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# An Industrial Approach to TSN

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# A Primer on EtherNet/IP

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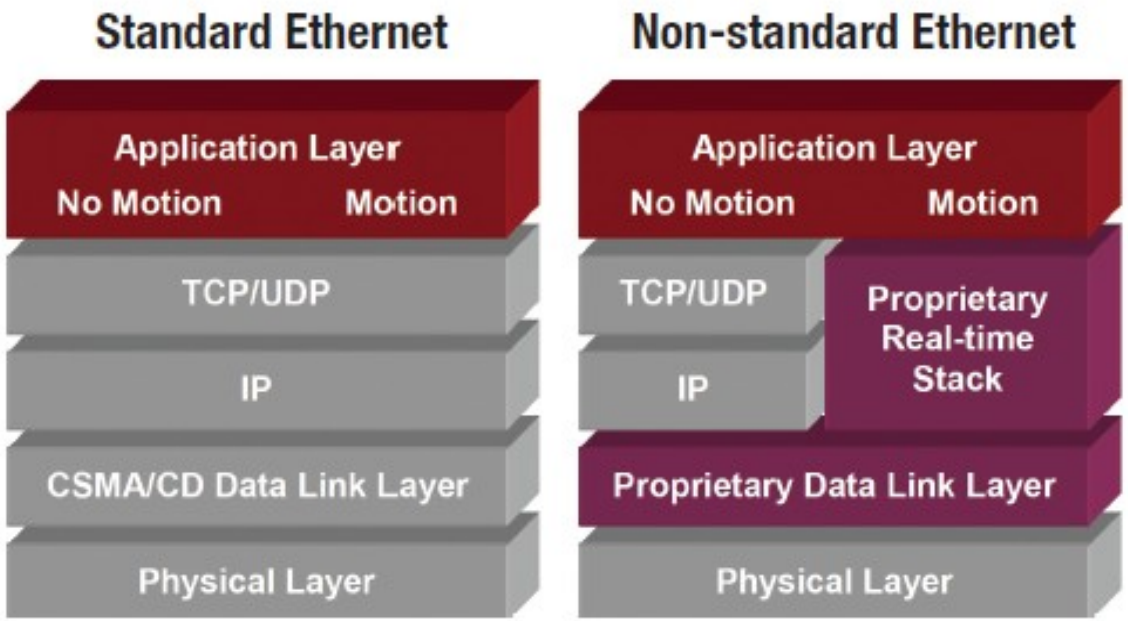
- EtherNet/IP is the name of the industrial automation protocol that the ODVA has standardized, and uses the Common Industrial Protocol (CIP) to communicate.
  - CIP installed base is numbered in the 10's of millions of nodes
  - EtherNet/IP has 24% market share and is the leading industrial Ethernet automation protocol today.
- EtherNet/IP is a layer 7 protocol that runs on a standard unmodified Ethernet stack.
- EtherNet/IP is used for all facets of industrial control including motion control (CIP Motion).

# A Primer on EtherNet/IP




- What makes EtherNet/IP successful is:
  - Using *architected* and *validated networks* to fit the end users application while limiting packet latency and jitter.
  - Using *Quality of Service (QoS) Differentiated Services Code Point (DSCP)* tags to differentiate types and priorities of traffic.
  - CIP Sync - *IEEE1588 Default Profile PTP* using an end-to-end delay mechanism.

# A Primer on EtherNet/IP

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- The goals for TSN provided at one time by Michael Johas Teener were:
  - Provide a network-wide precision clock reference
    - EtherNet/IP supports this today with CIP Sync
  - Limit network delays to a well-known (and hopefully small) value
    - EtherNet/IP supports this today through using QoS and reference architectures
  - Keep non-time-sensitive traffic from messing things up
    - EtherNet/IP supports this through implementation of reference architectures

# The role of EtherNet/IP in the Ethernet Ecosystem

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- As a provider of manufacturing devices which run on a converged industrial automation network it is our job to help our customers select and implement a network to meet their automation needs.
- In its essence, this is policy based prioritization!

# Impacts of Scheduling

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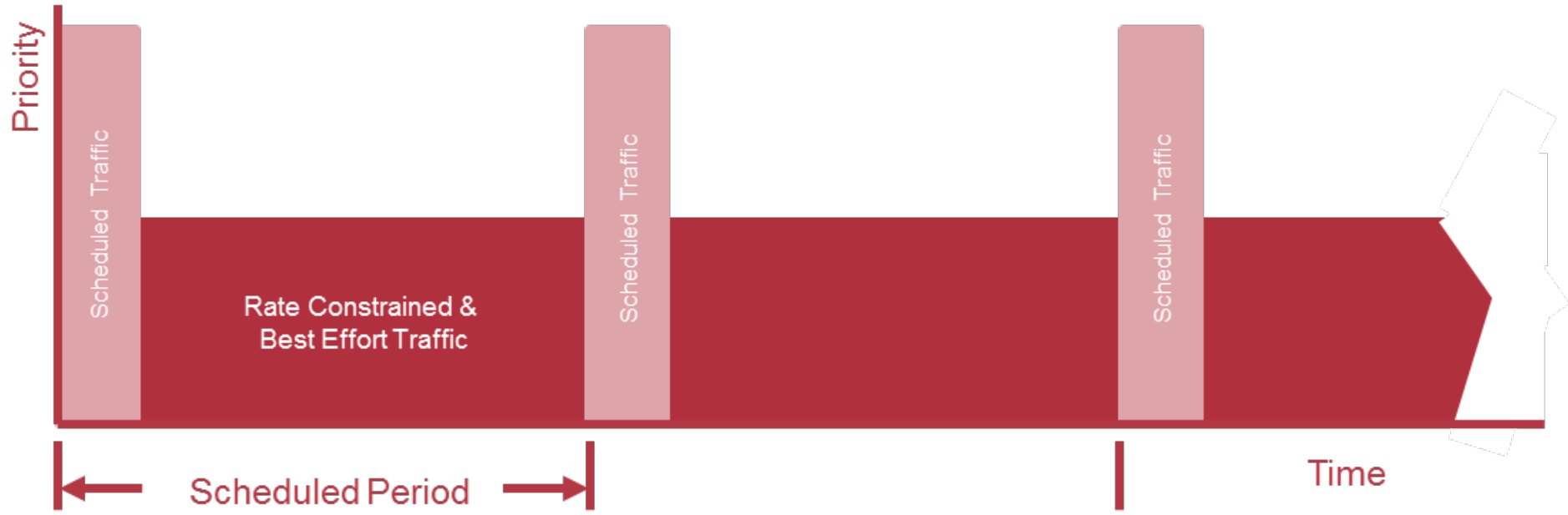
- Significant work in the TSN standards and compliance organizations focuses on 802.1Qbv, or scheduled Ethernet.
  - Tight, predictable control of multiple traffic streams
  - Absolute management of traffic timing to facilitate modeling and simulation of the network
    - Allows for an offline design workflow prior to acquisition of hardware or commissioning in the field
- However, scheduled traffic is now the highest priority traffic on the wire.
  - The challenge is to create mechanisms that allow for the “blending” of existing non-scheduled technologies and products within a new, scheduled, environment.

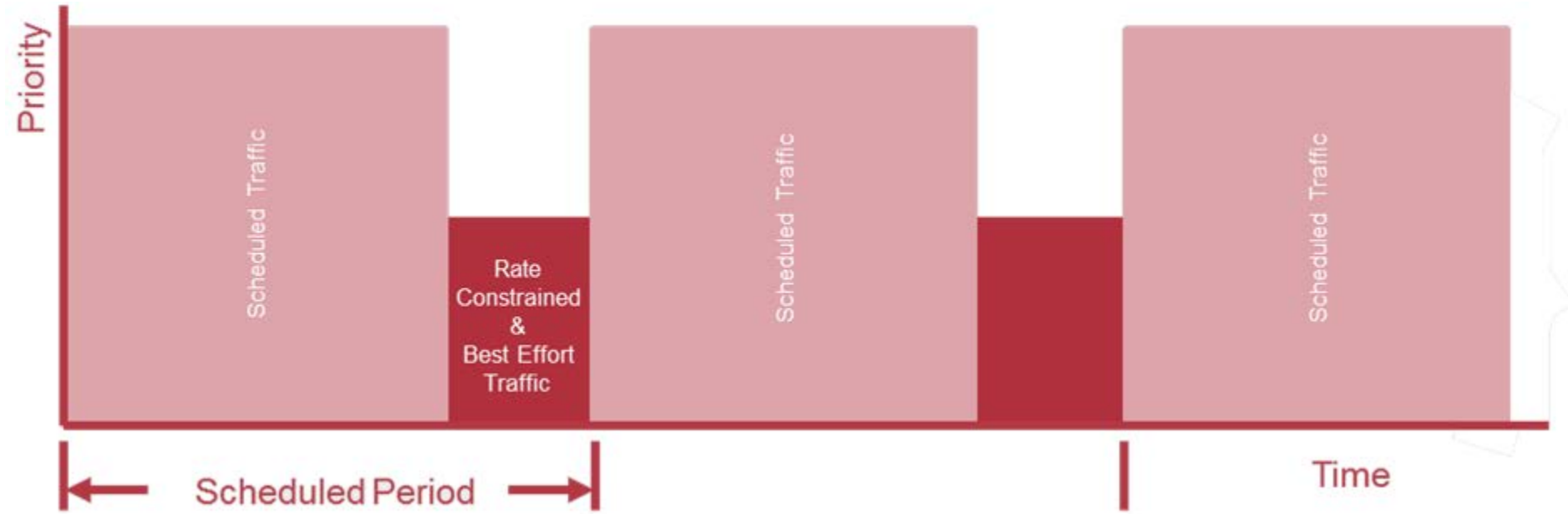
# Impacts of Scheduling

- Scheduled traffic is given highest priority above all else
- Existing traffic will fall into the rate constrained traffic category
- On a lightly loaded system, rate constrained traffic can coexist with scheduled traffic



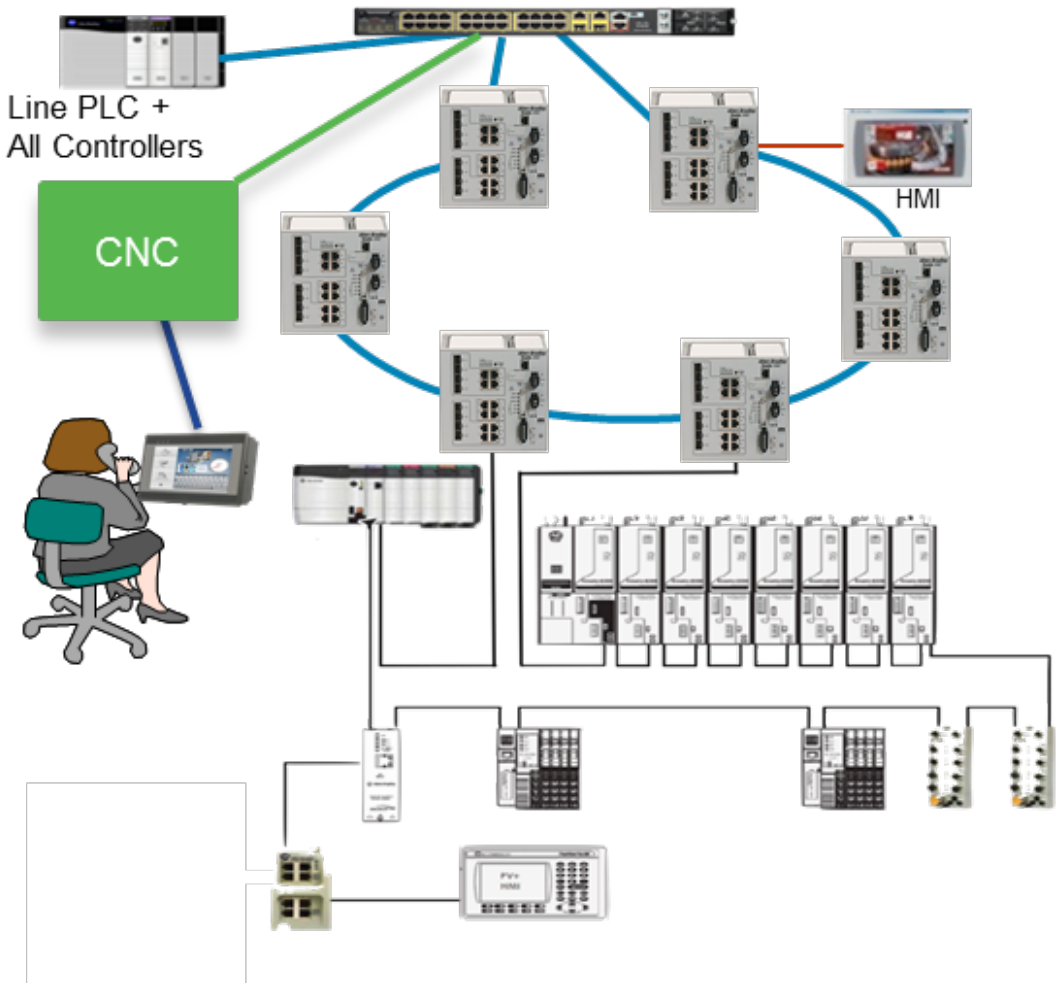
# Impacts of Scheduling

- On a heavily loaded system, where scheduled traffic has a high “duty cycle” within any given frame, all existing traffic is given less time on the wire.
- Is this a problem?
  - It depends on the application



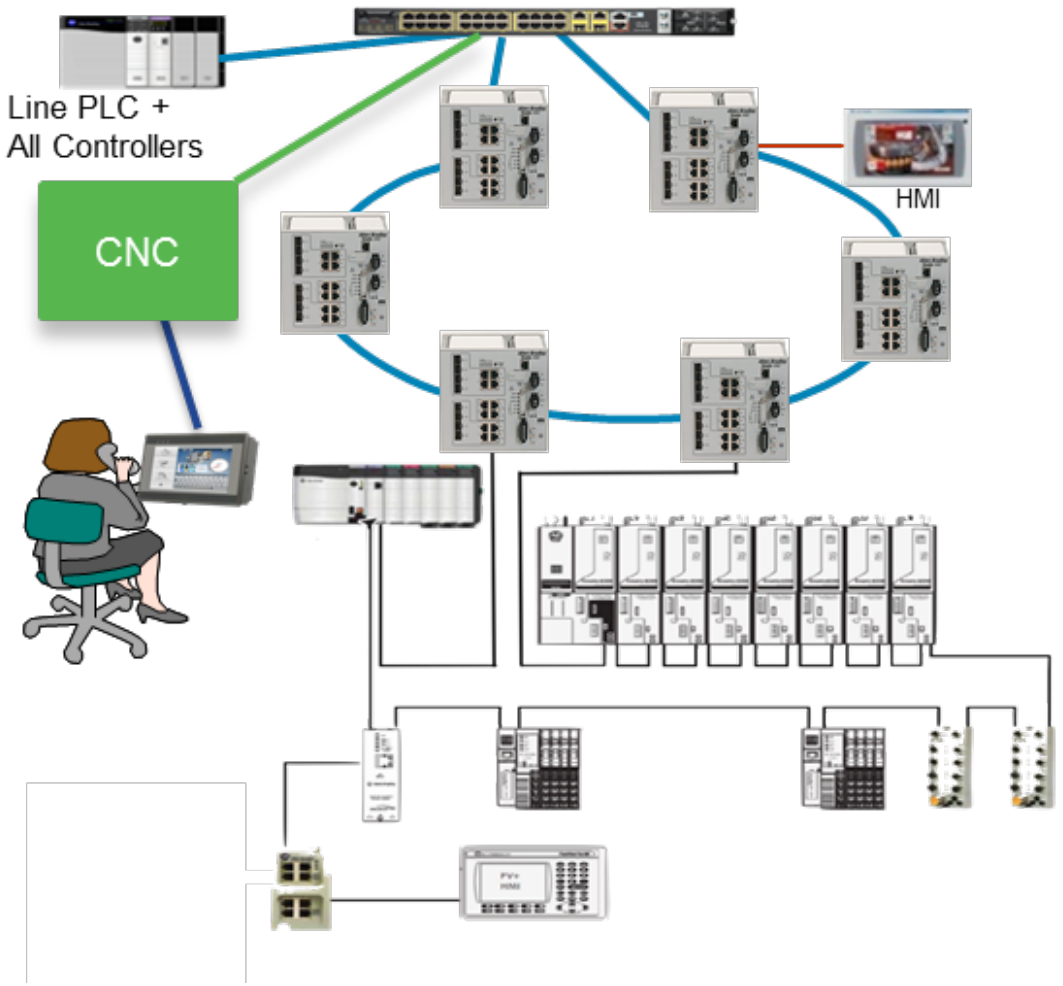
# Policy Based Prioritization

- System level configuration allows for control of both the network and the application
- Policies provide prioritization for traffic that is deemed important in the application
  - Telephone system different than motion system
- Policy information may be provided at a system level by the user through the CNC
- CNC is given all information necessary to configure the network for proper stream management
  - Payload, packet interval, latency, jitter, required schedule, policy information, etc.



# Policy Based Prioritization

- Per policy, it's possible that unscheduled traffic may be more important than scheduled traffic *in the application*
  - For example:  Motion > VOIP
- The CNC must solve and configure for successful operation of the application given all existing constraints
  - If not solvable – return an error to user for reconfiguration of the network
- Policy based prioritization is the counter-balance against data delivery mechanisms on the wire
  - Provides "fairness on the wire"



# Brownfield Migration

- Brownfield is the name we give to extending or expanding automation environments that already exist. There are more brownfield installations in our industry than greenfield installations.
  - Industrial automation is slow to move to new technology
  - Some equipment is used for 40 years or more.
- It is unlikely that TSN will gain either rapid or widespread adoption if it fails to support existing applications with no deterioration (or change) in performance.
- “On-ramps” need to be provided for existing applications to migrate to TSN.

# An Industrial Approach: Network Calculus + Qcc + Qbu/3br

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- Many TSN benefits can be realized without using Qbv scheduling
  - If the CNC knows the payload, packet interval, latency, and jitter requirements of every element on the network, the CNC will be able to calculate if the network will be able to service the needs of its streams using technologies such as QoS.
- The addition of preemption (802.1Qbu/802.3br) can be used for high priority streams containing motion data to increase the total number of motion axes supported.
- Qcc replaces the need for reference architectures and Qbu/3br decreases maximum jitter on high priority streams by a factor of 10.
- The author believes this method in spirit matches the approach being used for Fronthaul in 802.1CM.

# Future Work Suggestions

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- To date, no standardization activity has been agreed on around the following topics:
  - Time Gateway Functions
  - Support for Constrained Bridged End-Nodes
  - Confederation of CNC Functionality

# Time Gateway Functions

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- The EtherNet/IP time aware installed base is 100% based on CIP Sync, which is a 1588 PTP Default profile utilizing an end-to-end delay mechanism.
- This is not compatible with 802.1AS.
- A mechanism to convert between the 1588 Default profile and 802.1AS needs to be provided to allow backwards compatibility with installed equipment.
  - An acceptable solution can mandate that the source time profile is as accurate as the 802.1AS time profile.
  - An acceptable solution can contain manual BMCA configuration (Source->Destination time domain configuration)
- Should this be an 802.1AS activity? A liaison between 802.1AS and 1588?

# Constrained Bridged End-Nodes

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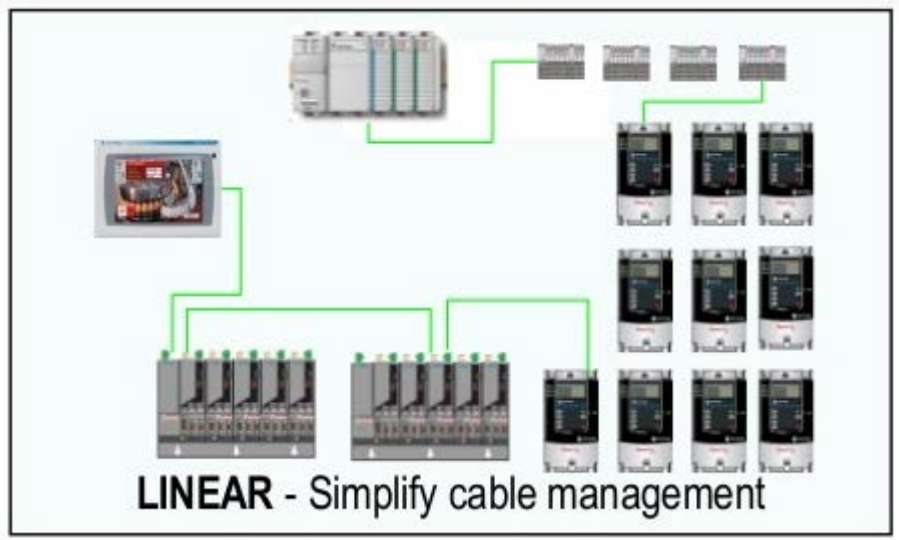
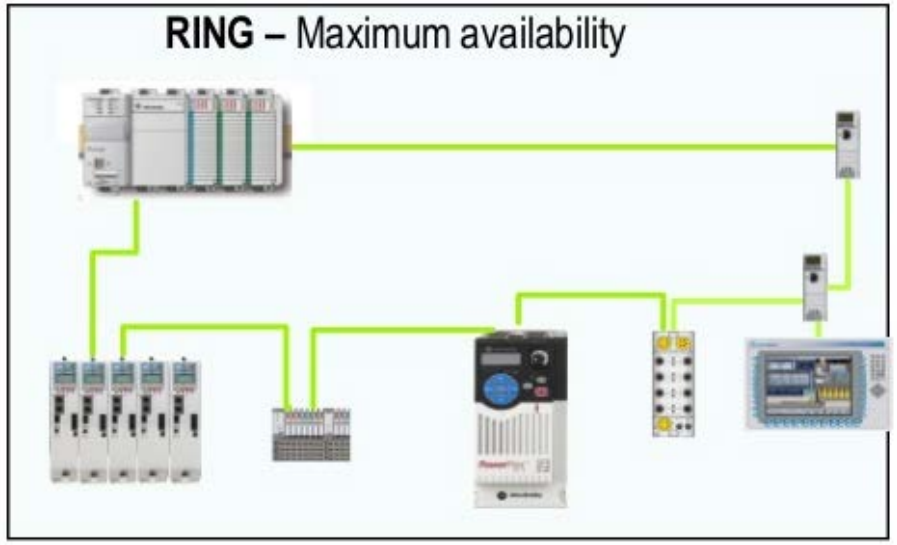
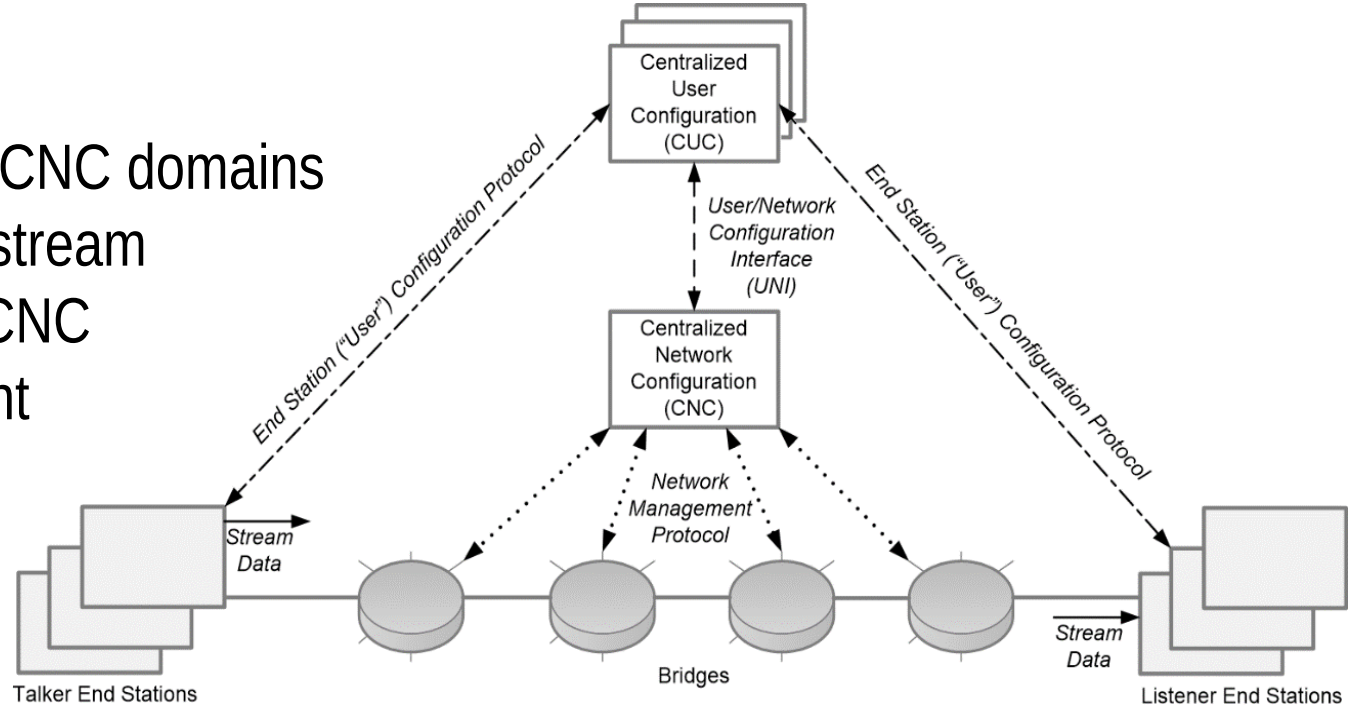
- Linear and ring topologies are common in factory automation architectures.
- Devices participating in a linear and ring topology embed a 3 port switch
- Often these switches are “lightly managed” meaning they support PTP and bubble up some statistics through their host device, but aren’t able to be actively managed through SNMP or other means.
- It has been discussed that 802.1Qcc will allow a CUC to communicate with a talker via a proprietary protocol to receive stream information and communicate schedule requirements.
- Should 802.1Qcc (in revision 2?) informatively reference that vendors can configure “lightly managed” infrastructure through a proprietary protocol?



# Confederation of CNC Functionality

- To date, the author has been aware of the definition of one and only one CNC.
- This approach is a great start but is not scalable.
- A method to confederate CNCs needs to be developed.
- This method could be as simple as
  - When a stream is defined to cross CNC domains the stream will need to register its stream requirements with each CNC. If a CNC is unable to support the requirement that request will be rejected.
- Should this be a part of 802.1Qcc revision 2?



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# Questions?

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