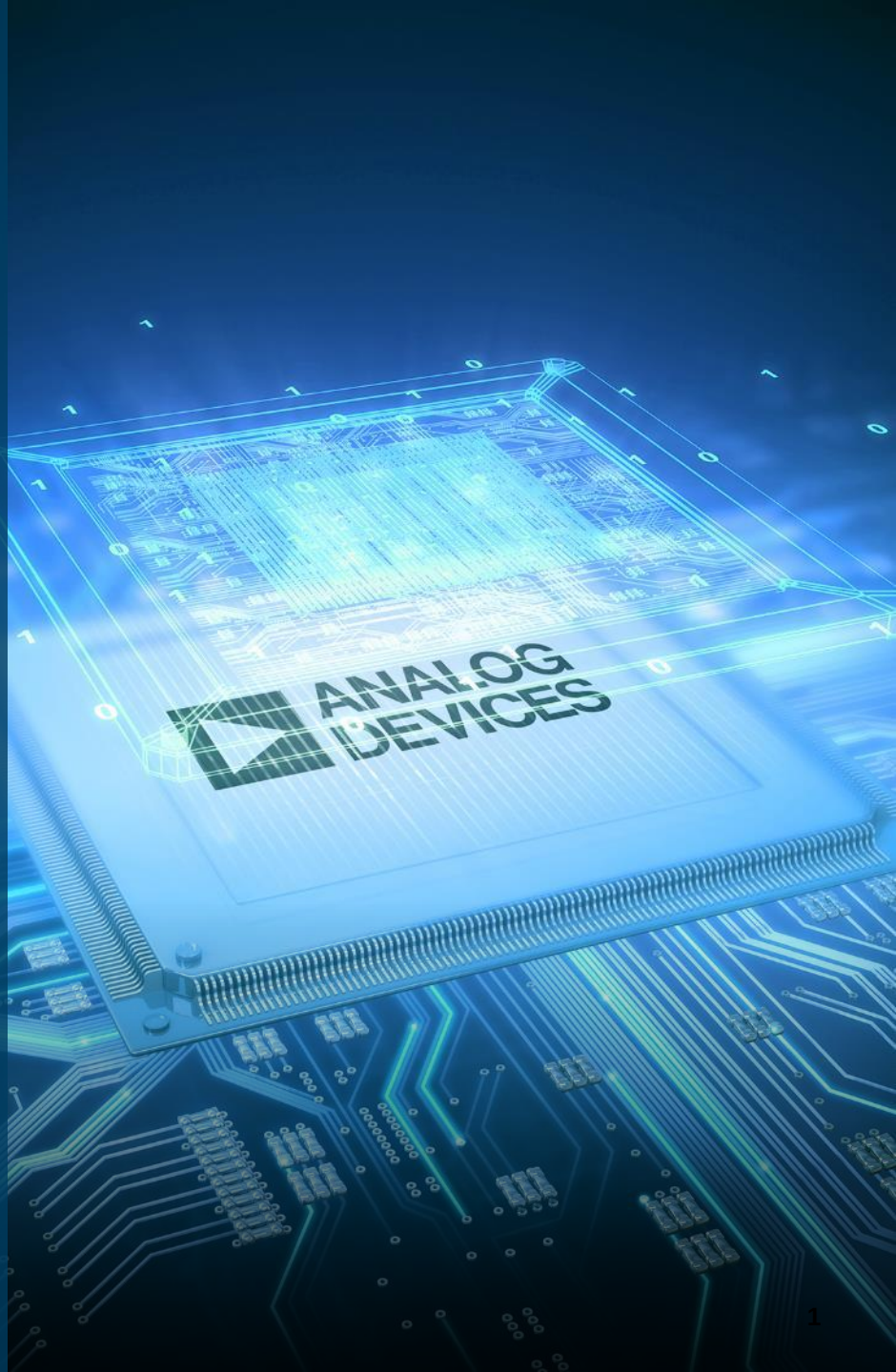
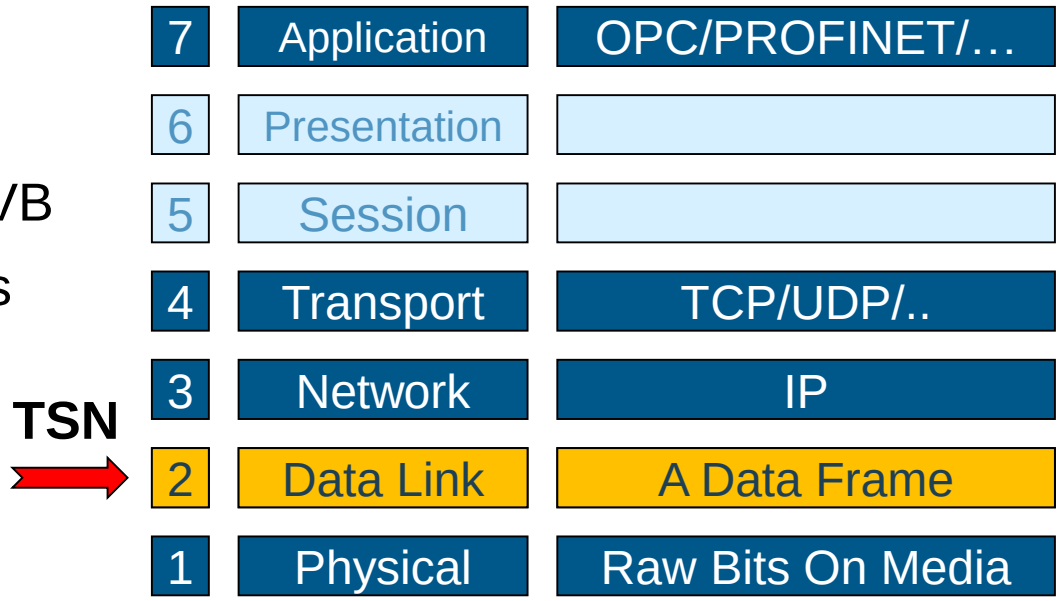
SYSTEMS APPLICATION ENGINEER



What is TSN?

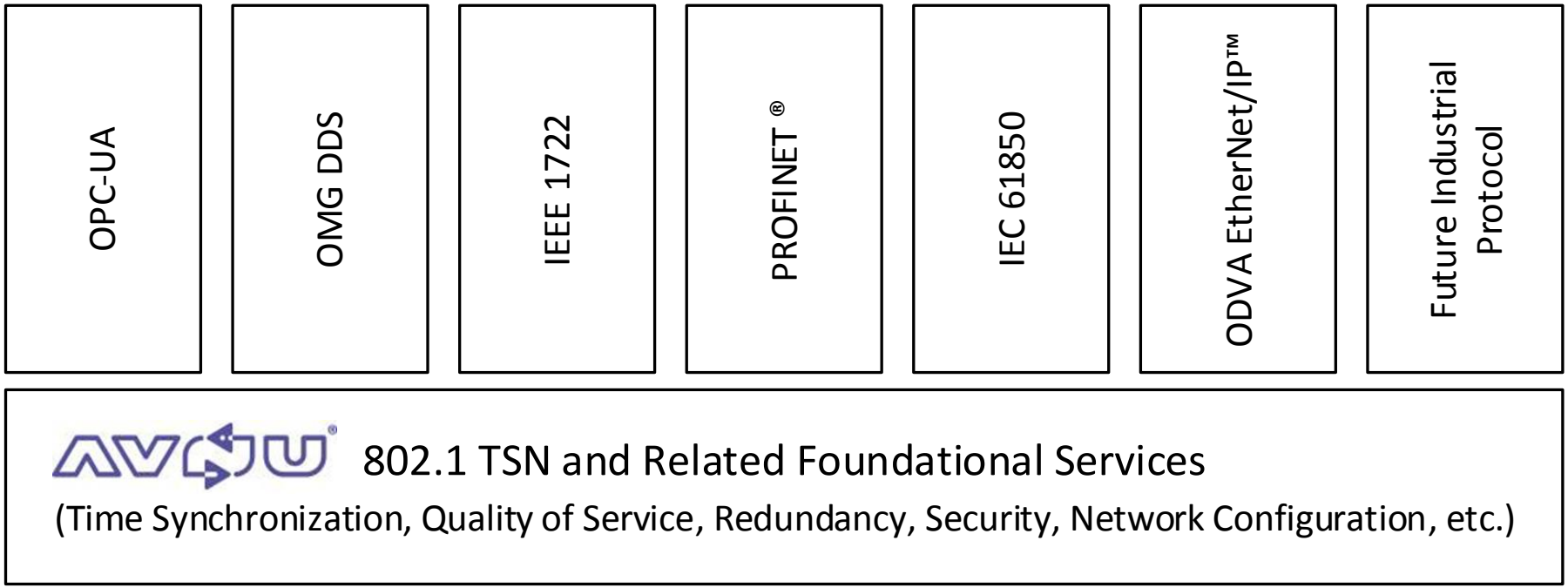
- TSN is all about Layer 2 of the OSI model and is an extension to IEEE 802.1 to make Ethernet
  - Deterministic
  - More Robust and Reliable
- Features are targeted at industrial, automotive, and AVB
- First and foremost, TSN adds time to standard Ethernet
  - Common understanding of time and clocks
- TSN uses time to ensure predicable message delivery
  - Traffic Shaping (Bandwidth, TDMA, etc.)
- TSN adds robustness and reliability with:
  - Seamless Redundancy
  - Preemption



Where did TSN come from?

- Bridging was originally defined by IEEE 802.1D
- When VLANs were added to this specification it became IEEE 802.1Q
- However, this didn't address the determinism and robustness requirements for industries like Factory Automation
  - Starting in 1999, various industry organizations were formed to address these requirements
  - PNO, ODVA, ETG, etc. developed their own "non-standard" deterministic Ethernet variants
- In 2006, IEEE began to address determinism with the formation of the Audio Video Bridging (AVB) Task Group in 2006
- In 2012, the charter of the AVB Task Group was expanded for a wider range of deterministic Ethernet requirements
  - This is the 802.1 Task Group we now call Time Sensitive Networking (TSN)

Why is TSN important?



- It provides a common Layer 2 for all upper layer protocols

What are the organizations driving TSN?

Organization	Purpose
IEEE	Develop standards and recommended practices in the areas of 802 LAN/MAN architecture, internetworking, security, and overall network management
AVNU	A community creating an interoperable ecosystem servicing the precise timing and low latency requirements of diverse applications using open standards through certification
industrial internet CONSORTIUM	Bring together the organizations and technologies necessary to accelerate the growth of the Industrial Internet

How does TSN work?

- A set of 802.1 sub-standards, addressing different needs
- Not all sub-standard have to be implemented
- The important sub-standards for Industrial Automation are:
  - 802.1AS (REV) Time Synchronization
  - 802.1Qbv Time Aware Traffic Shaper
  - 802.1Qci Ingress Policing
  - 802.1CB Seamless Redundancy
  - 802.1Qcc Network Management

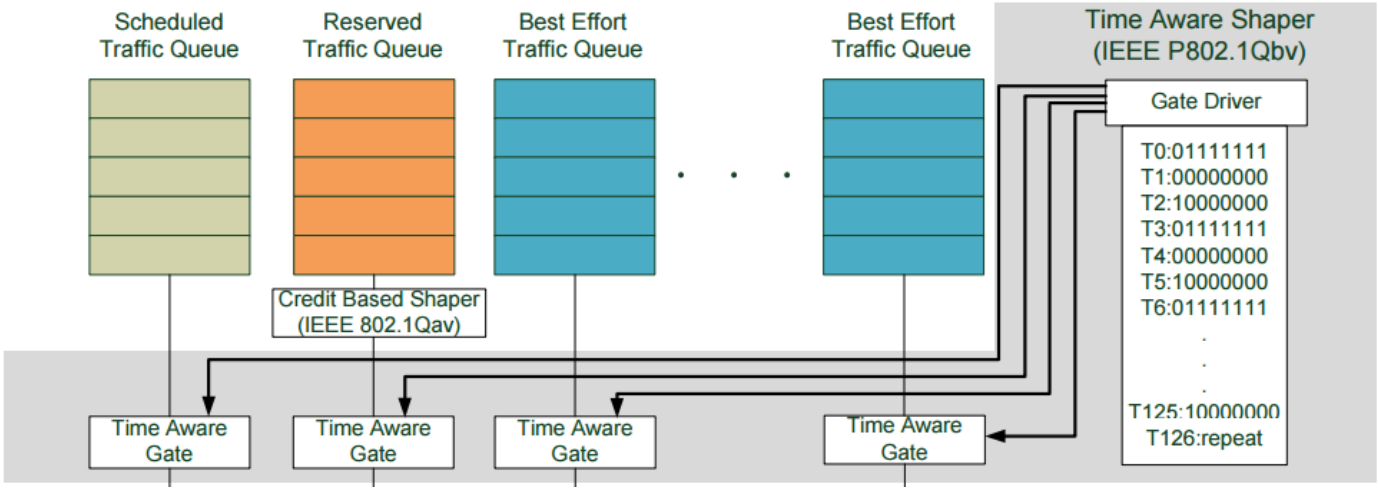
802.1AS (REV) Time Synchronization

- Purpose: provide network with accurate, reliable, simple-to-use time
- How? Define a time synchronization profile of IEEE 1588v2
- One or more Grand Masters provide time
  - A Best Master Clock Algorithm (BMCA) is used to select to select the Grand Master
  - Provides for Redundant GMs
- Synchronize time across the network
  - i.e. the grand master is the master to its slave device, that slave device is a master to its slave, and so on…
- Peer delay is used to keep time synchronized
  - Uses a one-step process with backward compatibility to two-step
  - Performed periodically up to a 10 s rate

- Supports working clock and monotonic clock
  - Working clock may jump (DST!) – Good for time stamping events (sequence of events)
  - Monotonic clocks do not jump – Good for continuous processes, including TAS

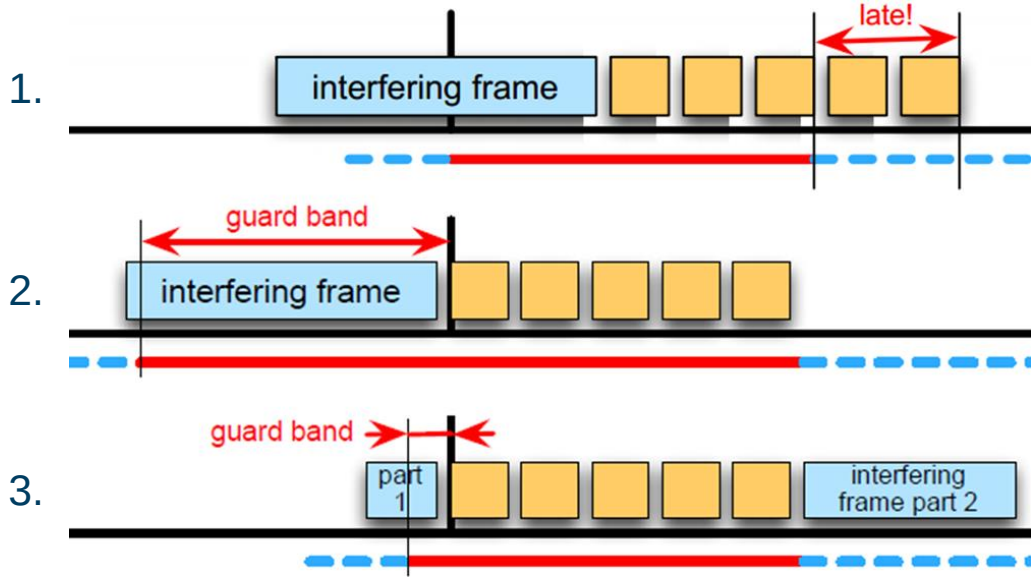
802.1Qbv Time Aware Shaper

- Purpose: Avoid interfering traffic
- How? Divide Ethernet traffic into different classes
  - ensure only one traffic class has access to the network
  - create a time-protected “channel” used by that traffic class alone
- Each egress port is gated, messages queued until scheduled time arrives
  - Send all queued messages until time window closes
  - Builds on 802.1AS so everyone has accurate time in network



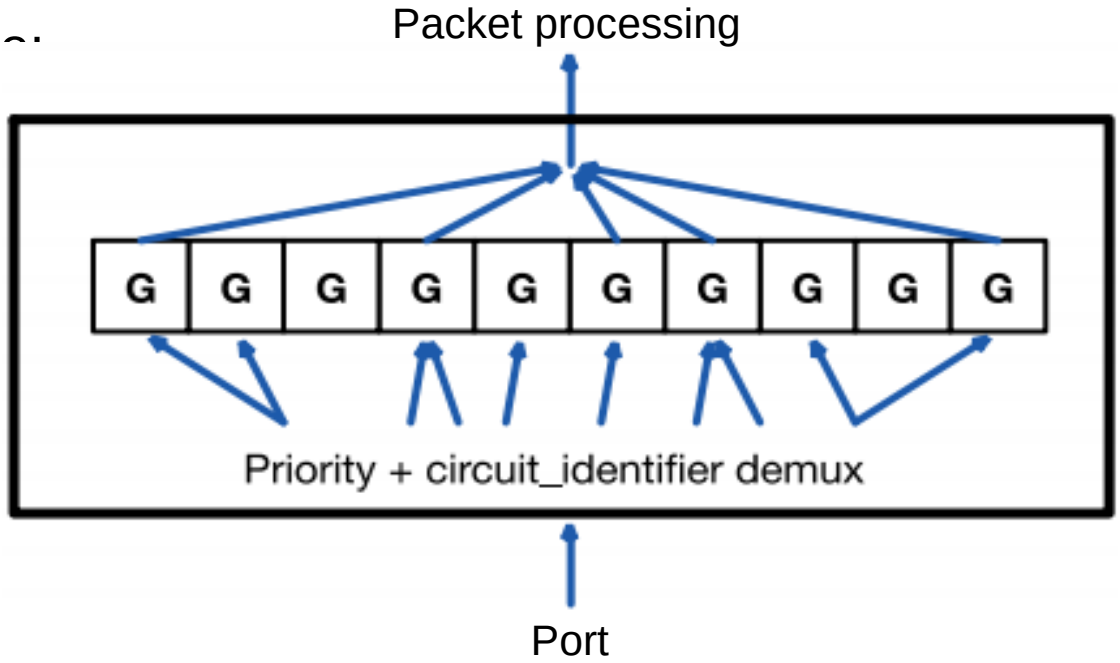
802.1Qbu Preemption

- Purpose: Reduce impact of frames interfering with scheduled traffic
- How? Break-up frames into smaller pieces
- Scheduled traffic requires a "guard band" so non-scheduled traffic frames don't cause scheduled frames to be late
  1. Frame transmission before the start of a reserved time period can extend outside its allocated window, interfering with more critical traffic
  2. Guard bands solves this problem, but reduce the transmission efficiency
  3. To solve this, preemption breaks interfering frames into smaller “fragments”



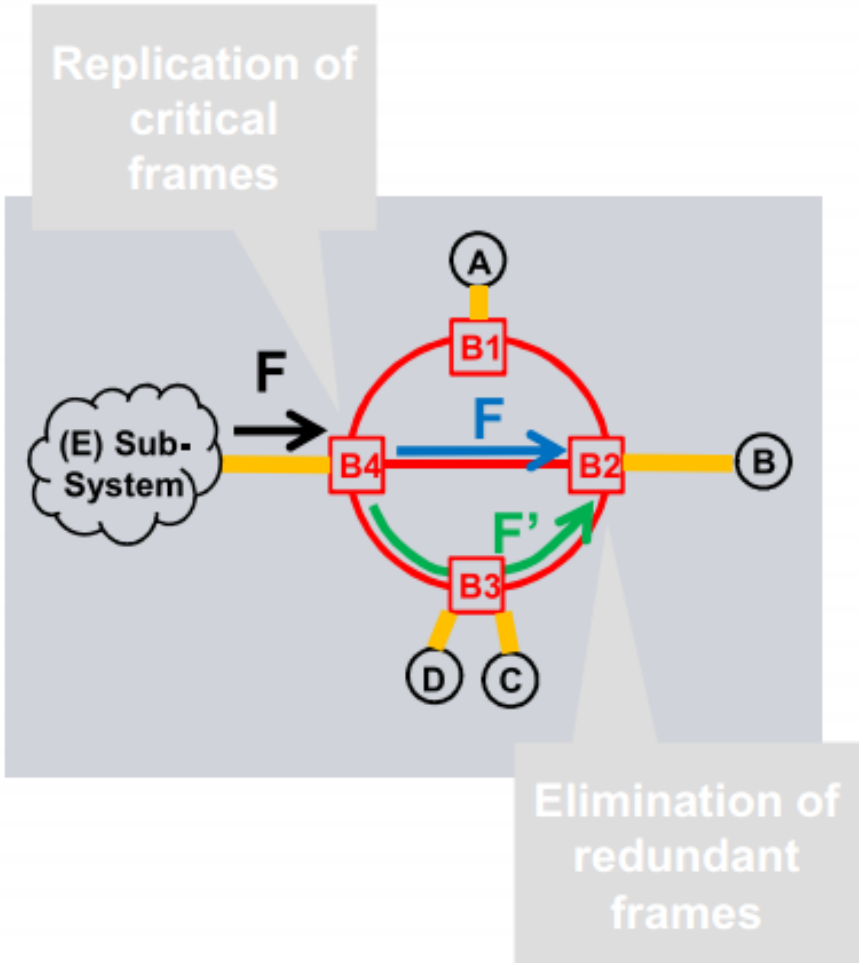
802.1Qci Ingress Policing

- Purpose: Prevent traffic overload conditions (DDoS, erroneous delivery) from affecting the receiving node
- How? Filtering traffic on a per stream basis by providing an input gate for each stream
- Input gate serves to enforce a "contract" between the talker and listener
- Contract functions could b~·
  - Pass/no-pass
  - "Leaky bucket" policing
  - Time/bandwidth-based
  - Threshold counter
  - Burst sizes
  - Packet sizes
  - Misuse of labels, etc.



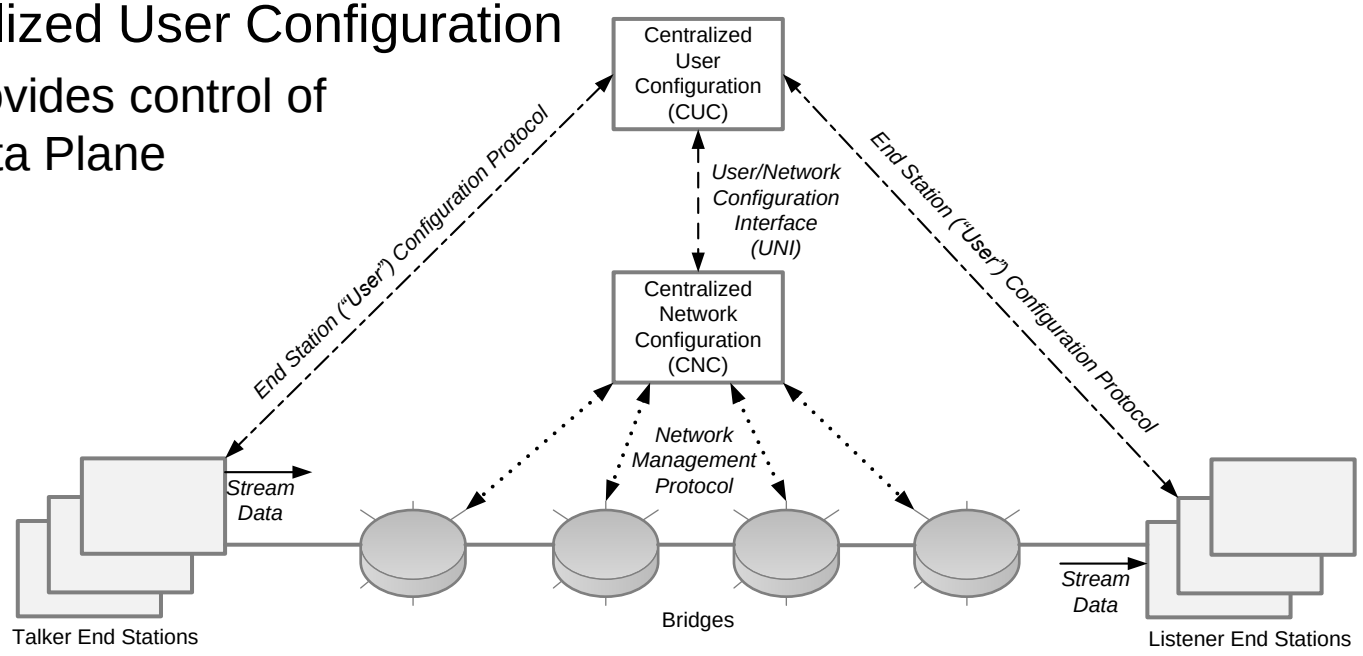
802.1CB Seamless Redundancy

- Purpose: Provide lightweight redundancy for reliable delivery of traffic streams
- How? Frame replication and elimination
- Send two copies of a message along maximally disjoint path to ensure delivery
- Use of redundant paths minimize packet loss due to
  - Link or device failures
  - Congestion
- Discard duplicate frames upon reception



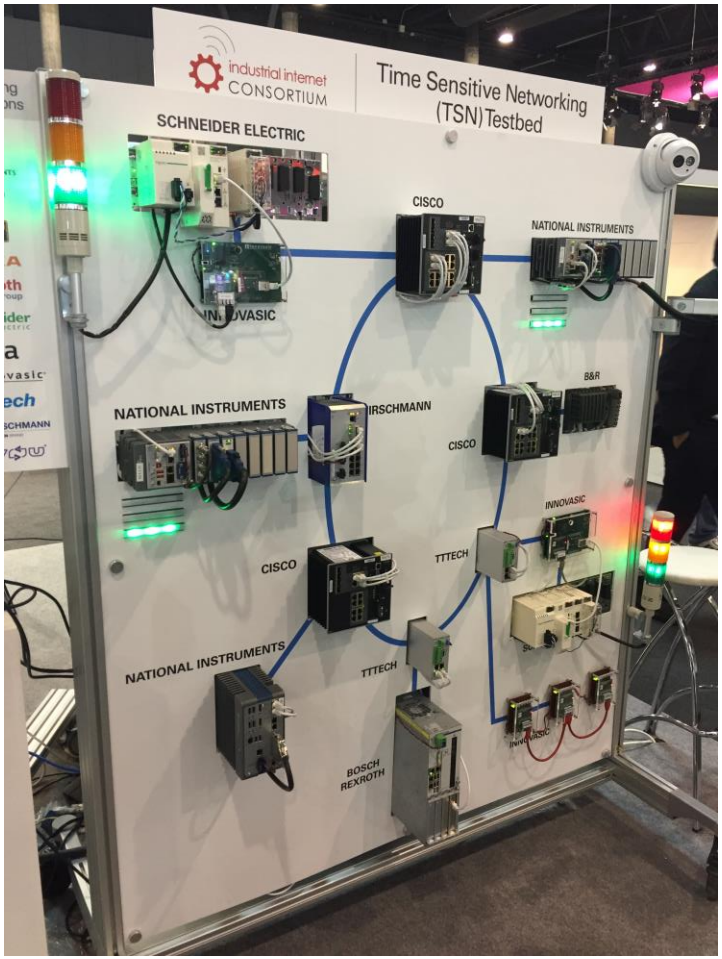
802.1Qcc Centralized Configuration

- Purpose: Provide network management for the control plane
- How: Use of YANG Models (“Yet Another Next Generator”) to describe properties of a TSN infrastructure components
- IETF NETCONF/RESTCONF infrastructure used to communicate between CNC (Centralized Network Configuration) and bridges.
- Centralized User Configuration
  - Provides control of Data Plane



Where are we now?

- AVNU Industrial Segment
  - Theory of operations complete
  - Goal is to certify devices in 2017
- IIC TSN Testbed
  - Network operational with initial set of vendors
  - Goal is to expand as use of TSN grows and to explore the technology
- Standardization bodies (PI, ODVA, ETG, OPC UA, etc.) across the industry working on integrating TSN into their specifications
- IEEE is in the process to finalize the remaining TSN sub-standards



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TSN and its future in Industrial Automation

- TSN is an opportunity to converged on a common Layer 2 technology for all Industrial Ethernet protocols
- It has the power to provide interoperability at Layer 2 in order to achieve a true converged network
- TSN can be adopted by existing industry standards like PROFINET or EtherNet/IP to gain
  - Better and broader hardware support
  - Converged real-time model at Layer 2
  - A path to Gigabit Ethernet

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THANK YOU!

QUESTIONS?