Data Distribution Service (DDS) over Time Sensitive Networking (TSN) for launchers

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INNOVATING SOLUTIONS

Speakers

GMV: Carlos Domínguez Sánchez, Head of Flight Software Section

Specialist in flight software and avionic systems for launchers, with expertise in real-time systems, reliability and security.

eProsima: Jaime Martin Losa, CEO

Over two decades of experience in networking middleware, leads the team behind Fast DDS, the most used DDS implementation worldwide with hundreds of thousands of users.

Contents

Introduction I

Motivation

- Launchers need **deterministic**, **reliable** communications.
- Interfaces are not always **standardized**, increasing the development and integration effort.
- Processing capabilities and **bandwidth.** increasing
- **Data** increasing.

TSN + DDS → standard, modular, reusable, deterministic

Introduction II

DDS Overview

- **Publish/Subscribe** middleware
- Standardized by the Object Management Group (OMG)
- Key features:
  - **Real-time** data exchange
  - **QoS** policies (reliability, latency, ordering)
  - Automatic **discovery** of node
- Widely used in **robotics** and **automotive**. Increasing in aerospace!

Introduction III

TSN Overview

- Extension of **Ethernet** with **deterministic** communication.
- Guarantees **bounded latency** and **reliability.**
- Widely used in **robotics** and **automotive.**
- Time-Sensitive Networking task group of **the IEEE 802.1** working group.

DDS: Real-Time "Publish / Subscribe"

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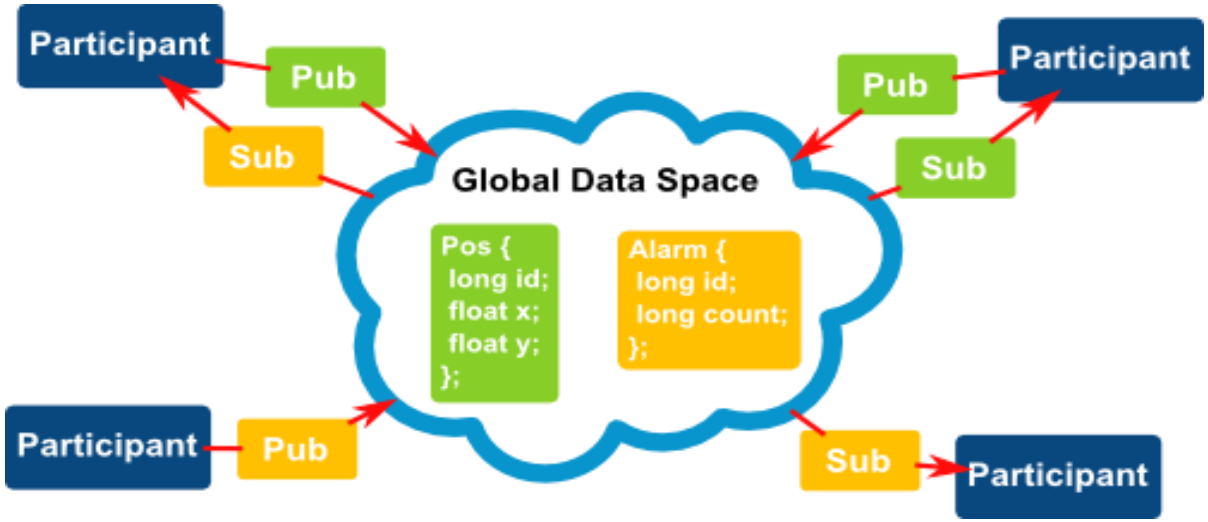

- Decoupled architecture,
- No Single Point of Failure
- Data Centered
- Plenty of QoS

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DDS Implementation trade-off for launchers

Trade-off

- Options evaluated: Fast DDS, Cyclone DDS, RTI Connext, EmbeddedRTSP, SafeDDS.

- Evaluation criteria: **reliability**, **memory usage, portability, licensing and safety**

DDS Implementation trade-off for launchers

Trade-off

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*it was decided to use Safe DDS to evaluate the feasibility of using **DDS over TSN**, due to its **maturity level**, specially coming from the **experience of developing a widely used solution as Fast DDS**, its design that facilitates the integration with different applications and the modular design that helps to adapt the software to TSN usage.*

Safe DDS for Space: Real-Time determinism

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ISO 26262 ASIL D

TSN Support

RTEMS Support

Fully European

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DDS over TSN

Adapting Safe DDS to TSN

- Mapping DDS to TSN **VLANs,** considering **Priority** and **QoS.**
- **Platform-independent** configuration model.
- **Reusable** modules across missions/projects.

OMG Standards Development Organization

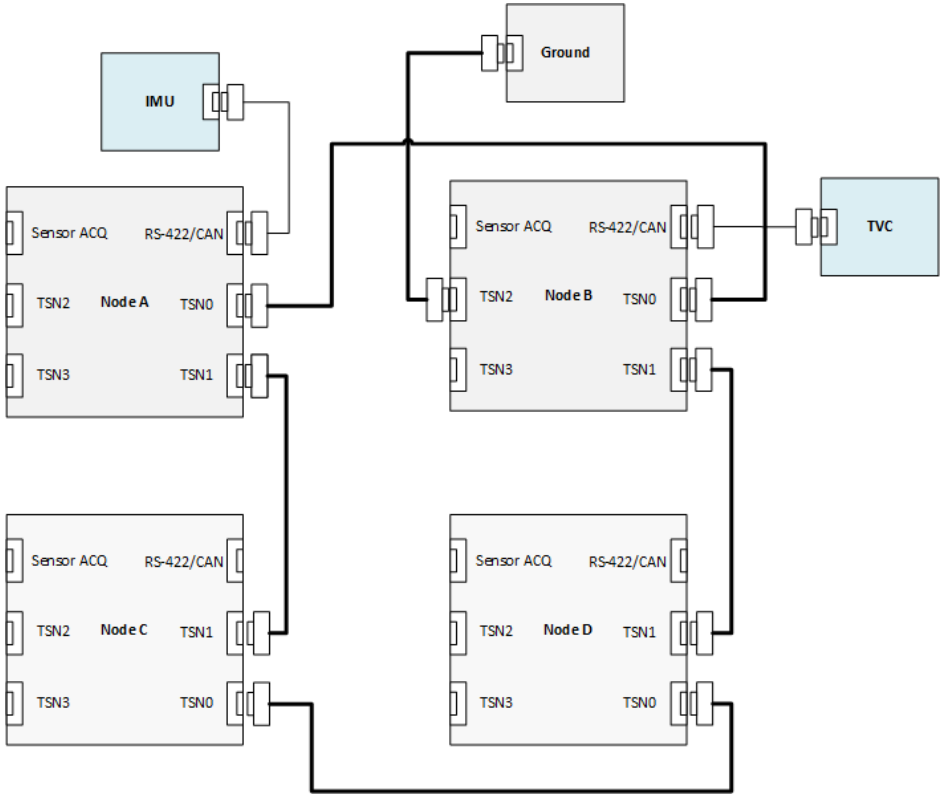
DDS Extensions for Time Sensitive Networking (DDS-TSN)

Version 1.0 - beta 1

Testing environment I

Micro-launcher ATB

- Zynq-7000 + ARM Cortex-A9.
- **RTEMS 5.3.**
- **TSN daisy-chain** topology.
- Connected subsystems: **IMU, TVC, sensors.**



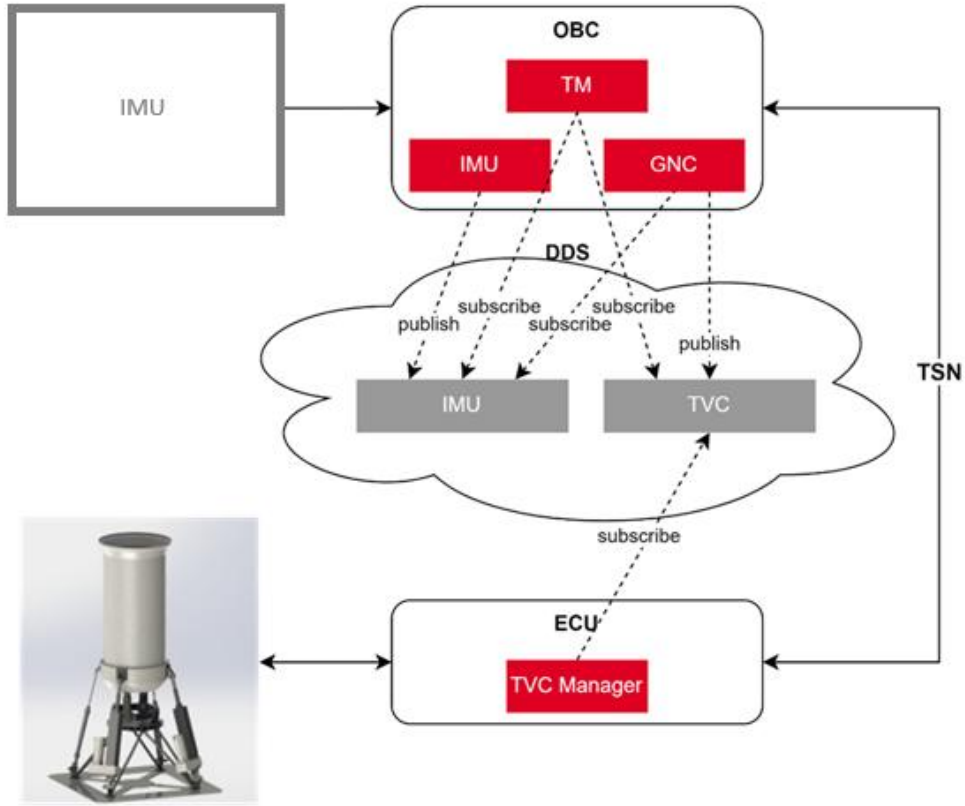
Testing environment II

Micro-launcher ATB

Results I

Experimental Setup

- **Custom C wrapper** around SafeDDS (static memory allocation).
- Topics tested: IMU-TM (100 Hz), TVC-TC (33 Hz), TVC-TM (33 Hz).



Results II

CPU Usage

- Node A: average **0.277 ms/cycle** (max 2,089 ms).
- Node B: average **0.185 ms/cycle** (max 1,883 ms).
- Overhead: **~3%** CPU load at 100 Hz cycle.

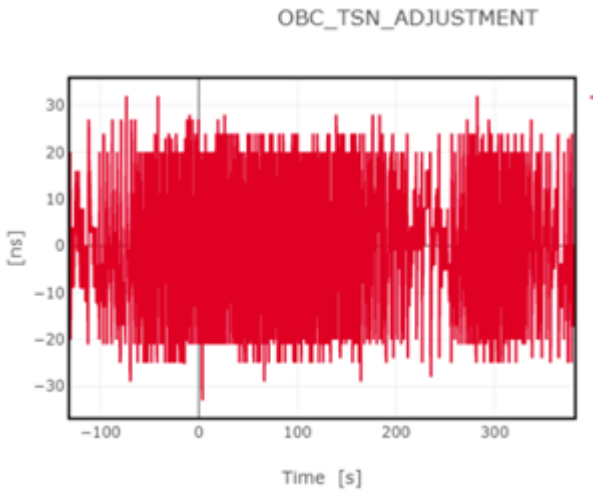
Memory Footprint

- RTEMS: **489 kB.**
- Lightweight for embedded systems.
- Overhead: **<5% memory.**

Results III

Network performance

- No packet lost.
- No **synchronization** lost.
- No real-time constraint violated.
- Clock adjustment under **60 ns.**
- Link delay under **500 ns.**



TSN performance was maintained

Conclusions I

Summary

- DDS over TSN is **feasible** for launcher avionics.
- **Minimal CPU** and **memory** overhead.
- Provides **modularity**, **scalability** and **reliability.**
- Eases the **reusability.**
- **Speeds-up** development and integration tasks.
- **Validated** in realistic ATB.

Conclusions II

Future work

- **Scale** to larger TSN networks with **larger data**.
- Integration to space standards such as **PUS**.
- Integration in **real missions.**
- It was demonstrated that DDS over TSN is suitable for launchers, Could it be suitable for **other space systems**?

Acknowledgement

Thank you

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