THE NEXT WAVE OF INDUSTRIAL NETWORKING WITH TSN

JEFF STEINHEIDER
PRODUCT MARKETING

AMF-IND-T2643 | JUNE 2017

NXP

SECURE CONNECTIONS
FOR A SMARTER WORLD

AGENDA

- Market Needs For TSN
- TSN Benefits
- Applying TSN
- Solutions
- TSN Reference Design Demonstration

Industrial IoT Requirements

Real time
response to IoT data

Deterministic Ethernet for
Operational Technology Traffic

Increasing security
threats and costs

Analytics Driving
Edge Computing
IoT data requires local processing to make immediate decisions and reduce the data passed on to the cloud.

Network
Convergence
One network to support both IT and OT data. TSN guarantees bandwidth, latency, and reliability for OT streams.

Secure Platform
The IoT increases the number of targets for cyber attacks, and now devices can interact with the physical world.

Time Sensitive Networking (TSN):

Extend use cases from audio/video applications to control systems

- Reduced worst-case delays
  - 4 μs or less per hop @ 1 Gbps for short messages (plus cable delays)
- Improved robustness:
  - Alternative paths with "instant" switchover
  - Multiple clock sources with "instant" switchover
- Scalability
  - Reduced management traffic for reservations and configuration

Converged Networks

Major Markets For TSN

Automotive

- Low, Bounded Latency
- Reserved Bandwidth
- Growing Bandwidth

Industrial

- Very Low Latency
- Time Sync
- High Bandwidth
- Redundancy
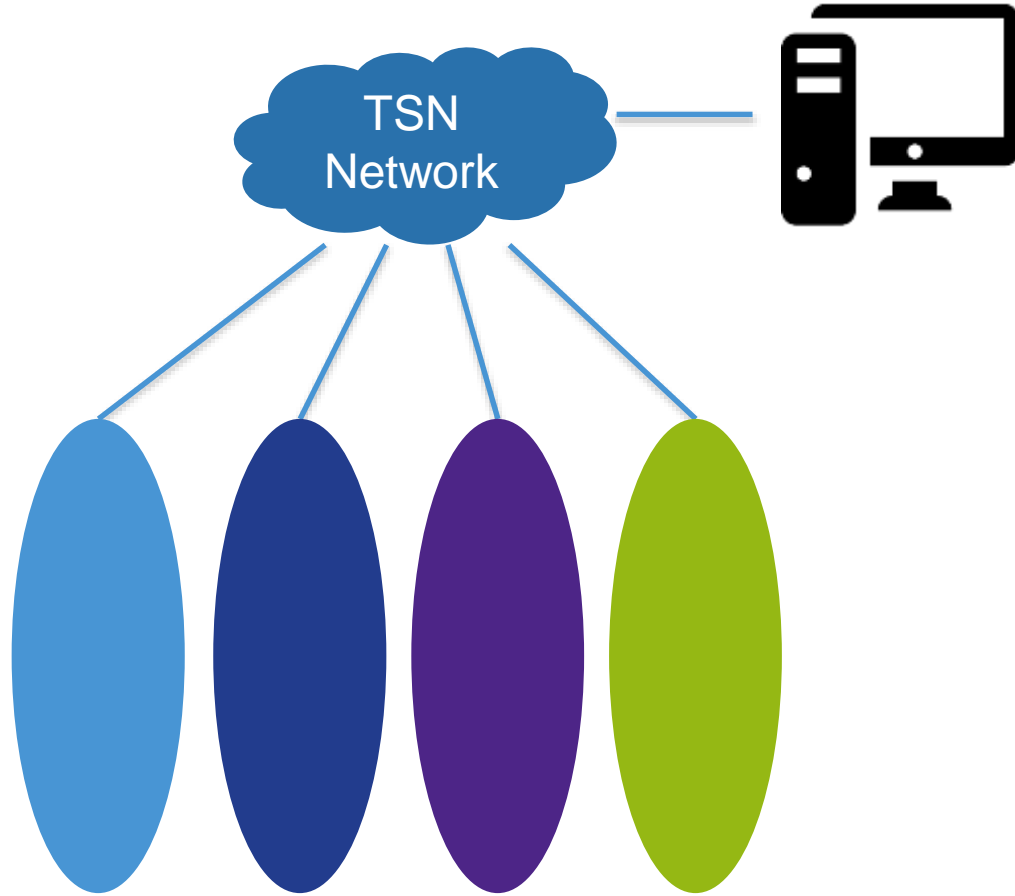- Network Convergence

Pro A/V

- Time Sync
- Bounded Latency
- Ease of Deployment

Consumer

- Interoperability
- Flexibility for new media

TSN in Industrial Automation

Legacy FieldIO and Industrial
Ethernet Networks

Use TSN to network existing Industrial
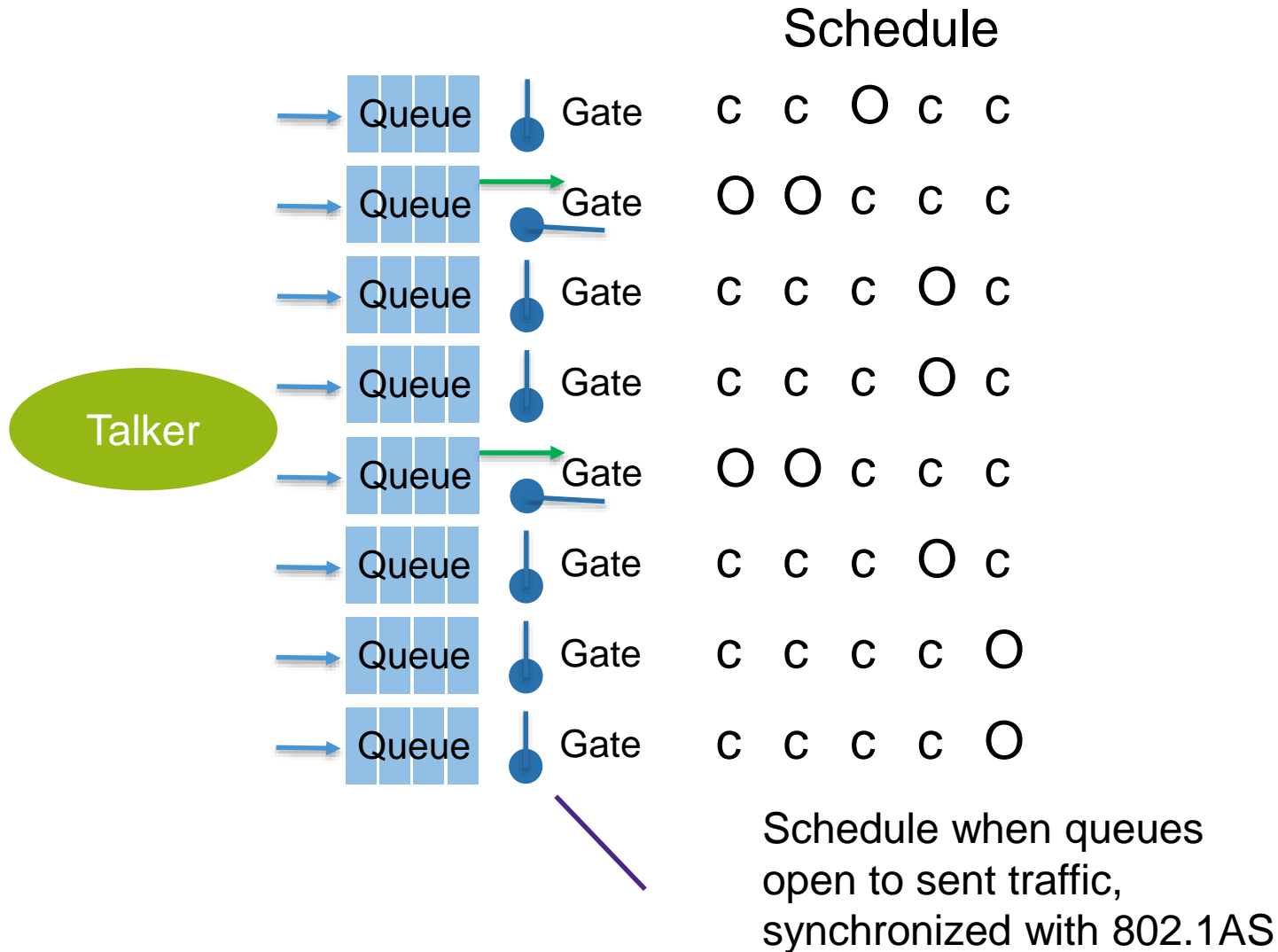Networks islands together

Enable the Industrial IoT

One network to support both high bandwidth
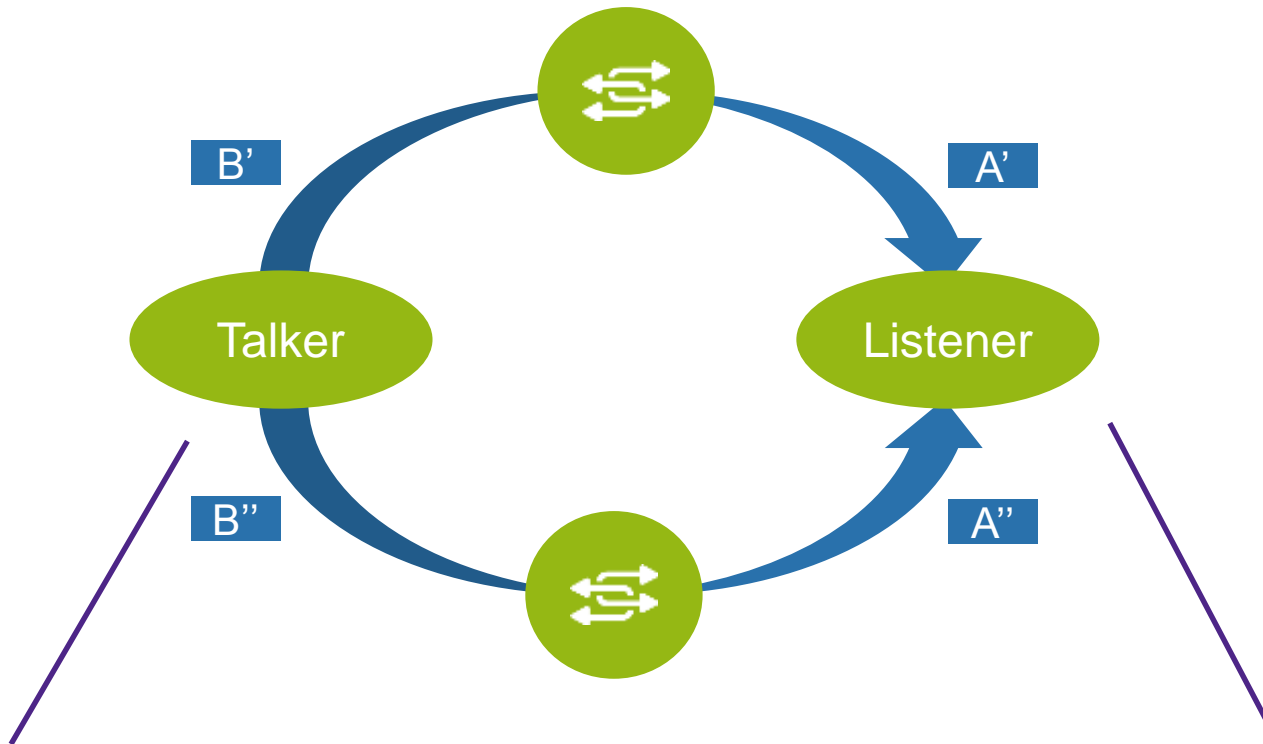IT traffic and time sensitive control traffic

TSN Performance

Feature	Specification
Reduced latency/worst case delay	<4 µs per hop with gigabit Ethernet
Determinism	Multiple QoS queues with time aware shaping
Determinism	Time Synchronization within 1 µs
Determinism	Resource Reservation
Determinism	Frame pre-emption for express traffic
Improved robustness	Alternate paths with instant switchover
Improved robustness	Multiple clock sources with instant switchover
Scalability	Reduced management traffic for reservations and configuration

802.1.Qbv – Time Aware Shaping

Schedule

c	c	O	c	c
O	O	c	c	c
c	c	c	O	c
c	c	c	O	c
O	O	c	c	c
c	c	c	O	c
c	c	c	c	O
c	c	c	c	O

Schedule when queues open to sent traffic, synchronized with 802.1AS

- Different priority traffic allocated for each queue
- Queue gate schedule synchronized to global time

802.1CB – Frame Replication and Elimination for Reliability

- TSN hardware performs replication/elimination
- Zero time failover if 1 path fails
- No need for upper level retry mechanisms
- Simpler code base with reliability

Talker replicates Ethernet frames and sends over multiple paths to Listener

- Listener provides first Ethernet frame that arrives to application
- Listener removes duplicates

802.1Qbu – Frame Pre-emption

- Ensure zero delay for express traffic

- Efficient use of bandwidth for pre-emptable traffic
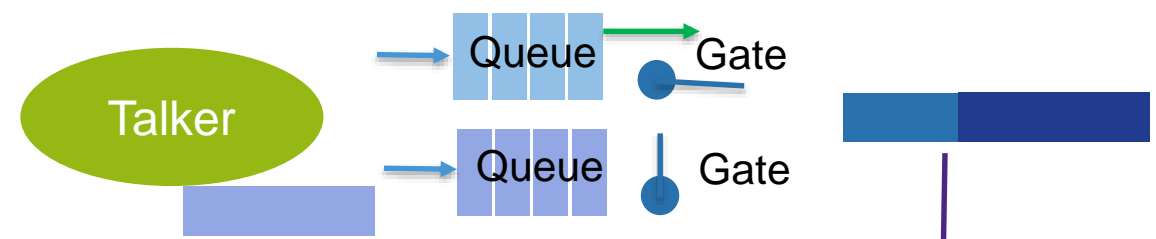
- Used with TAS, or stand-alone

Express Traffic

Talker

Queue   Gate

Queue   Gate
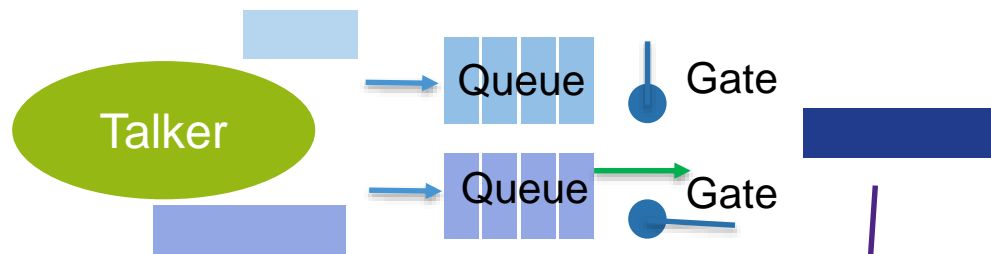
Pre-emptable Traffic

Start to transmit frame of pre-emptable traffic
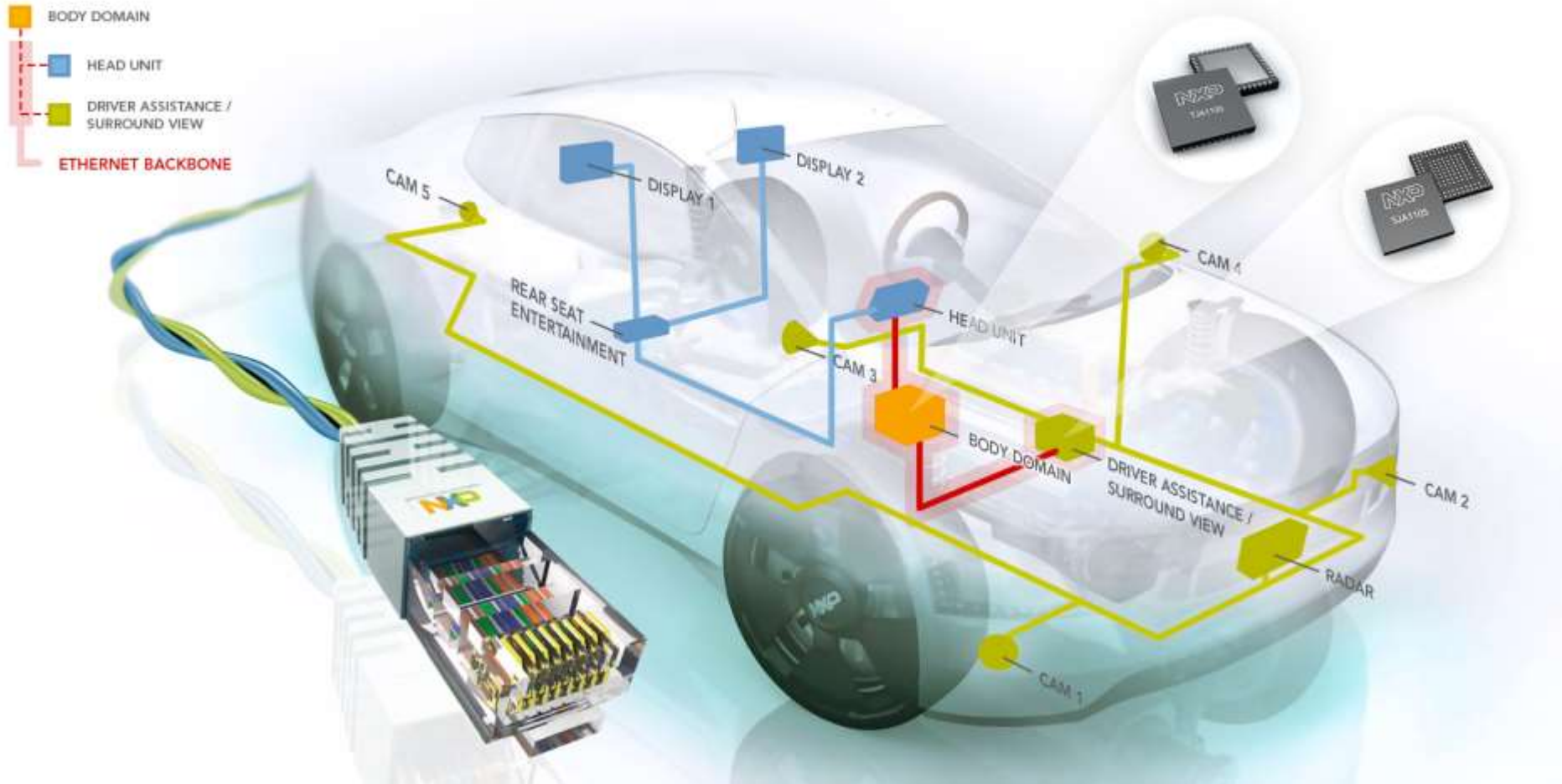
Express Traffic

Talker

Queue   Gate

Queue   Gate

Pre-emptable Traffic

Interrupt pre-empable frame with express frame. Will transmit remaining pre-emptable frame once express frame complete
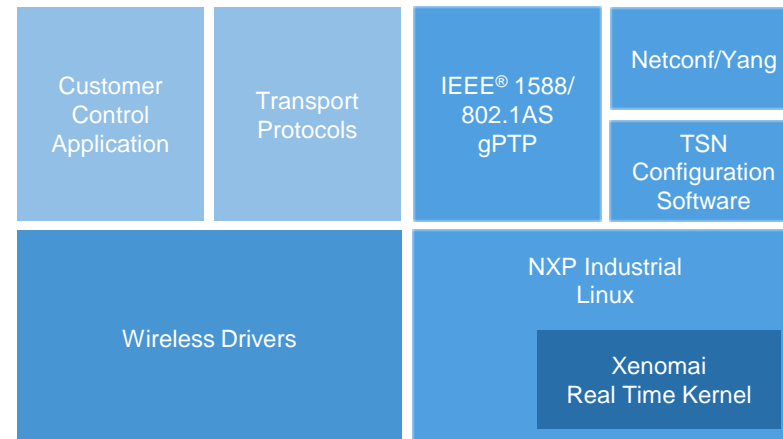
NXP and TSN

- SJA1105T Automotive TSN Ethernet switch announced August, 2015

- In production today

- TSN, AVB, Deterministic Ethernet

LS1021ATSN – TSN Solution Reference Design

- Synchronization with IEEE® 1588
- 4 Switched Gigabit Ethernet TSN interfaces
  - Time Aware Shaping
  - Per-Stream Filtering and Policing
- Arduino Shield for IoT Wireless Integration
- Expandable IO – mini PCIe, SATA, USB 3.0, SD Card, GPIO

TSN Solution

Customer Control Application	Transport Protocols	IEEE® 1588/ 802.1AS gPTP	Netconf/Yang
			TSN Configuration Software
Wireless Drivers		NXP Industrial Linux	
		Xenomai Real Time Kernel	

Industrial Linux SDK

LS1021ATSN Reference Design

TSN Industrial Linux SDK Development

Jan 2017

- Consolidate TSN Programming into single application
- File based TSN configuration
- 1588 Boundary clocking on LS1021A (2-step)

May 2017
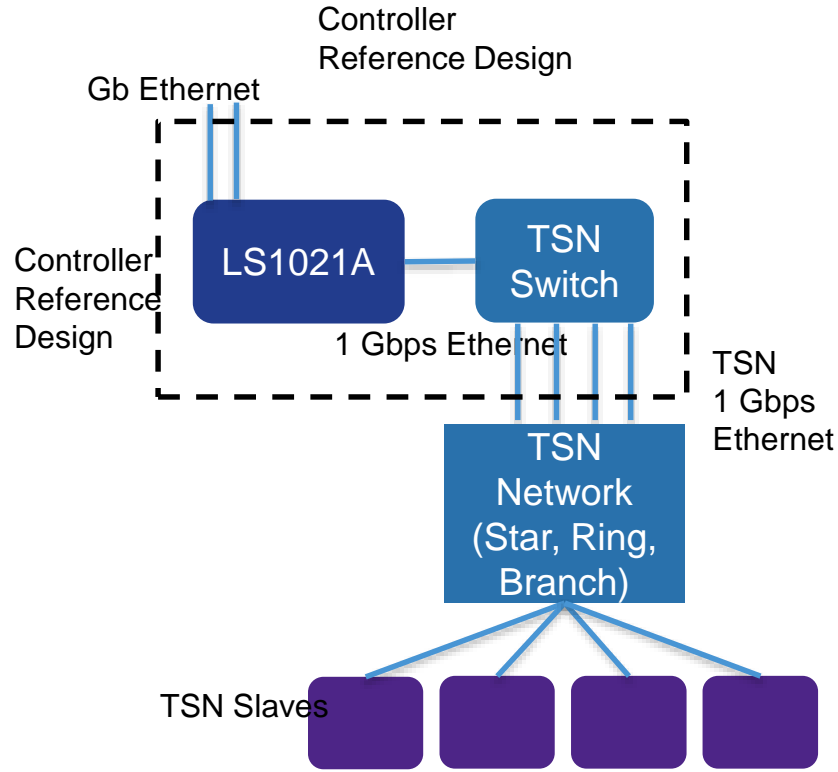
- Netconf configuration of TSN
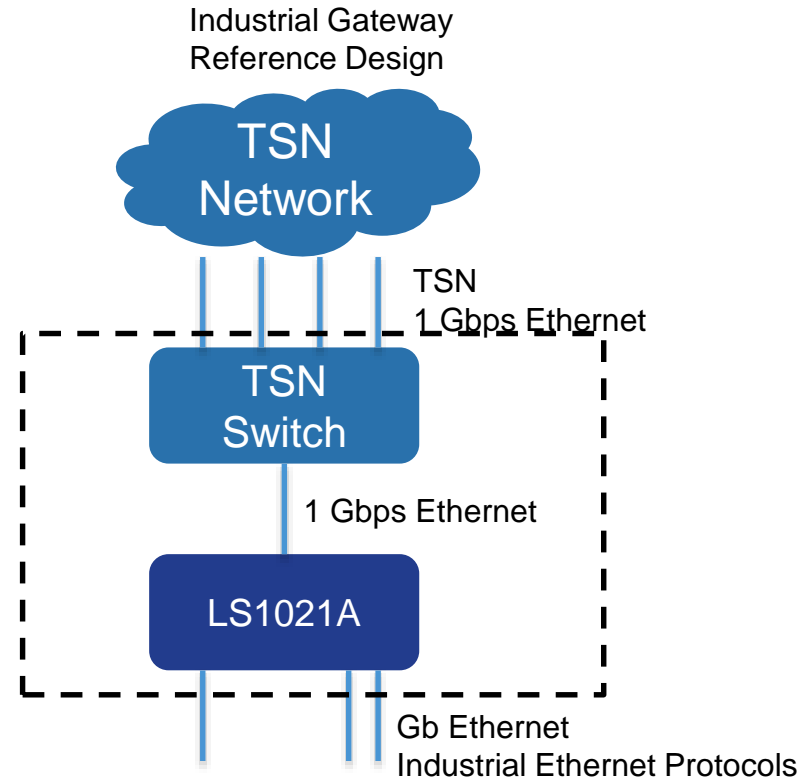
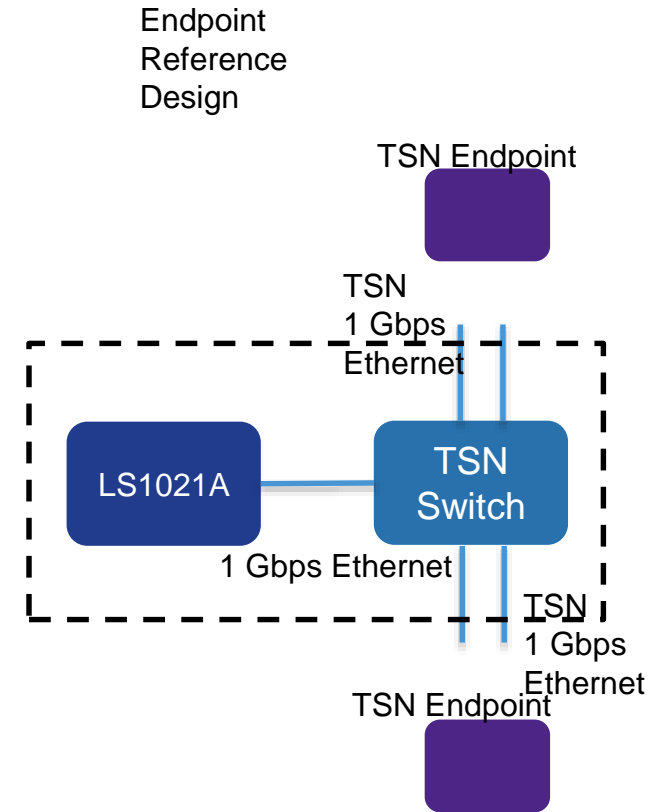**Q3 2017**

- 1588 Transparent clocking (1-step)

Available Now

TSN Reference Design for Application Development

Controller Reference Design

Gb Ethernet

Controller Reference Design

LS1021A — TSN Switch

1 Gbps Ethernet

TSN 1 Gbps Ethernet

TSN Network (Star, Ring, Branch)

TSN Slaves

Applications
TSN PLCs, Automotive Gateway

Industrial Gateway Reference Design

TSN Network

TSN 1 Gbps Ethernet

TSN Switch

1 Gbps Ethernet

LS1021A

Gb Ethernet
Industrial Ethernet Protocols

Applications
Legacy Industrial PLC, Industrial Gateway

Endpoint Reference Design

TSN Endpoint

TSN 1 Gbps Ethernet

LS1021A — TSN Switch

1 Gbps Ethernet

TSN 1 Gbps Ethernet

TSN Endpoint

Applications
Robotics controller, motor control, synchronized audio playback

Introducing
Layerscape **LS1028A SoC**

Converged IT and OT Ethernet Networks

Industrial HMI and Control

Long Product Lifecycles

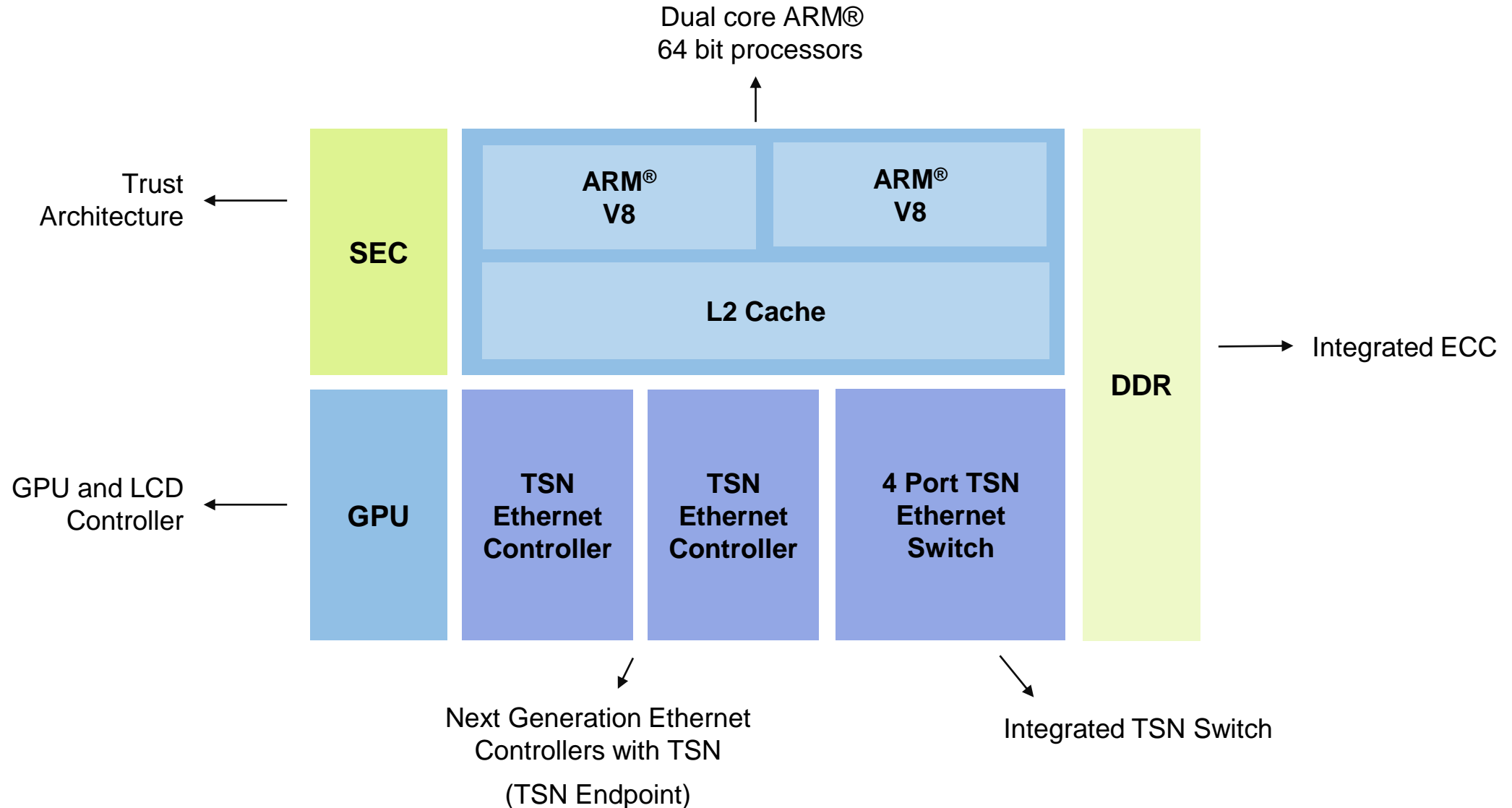High performance ARM® 64 bit multi-core processor

Integrated TSN bridge and endpoints
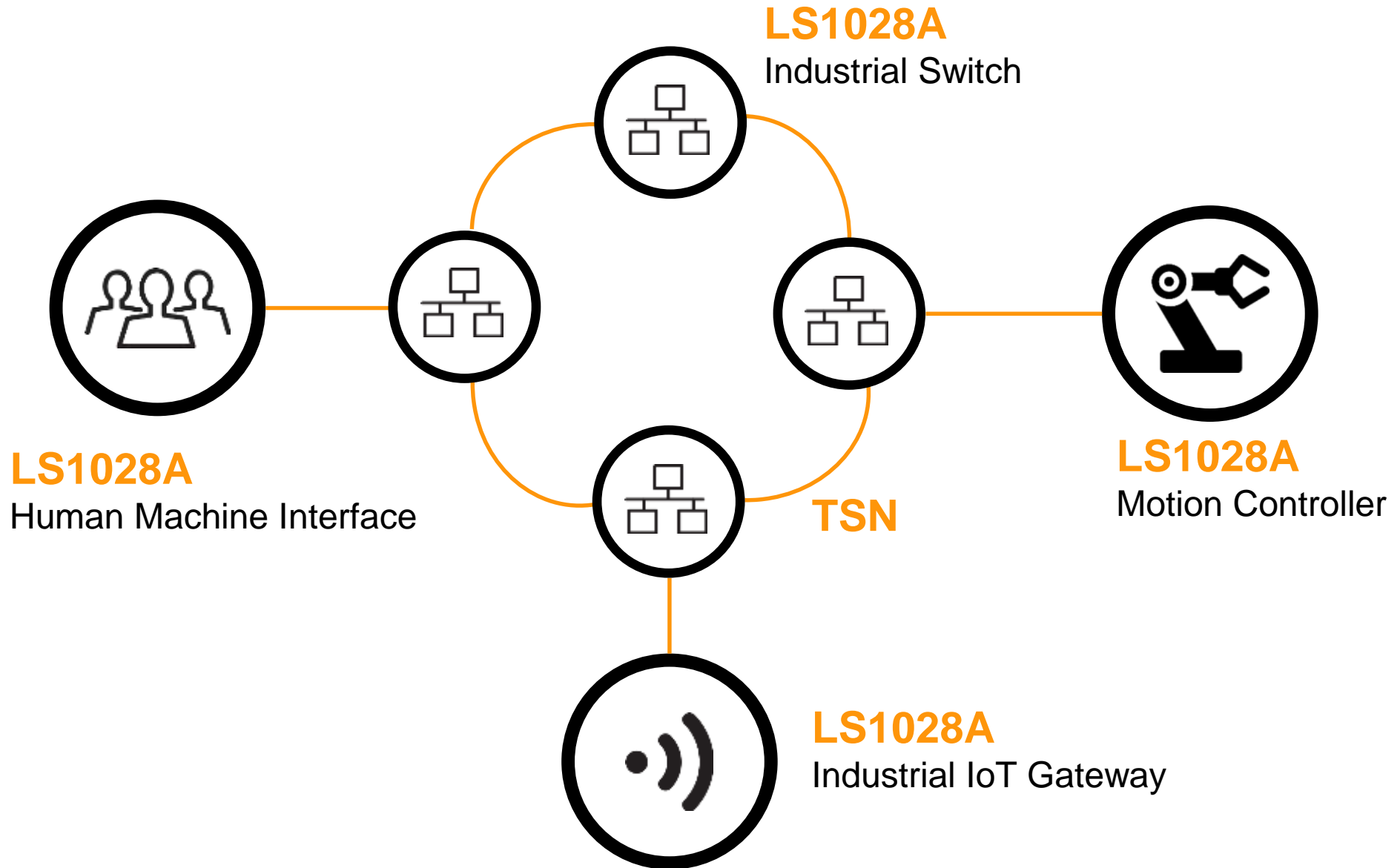
3D GPU and LCD Controller for HMI

15-year supply longevity

125 Deg C Junction Temp

Layerscape LS1028A – Industry Ready

Dual core ARM®
64 bit processors
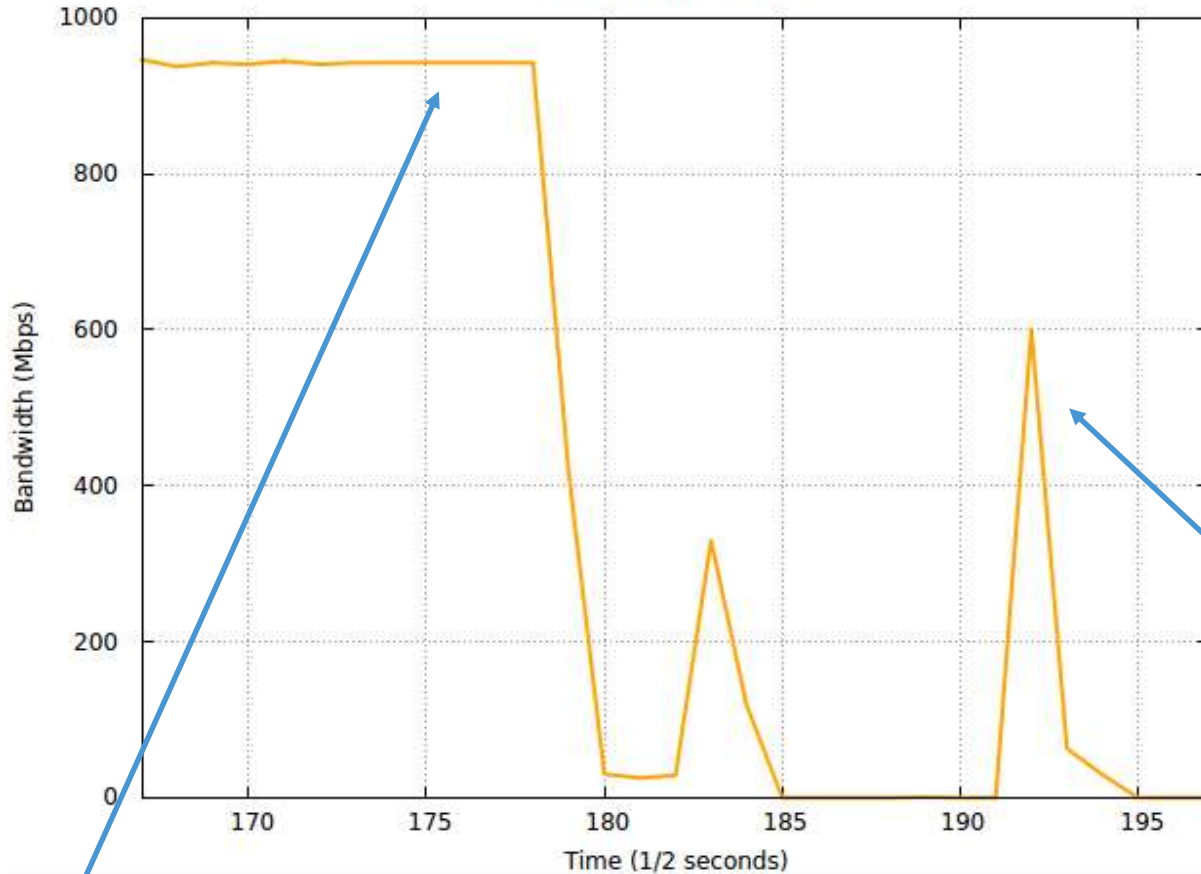
Trust Architecture

SEC

ARM® V8

ARM® V8

L2 Cache

DDR

Integrated ECC

GPU and LCD Controller

GPU

TSN Ethernet Controller

TSN Ethernet Controller

4 Port TSN Ethernet Switch

Next Generation Ethernet Controllers with TSN

(TSN Endpoint)

Integrated TSN Switch

NXP

LS1028A in Industrial Automation

LS1028A
Industrial Switch

LS1028A
Human Machine Interface

TSN

LS1028A
Motion Controller

LS1028A
Industrial IoT Gateway

TSN Demonstration

- 3 host Linux machines connected through a switch
- 2 TCP flows competing for bandwidth
- Flows bottlenecked because they are sharing the same link towards Host 2
- Combined throughput cannot exceed 1000Mbps
- Utilize TSN features to isolate flows
  - *Ingress Policing*: rate-limit traffic coming from Host 3
  - *Time Gating*: schedule the 2 flows on different time slots

Host 3

VLAN
PRIO 7

VLAN
PRIO 3
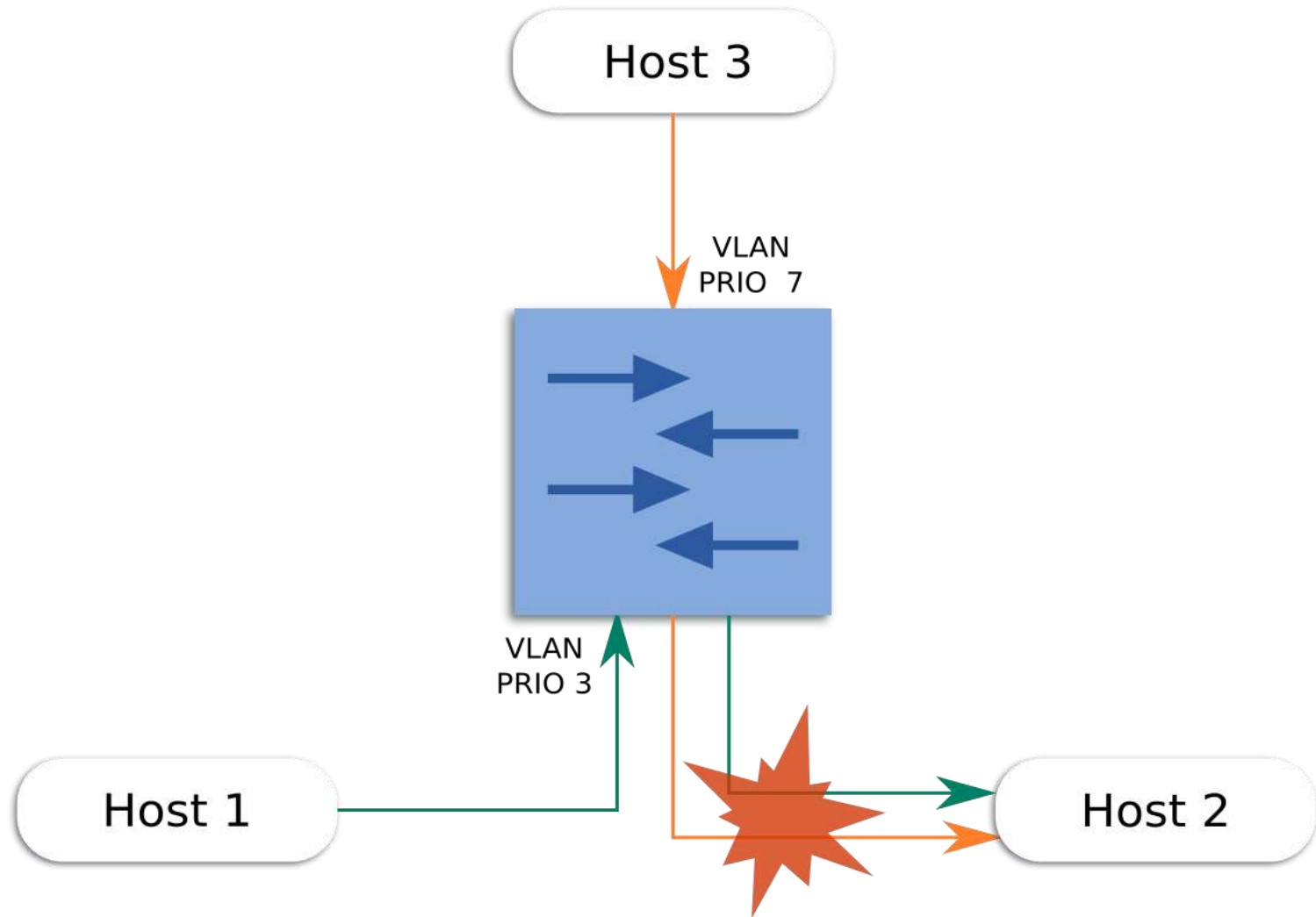
Host 1

Host 2

Setting the stage – Standard Ethernet with Competing Traffic

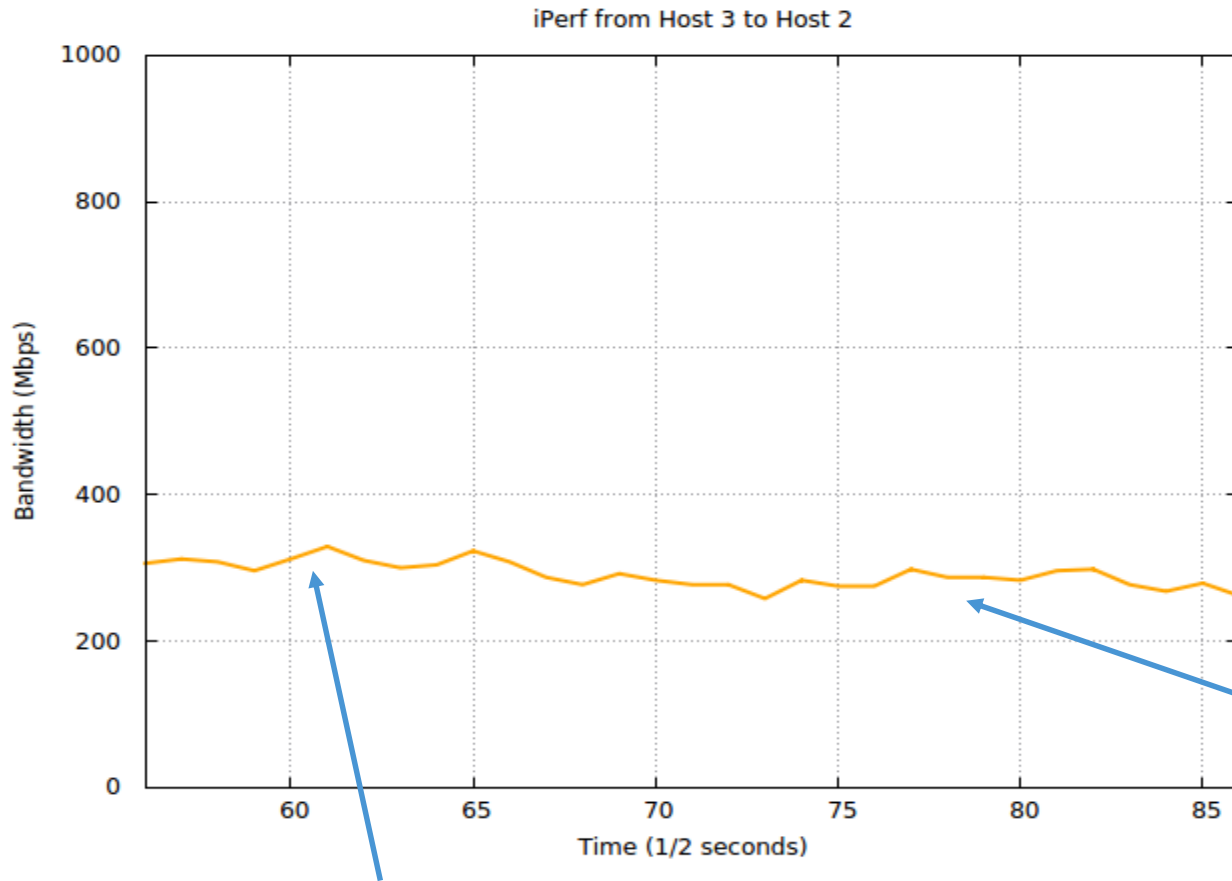First stream utilizes 100% of the bandwidth with no competing traffic

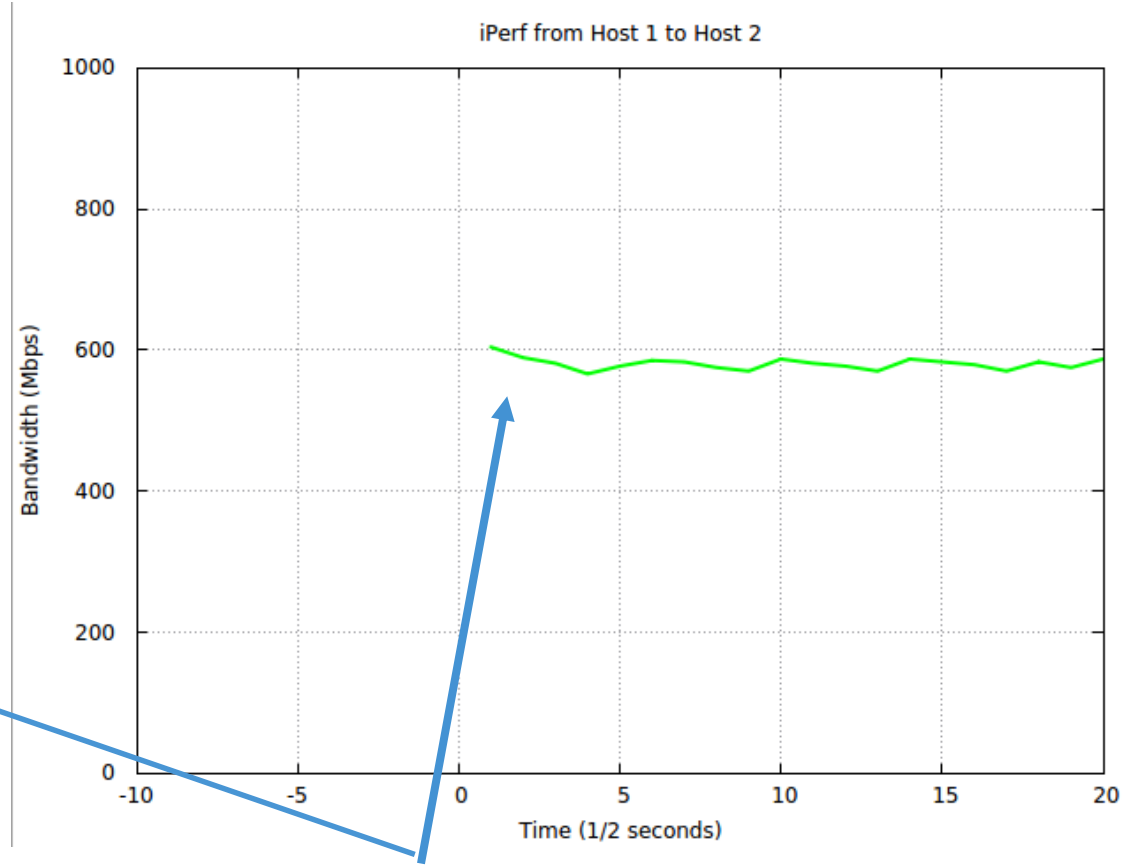Second stream starts and competes for bandwidth, large variation of bandwidth that each stream achieves over time

802.1Qbv Time Aware Shaper Configuration

802.1Qbv – Time Aware Shaper

iPerf from Host 3 to Host 2
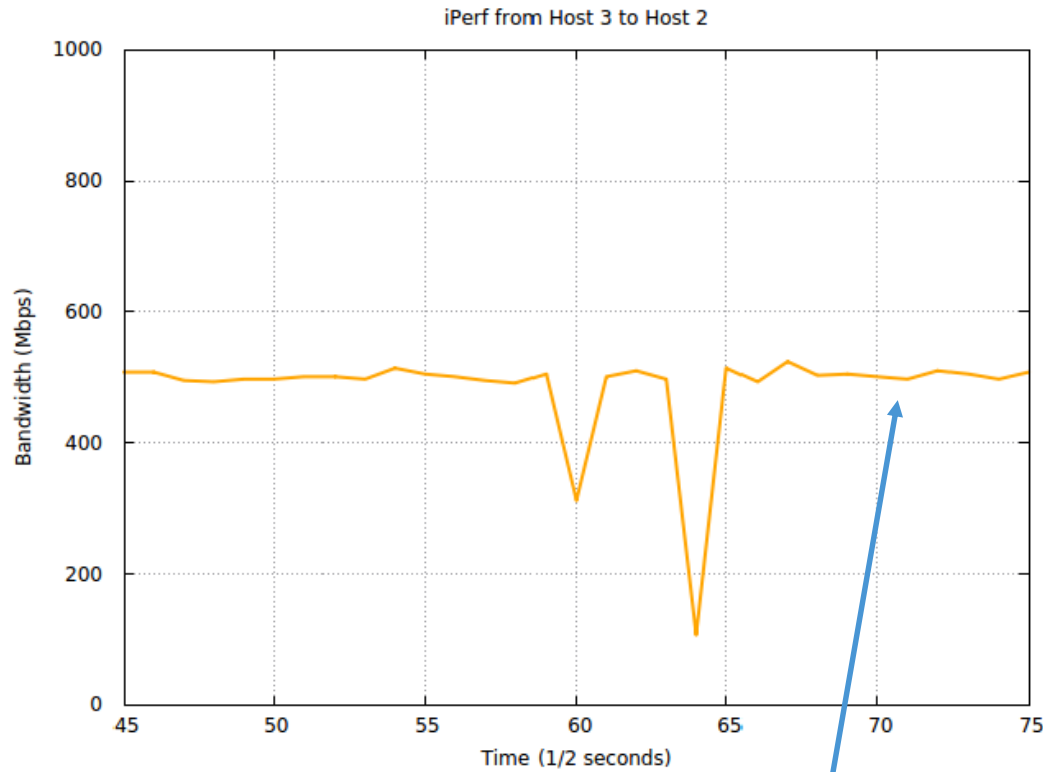
iPerf from Host 1 to Host 2
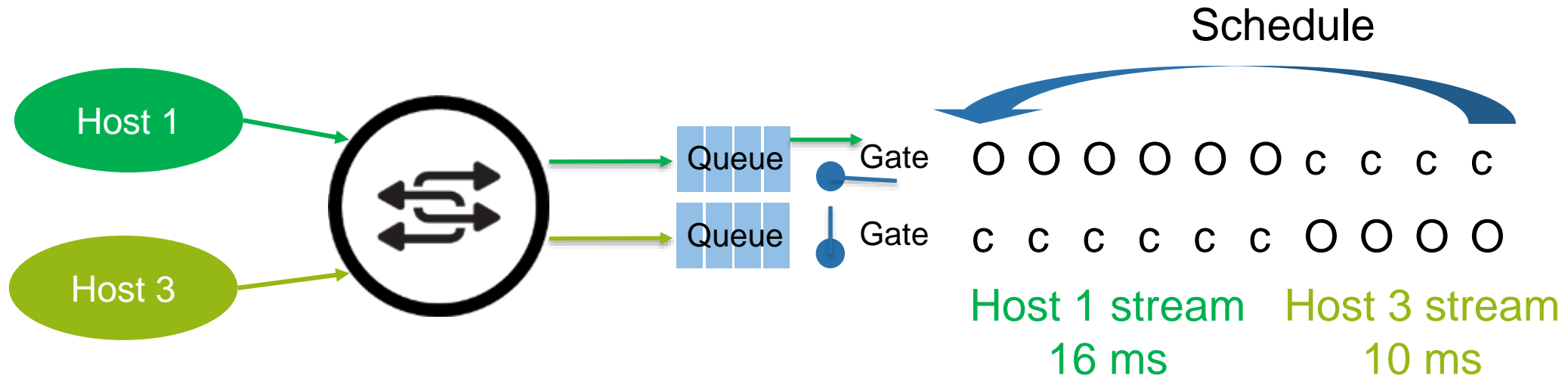
Time aware shaper limits bandwidth of each stream, even with only 1 stream transmitting
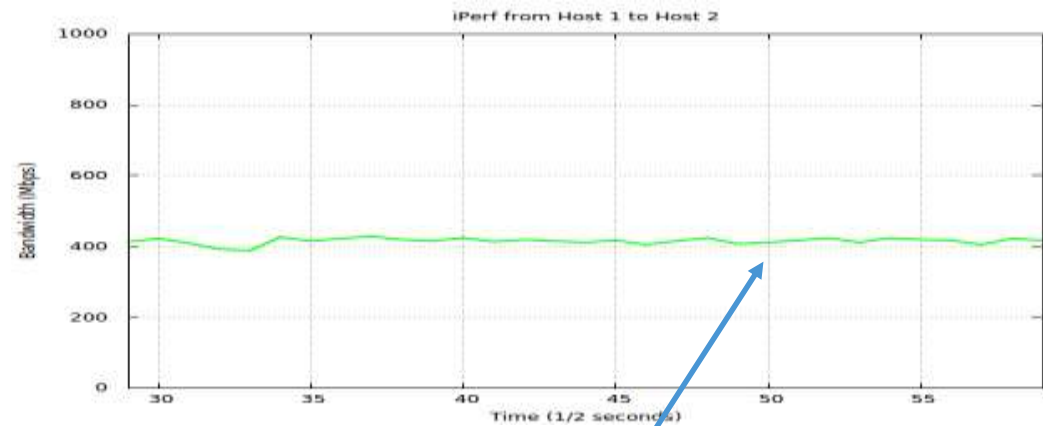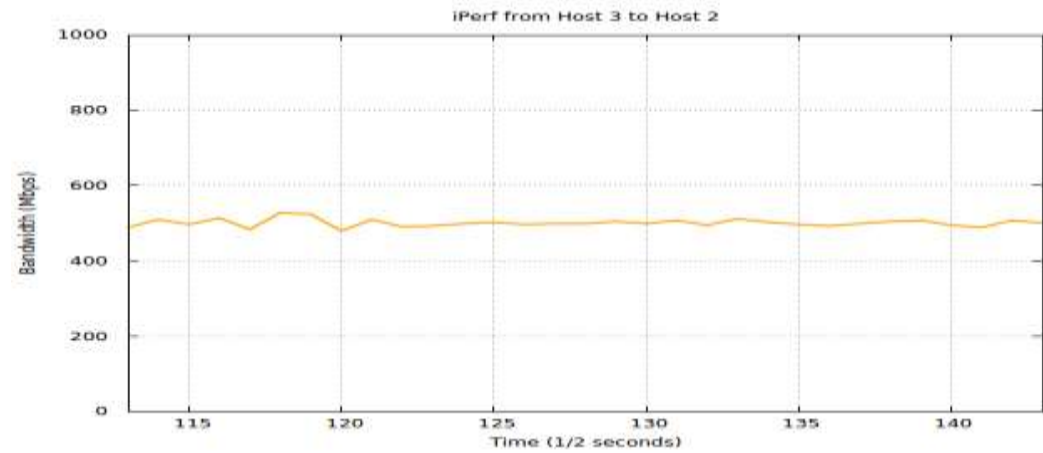
Bandwidth remains stable on each stream, even when second stream starts

802.1Qci – Per-Stream Policing and Filtering

Host 3 will never achieve more than 600 Mbps bandwidth due to ingress limit

Host 1 will utilize remaining bandwidth when it starts to transmit

Real time response to IoT data

Deterministic Ethernet for **Operational Technology** Traffic

Increasing security threats and costs

Analytics Driving
Edge Computing

LS1028A supports full virtualization, to enable local analytics and real time control for the industrial IoT

Network
Convergence

LS1028A enables IT and OT networks to merge, protecting critical OT data with TSN, while interoperating with legacy IT networks

Secure
Platform

Build trusted applications and services on a root of trust using Layerscape trust architecture

SECURE CONNECTIONS
FOR A SMARTER WORLD