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System-on-Chip *engineering*

DDS over TSN to Support NATO Generic Vehicle Architecture (NGVA) for Land Systems

Presenter: Armando Astarloa
Authors: Armando Astarloa (SoC-e)
Fernando Garcia (RTI)

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TSN Technology & Applications

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DDS & TSN for Military Land System

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DDS & TSN for Military Land Systems

- Strong standardization effort in the Sector:
  - » VICTORY architecture standard
  - » NATO GENERIC VEHICLE ARCHITECTURE (NGVA) FOR LAND SYSTEMS

NGVA is a NATO Standardisation Agreement (STANAG 4754) based on open standards to design and integrate multiple electronic sub-systems onto military vehicles which are controllable from a multifunction crew display and control unit.

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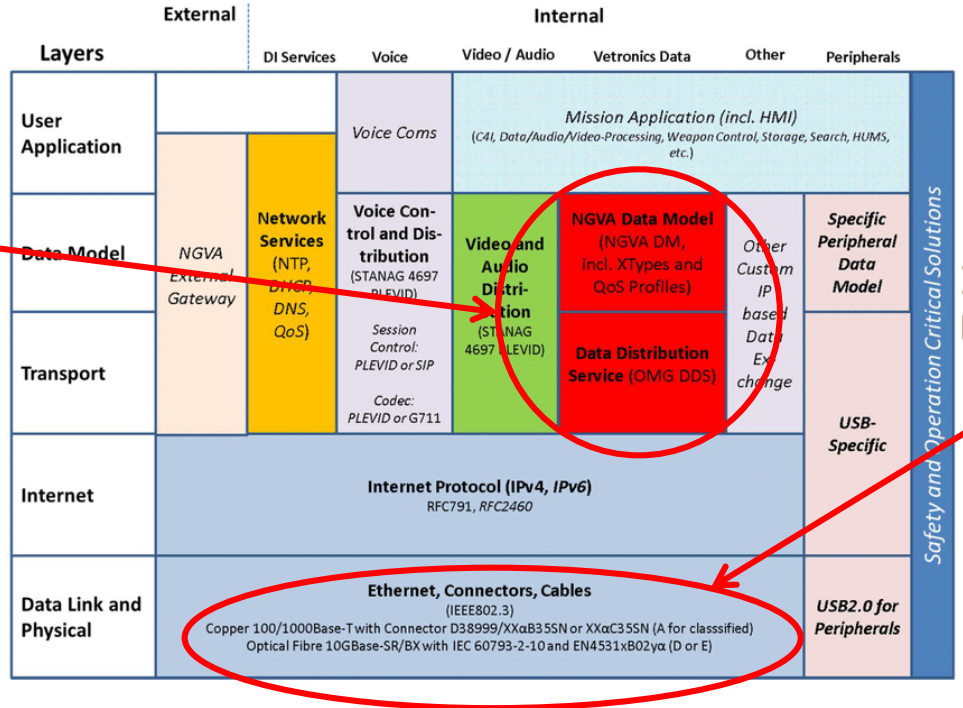
DDS & TSN for Military Land Systems

- Data Link and Physical: Ethernet => *No support for Real-Time traffic*

DDS Data Model



Ethernet (Basic QoS-priorities)

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DDS QoS and TSN

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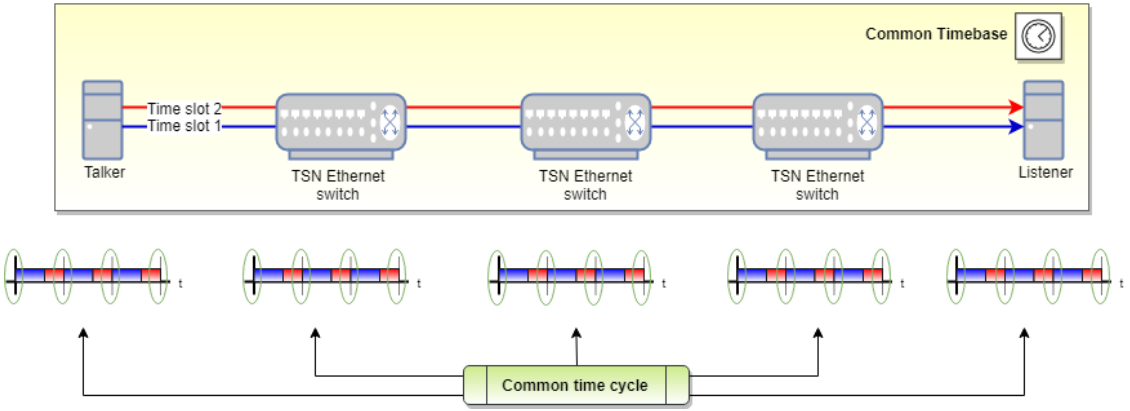
DDS QoS and TSN

- Time-Sensitive Networking (TSN):
  - » Set of standards (IEEE TSN TG of 802.1 WG)
  - » Time-sensitive transmission of data over Ethernet IEEE802.3
  - » *Time Synchronization*, *Traffic Scheduling* ,*Traffic shaping*, *Communication paths* management(fault-tolerance)



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DDS QoS and TSN

- TSN traffic types:
  - *Scheduled Traffic:* Hard Real-Time traffic. Automation, Control. Latency & Jitter (OT).
  - *Reserved Traffic:* Soft Real-Time traffic. User Experience ensured(OT,IT).
  - *Best-Effort traffic :* General Traffic (IT).

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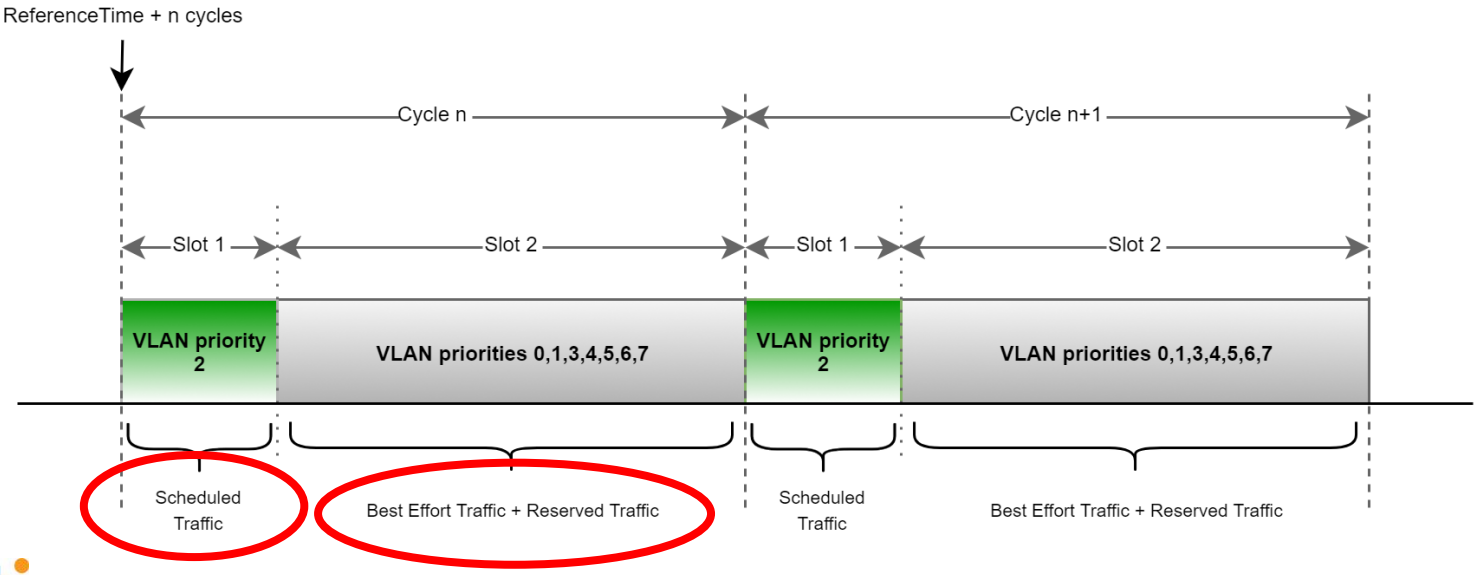
DDS QoS and TSN

- TSN is Deterministic Ethernet



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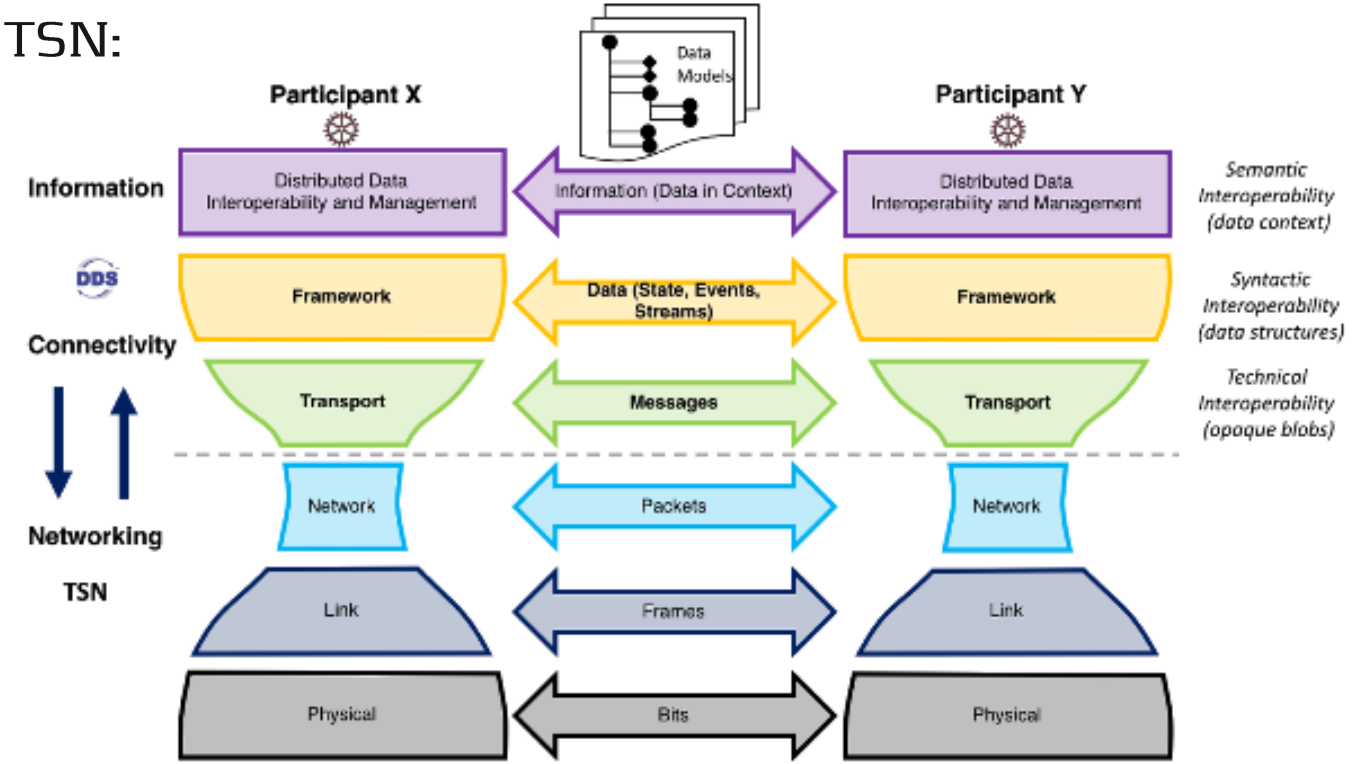
DDS QoS and TSN

- DDS over TSN:



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DDS QoS and TSN

- DDS quality parameters:
  - **Reliability:** It determines whether or not data published by a DataWriter will be reliably delivered by Connext DDS to matching DataReaders.
  - **Time Based Filter:** It allows to specifying that data should not be delivered more than once per specified period for data-instances of a DataReader—regardless of how fast DataWriters are publishing new DDS samples of the data-instance.
  - **Deadline:** This Qos Policy states the maximum period in which the application expects to receive new values for the Topic, or to call write() on the DataWriter, thus publishing a new DDS sample.
  - **Latency Budget:** It provides a hint as to the maximum acceptable delay from the time the data is written to the time it is received by the subscribing applications.
  - **Transport Priority:** It allows to specifying on a per-DataWriter or per-DataReader basis that the data sent by a DataWriter or DataReader is of a different priority.
  - **Allow Interfaces List:** A list of strings, each identifying a range of interface addresses that can be used by the transport.

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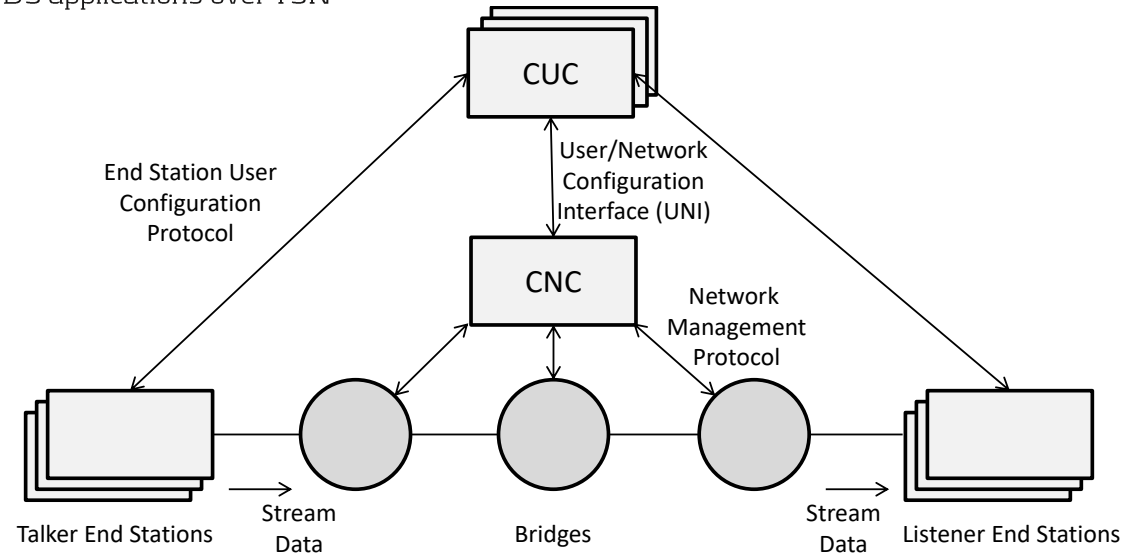
DDS

DDS QoS and TSN

- DDS-TSN Configuration:
  - » IEEE 801.Qcc defines different configuration models
    - > From fully distributed to fully centralized
  - » OMG DDS-TSN introduces a fully-centralized model
    - > Configures the behavior of DDS applications over TSN



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DDS QoS and TSN

- DDS-TSN Configuration:
  - The model introduces a DDS CUC that captures information on
    - DDS applications and entities
    - Deployment nodes
    - Data streams
  - DDS CUC provides the CNC with the necessary information required to
    configure, paths, etc.
    - Maps DDS CUC configuration to YANG models

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DDS & TSN implementation on a Military Certified Edge Computing & Networking Equipment

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NGVA & DDS & TSN Set-up: Description

DDS publisher
- Scheduled Traffic: NGVA Brake Info (DDS Stream 1)
- Reserved Traffic: Camera Real Time Video (DDS Stream 2)
- Best Effort Traffic: Remaining TCP/IP traffic

Visualization

Traffic Injector
- Best Effort Traffic

Camera Real Time Video

TSN Network

DDS subscriber
- Rugged Computer + TSN PCIe NIC

Brake system (NGVA Brake Info)

TSN/A Demo Setup

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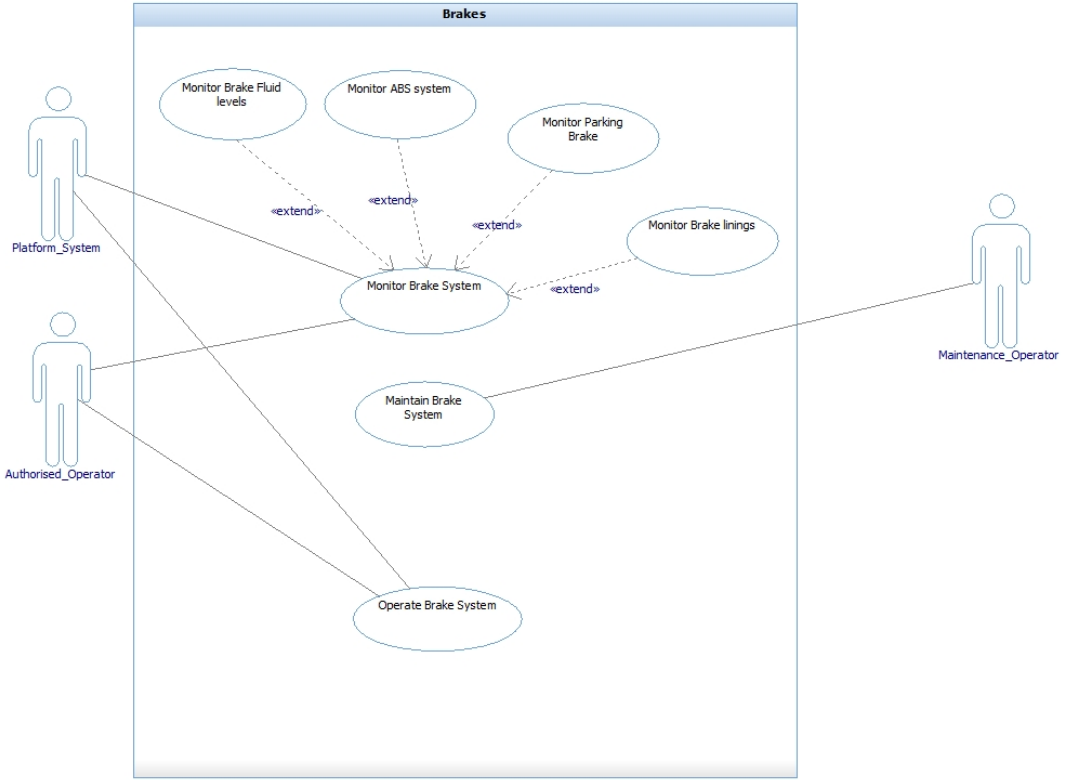
NGVA & DDS & TSN Set-up: Description

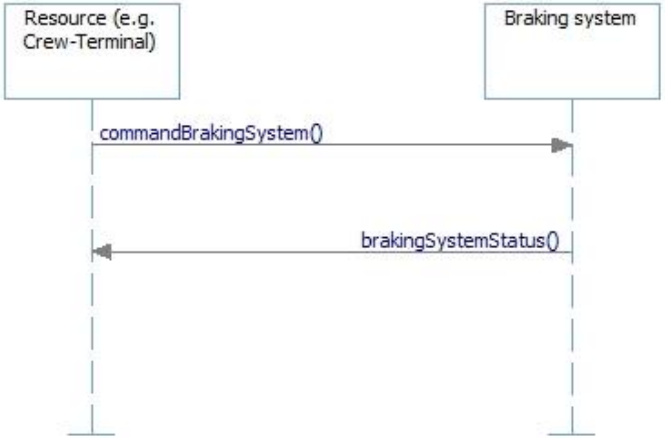
- NGVA Brake Info:

```
#include "LDM_Common.idl"// Responsibilities of this domain are:
//
// controlling the brake system which includes
//          controlling of the park brake system
//          controlling of the ABS
//          controlling of an optional engine brake
//
// monitoring the status of the braking system which includes
//          monitoring the status of the ABS system
//          monitoring the status of the brake linings (if available)
//          monitoring the status of the brake fluids (if available)
//          monitoring the status of the optional engine brake
//
//
```

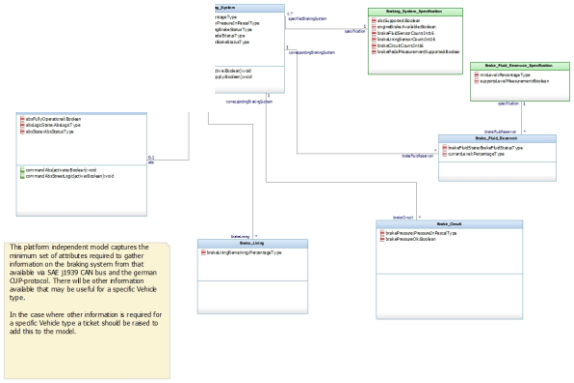


NGVA & DDS & TSN Set-up: Description

- NGVA Brake Info:



An authorized user command the braking system via his crew terminal.
The braking system processes the command.
After processing the new status will be sent.



NGVA & DDS & TSN Set-up: Configuration

- TSN traffic types:
  - *Hard Real-Time traffic*: Automation, Control. Latency & Jitter (OT).
    - Scheduled Traffic (ST): NGVA Brake Info (DDS Stream 1)

      VLAN 11, PCP 2

      ST (DDS NGVA BRAKE)
  - *Soft Real-Time traffic* : User Experience ensured(OT,IT).
    - Reserved Traffic (RT): Camera Real Time Video (DDS Stream 2)

      VLAN 12, PCP 5

      RT (DDS VIDEO)
  - *Best-Effort traffic :* General Traffic (IT).
    - Best Effort (BE) Traffic: Remaining TCP/IP traffic
    - Noise Traffic (N),:Traffic Generator

      VLAN 3, PCP 6

      Remaining Traffic (Noise+others)

- Slots configuration:
  - 4 slots
  - Cycle-time: 20 ms
  - Slot 1: Free; Slot 2: ST; Slot 3: Free; Slot 4: RT+BE+N

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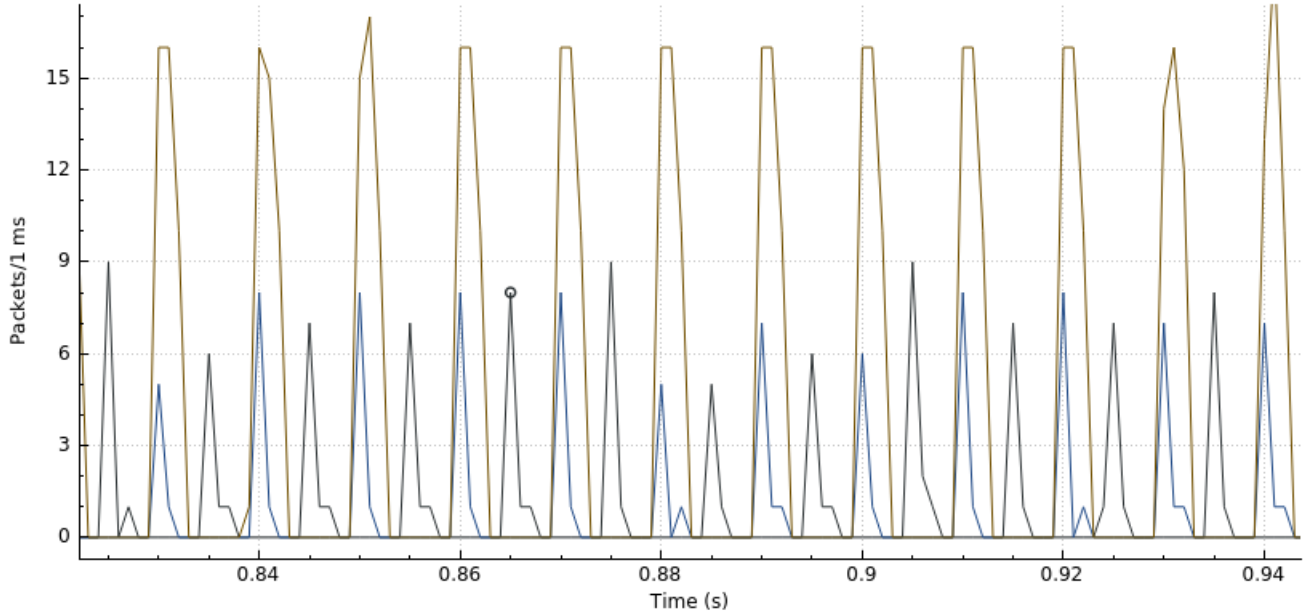
NGVA & DDS & TSN Set-up: Traffic Shaping



Click to select a portion of the graph.

Name	Display filter	Color	Style	Y Axis	Y Field	Smoothing
☑ vlan_2	vlan.priority == 2		Line	Packets		None
☑ vlan_5	vlan.priority == 5		Line	Packets		None
☑ noise	vlan.priority == 6		Line	Packets		None

ST (DDS NGVA BRAKE)
RT (DDS VIDEO)
Remaining Traffic (Noise+others)

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NGVA & DDS & TSN Set-up: Functional Results

Functional Report	TEST 1: AS OFF, TAS OFF, CBS OFF, NOISE OFF	TEST 2: AS OFF, TAS OFF, CBS OFF, NOISE ON	TEST 3a: AS OFF, TAS ON, CBS OFF, NOISE OFF	TEST 4a: AS OFF, TAS ON, CBS OFF, NOISE ON	TEST 3b: AS ON, TAS OFF, CBS OFF, NOISE OFF	TEST 4b: AS ON, TAS OFF, CBS OFF, NOISE ON	TEST 5: AS ON, TAS ON, CBS OFF, NOISE OFF	TEST 6: AS ON, TAS ON, CBS OFF, NOISE ON	TEST 7: AS ON, TAS ON, CBS ON, NOISE OFF	TEST 8: AS ON, TAS ON, CBS ON, NOISE ON
ST (DDS NGVA BRAKE):	CORRECT	NULL	NULL OR INFORMATION LOST	NULL OR INFORMATION LOST	CORRECT	INFORMATION LOST	CORRECT	CORRECT	CORRECT	CORRECT
RT (DDS VIDEO):	CORRECT	NULL	NULL OR BAD QUALITY	NULL OR BAD QUALITY	CORRECT	BAD QUALITY	CORRECT	BAD QUALITY	CORRECT	CORRECT
Noise: Hardware generated frames (>100% throughput)										

OVERLOAD STANDARD ETHERNET NETWORK

OVERLOAD TSN NETWORK

AS: Synchronization
TAS: Time-aware Shaper
CBS: Credit-based shaper
Noise: Injected traffic

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NGVA & DDS & TSN Set-up: Reliability

Real Thorughput Results (effective traffic lost)	TEST 1: AS OFF, TAS OFF, CBS OFF, NOISE OFF	TEST 2: AS OFF, TAS OFF, CBS OFF, NOISE ON	TEST 3a: AS OFF, TAS ON, CBS OFF, NOISE OFF	TEST 4a: AS OFF, TAS ON, CBS OFF, NOISE ON	TEST 3b: AS ON, TAS OFF, CBS OFF, NOISE OFF	TEST 4b: AS ON, TAS OFF, CBS OFF, NOISE ON	TEST 5: AS ON, TAS ON, CBS OFF, NOISE OFF	TEST 6: AS ON, TAS ON, CBS OFF, NOISE ON	TEST 7: AS ON, TAS ON, CBS ON, NOISE OFF	TEST 8: AS ON, TAS ON, CBS ON, NOISE ON
ST (DDS NGVA BRAKE): 10 Mbps modeled	10 Mbps	0 Mbps	Inestability (Variable throughput)	Inestability (Variable throughput)	10 Mbps	0,3 Mbps	10 Mbps	10 Mbps	10 Mbps	10 Mbps
RT (DDS VIDEO): 10 Mbps modeled	10 Mbps	0 Mbps	Inestability (Variable throughput)	Inestability (Variable throughput)	10 Mbps	0,2 Mbps	10 Mbps	0,1 Mbps	10 Mbps	10 Mbps
Reliability: Realiable Mode										
Noise: Hardware generated										

OVERLOAD STANDARD ETHERNET NETWORK

OVERLOAD TSN NETWORK

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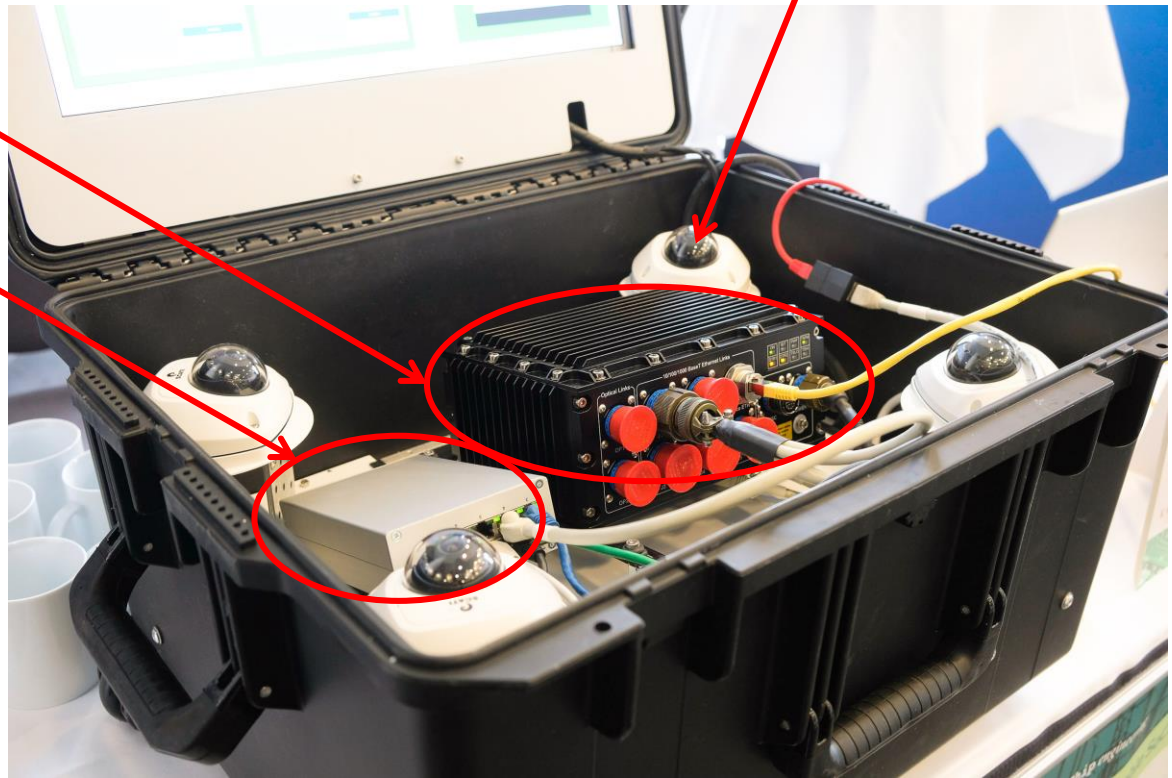
NGVA & DDS & TSN Set-up: Demo Set-up

Cameras

Military Switch

RELY-RB+



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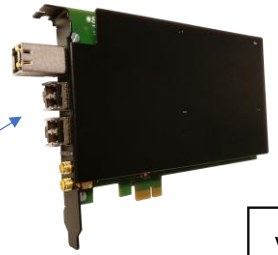
NGVA & DDS & TSN Set-up: Evaluation Set-up

DDS publisher

- Scheduled Traffic: Emulated NGVA Brake Info (DDS Stream 1)
- Reserved Traffic: Pre-stored video Stream (DDS Stream 2)
- Best Effort Traffic: Remaining traffic (Traffic Injector)

TSN Network



Visualization

DDS subscriber

- PC Computer + TSN PCIe NIC

Pre-stored Video Stream

Brake system (NGVA Brake Info)

Traffic Injector

- Best Effort Traffic

RELY-PCIe Kit Setup

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Conclusions

- Many specific sectors are adopting standardized open architectures (e.g. NGVA)
- Adoption of open and standardized protocols (Ethernet) and data models (DDS)
- TSN&DDS ensures QoS and OT/IT in critical systems
- TSN&DDS solutions allow simplifying complex system implementations

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About SoC-e

- Provides **IP cores, modules and end-equipment** for
  - **Networking:**
    - Deterministic Ethernet:
      - MTSN, D-HSR
    - High-availability Ethernet:
      - HSR/PRP, MRP, S-HSR
    - Time-aware Ethernet:
      - MES, UES, Field-buses
  - **Synchronization:**
    - IEEE1588, Irigb
  - **Real-time Cyber-security**

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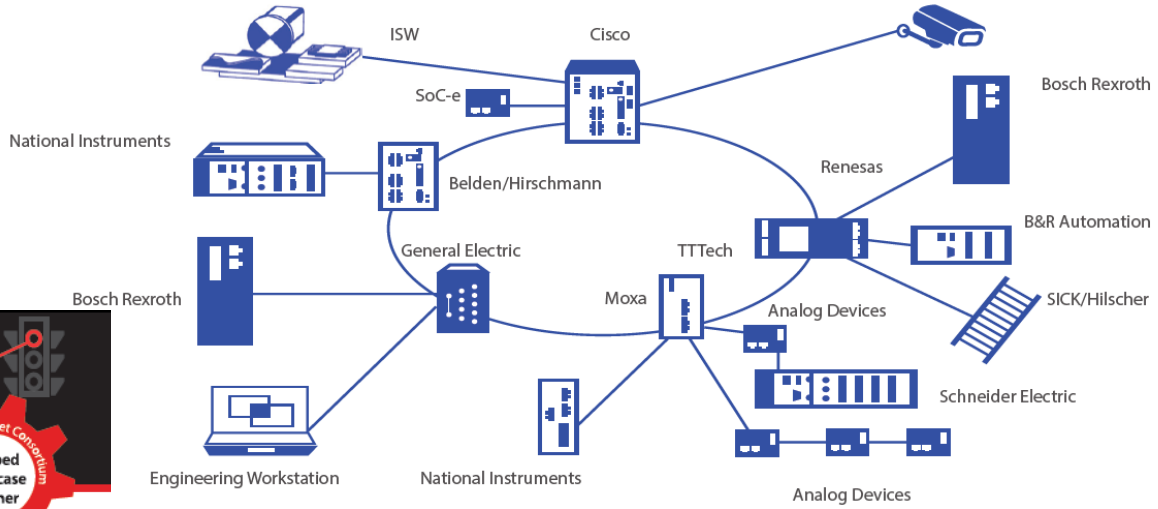

Time Sensitive Networking (TSN) is key for industrial applications such as process and machine control where low communication latency and minimal jitter are critical to meeting closed loop control requirements. TSN is the first fully open, standard and interoperable way to fulfill these requirements.

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RTI and the Industrial IoT

About RTI

- RTI is the largest IIoT connectivity vendor
- Connext DDS has 1300+ designs, many real-world programs across industries
- Full DDS, tools, services, support, secure & certified versions










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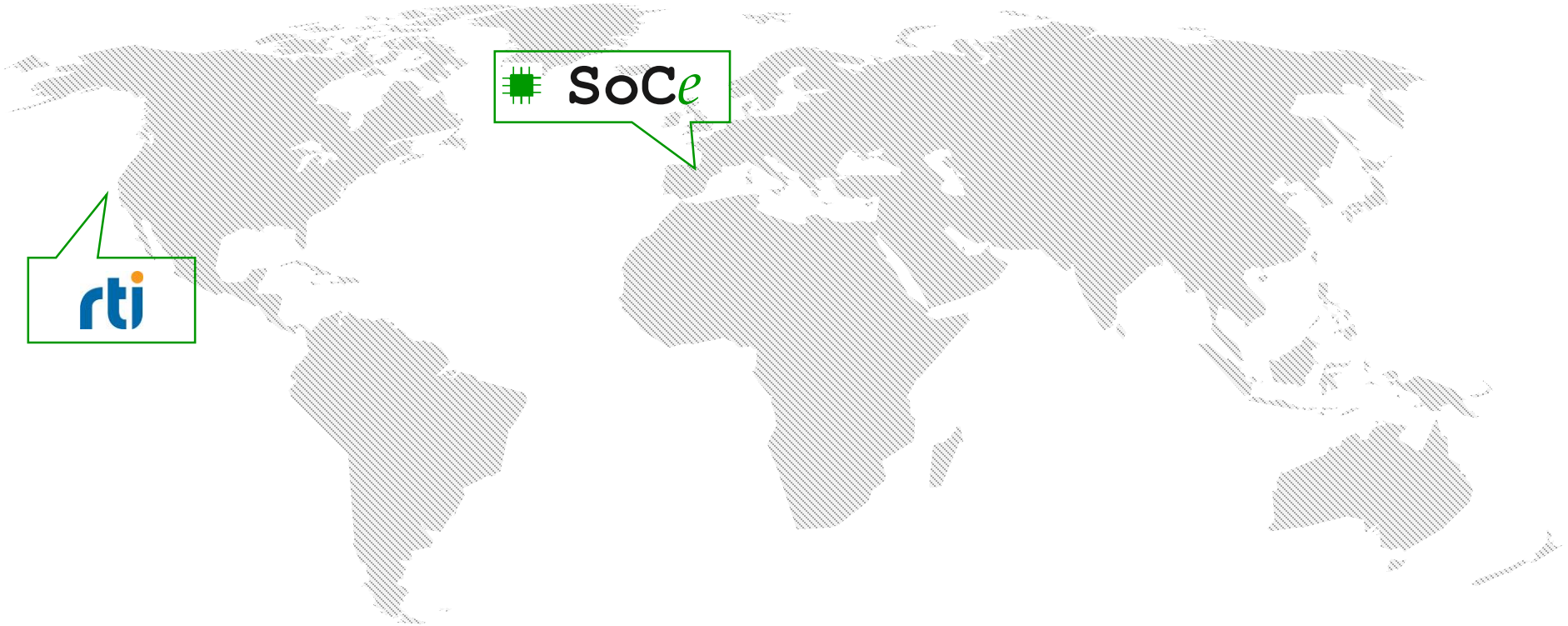
AUTOSAR
ROS
MD PnP
Getting connected for patient safety
OpenFog
industrial internet CONSORTIUM
SOA
OMG
OBJECT MANAGEMENT GROUP
FACE
Future Airborne Capability Environment
THE OPEN GROUP
OPEN PROCESS AUTOMATION™ FORUM
Smart Electric Power Alliance
ICE
Alliance
Integrating Clinical Environments
AVNU



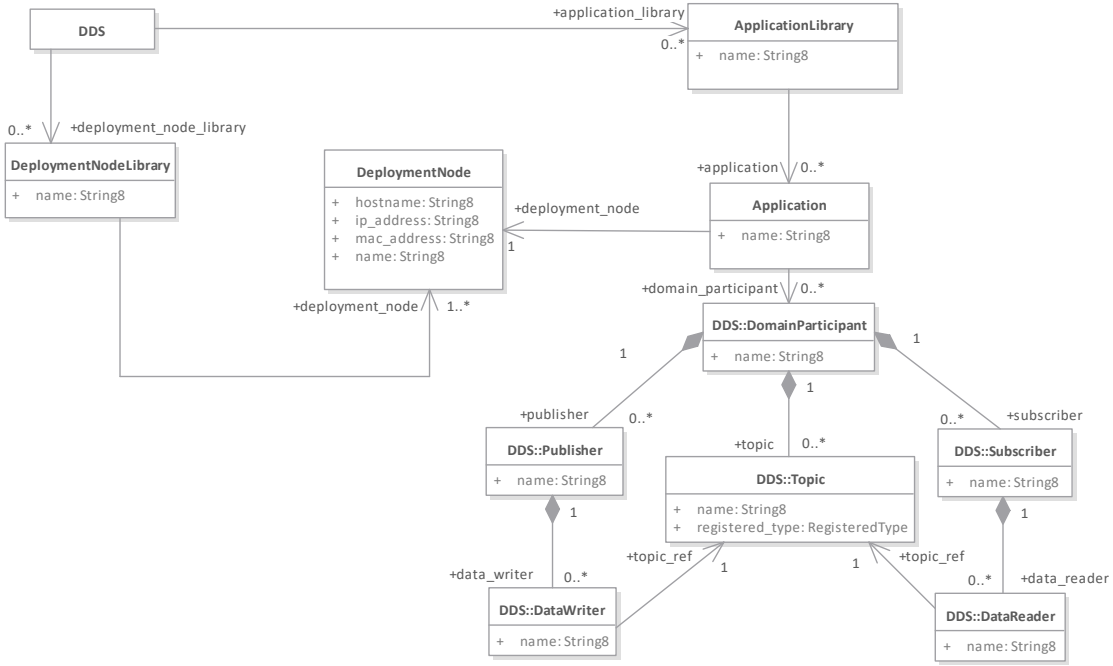
www.soc-e.com

info@soc-e.com

Edificio Udondo, 6º planta
Avd. Ribera de Axpe, 50
48950 Erandio · Bizkaia | SPAIN

DDS QoS and TSN

- DDS-TSN Configuration. Deployment Configuration:



DDS QoS and TSN

- DDS-TSN Configuration. TSN Configuration: