Concurrent Technologies Solution Brief

Time Sensitive Networking (TSN) & The Warfighter

Supporting Generic Vehicle Architectures (GVA/NGVA)

Time Sensitive Networking (TSN) is the standard technology that provides deterministic messaging on standard Ethernet. Defined by the IEEE 802.1Q specification, it represents an exciting opportunity for the communications backbone in the next generation of military embedded systems.

Before the introduction of this specification, standard Ethernet didn't have a pure Layer 2 deterministic capability. This meant that deterministic communication was achieved using non-standard technologies for Ethernet.

TSN makes it possible to carry data traffic of time-critical applications over a bridged Ethernet network shared by various applications with different quality of service (QoS) requirements.

TSN enables guaranteed data transport with bounded low latency, low delay variation, and extremely low data loss. As such, it ticks a lot of boxes for military applications based on the Data Distribution Service™ (DDS) standard.

By reserving resources for critical traffic, and applying various queuing and shaping techniques, TSN achieves zero congestion loss for critical data traffic.

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AFDX & TTE

In civil aviation, Ethernet technologies such as ARINC 664 (AFDX) and Time-Triggered Ethernet (TTE) have been implemented in some applications, but they require significant capital investment and incur high running costs.

These legacy avionics solutions also aren't flexible once deployed and cannot be dynamically configured.

As an open standard technology supported by a wide ecosystem of suppliers, TSN is designed to operate alongside existing low-cost Ethernet technologies.

TSN Profiles

TSN is a collection of IEEE specifications so working groups are using a 'profiles' approach to

This, in turn, allows TSN to guarantee a worst-case end-to-end latency for critical data.

TSN delivers data traffic reliably via a data packet level mechanism, as well as protection against bandwidth violation, malfunctioning, malicious attacks, etc. TSN includes reliable time synchronisation, a profile of IEEE 1588, which provides the basis for many other TSN functions.

TSN is an Ethernet standard, not an Internet Protocol standard. The forwarding decisions made by the TSN bridges use the Ethernet header contents, not the IP address.

The payloads of the Ethernet frames can be anything and are not limited to Internet Protocol. This means that TSN can be used in a variety of environments and can carry the payload of multiple defence applications.

These features make TSN applicable and economical for various use cases and can be used in multiple verticals, such as:

- Defence applications for sensor systems or inter/intra communications across land, air and sea-based vehicles
- Industrial automation networks being developed for smart factories
- Networks for critical machine-to-machine communication
- New networking approaches in vehicles, including support for autonomous driving
- And many more, with a constantly expanding list

Architecture Benefits

Military applications traditionally rely on technologies such as MIL-STD-1553, ARINC 429, and CANBus to support time-critical communications, as they are reliable and field-proven. However, those older data buses have not evolved to meet today's system operating speeds.

TSN provides a better alternative by utilising Ethernet as the converged fabric for time-critical and non-time-critical communication.

define which specific set of features, options, configurations, and protocols are appropriate for a particular set of TSN applications.

Some profiles are well-defined, while others are still works in progress.

Having a narrower focus of specifications through the use of profiles improves interoperability and eases integration and deployment.

Components of the TSN toolset are defined under these categories:

- Synchronization
- Latency
- Reliability
- Resource Management

TSN Education Resources from IEEE

Time-Sensitive Networking (TSN) Task Group:

https://1.ieee802.org/tsn/

Introduction to Time-Sensitive Networking:

https://ieeexplore.ieee.org/abstract/document/8412458

IEEE Time-Sensitive Networking Webinar Series:

https://ieeexplore.ieee.org/abstract/document/8412458

In fact, the Open Group SOSA™ Consortium defines Ethernet as the system fabric for what will become the next generation of military-embedded systems.

Prime contractors and integrators are developing Ethernet backbones for future ground vehicles (Generic Vehicle Architecture, GVA/NGVA) and aircraft that support not only traditional data and communications traffic, but also precision control over Ethernet for sensor systems, autonomous vehicles, and other devices historically controlled via legacy data buses.

TSN Solution: TR L9x/6sd-RCx

Key Features

Concurrent Technologies TR L9x/6sd-RCx is a rugged 3U VPX Plug-In Card based on the Intel® Xeon® W-11000E Series Processor for general-purpose computer applications.

It is designed in alignment with the SOSA™ technical standard for I/O intensive processor boards and, in addition to the core features below, can operate as a TSN switch or payload card.

- Up to 8-core processor for high performance
- x4 Gen 4 PCI Express Expansion plane for high-speed communication with adjacent board(s)
- Optional M.2 module for storage with Write/Protect and Opal 2.0 compliance
- XMC site for additional I/O resources
- 100G Ethernet Data plane

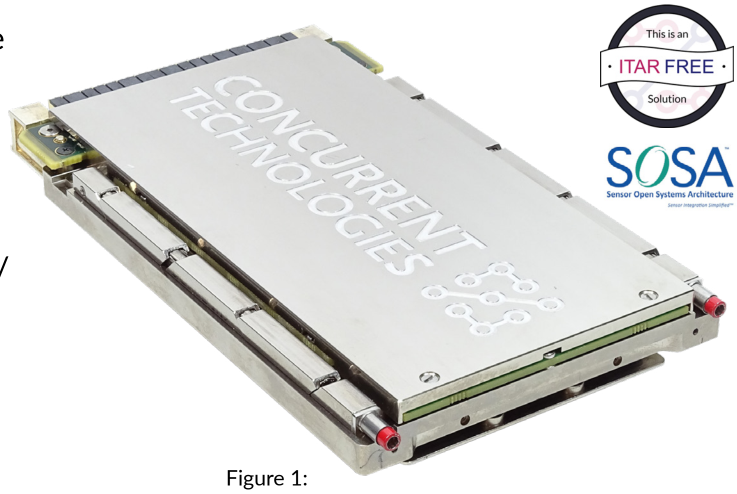

Figure 1:
A Concurrent Technologies TR L9x/6sd RCx

Block Diagram

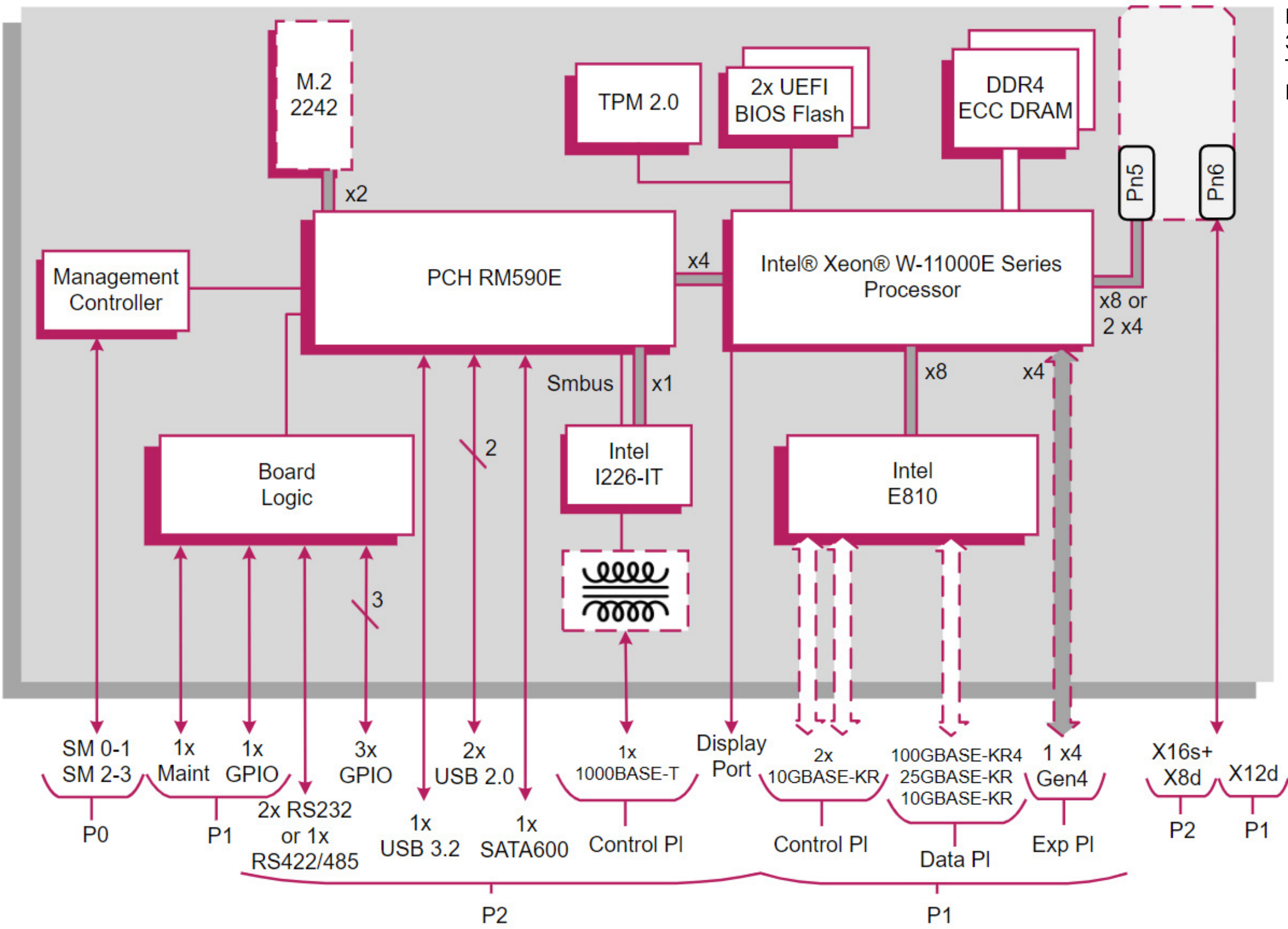

Figure 2:
3U VPX
TR L9x/6sd-RCx
Block Diagram

Want to find out more? **Visit TR-L9x/6sd RCx Product Page**

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DDS

The UK MoD Generic Vehicle Architecture (GVA) and its NATO version (NGVA) require the Data Distribution Service™ (DDS) standard for information exchange between critical sub-systems.

Published by the Object Management Group®, DDS is a family of middleware standards based on a publish-subscribe model that connects the receivers and providers of messages. This model generates standardized messages, called Topics, to be exchanged among the vehicle electronics systems.

DDS also provides a comprehensive set of Quality-of-Service (QoS) policies that configure the way information flows from publishers to subscribers. Since these QoS policies are independent of the underlying transport infrastructure, DDS can communicate reliably on top of unreliable transports such as UDP. However, some QoS policies, such as latency budget and deadline, cannot be enforced without a deterministic network infrastructure. Therefore, DDS and TSN have a synergistic relationship in delivering QoS-aware deterministic communication and efforts are underway to evolve DDS to become TSN-aware.

Traffic Definitions

In an NGVA/GVA implementation, the communication of the parameters could be defined as Scheduled Traffic, Reserved Traffic, and Best-Effort Traffic.

Scheduled Traffic	Reserved Traffic	Best-Effort Traffic
Appropriate for messages with strict real-time requirements. It has dedicated windows to guarantee the deterministic behaviour of the messages to be suitable for the most time critical applications	Is a higher priority than Best-Effort Traffic and a lower priority than Scheduled Traffic.	Made up of general-purpose messages that use the standard Ethernet Quality-of-Service capabilities. It is accommodated in the rest of the temporary windows of each operation cycle.

Messages assigned to different time windows with a reservation of bandwidth set for each priority type are considered Reserved or soft real-time traffic. This specific bandwidth reservation capacity is very useful for information with soft real-time requirements, such as video streams.

Systems Perspective

Both DDS and TSN standards provide the necessary building blocks for scalable, reliable, safe, secure, and performant in-vehicle communications through an approach combining technologies at the application software and network hardware levels.

In a typical SOSA™-aligned 3U chassis, a TSN switch within the chassis would be driving the system-wide fabric both within and beyond the chassis, sending traffic to/from external components such as sensors.

To add traditional serial buses within the chassis, the 3U payload cards may be fitted with XMC modules. Other 3U payload cards are providing their core functionality using a range of technologies such as GPGPU, FPGA, NVMe, and SSD.

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Although not a requirement, these payload cards can be TSN-enabled – the system is compatible with non-TSN cards, but they will be performing at best-effort traffic levels.

The transition from legacy serial buses to Ethernet TSN will require conversion technology as the two backbones co-exist during the migration period. A remote serial sensor gateway may provide a solution to bridge the gap in existing deployments.

Time Sensitive Systems Perspective

3U SOSA Chassis

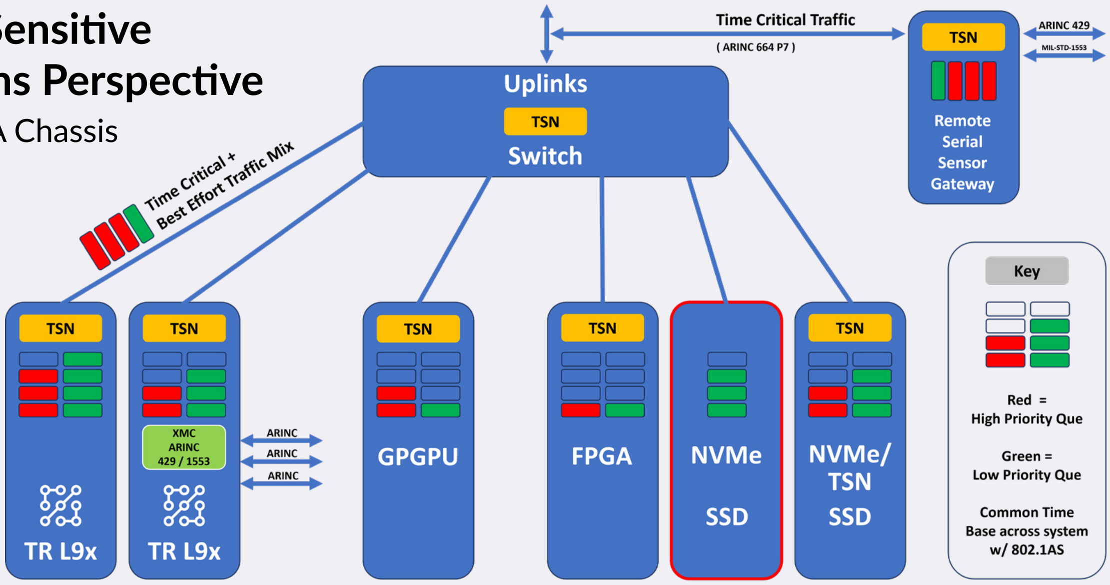

Figure 3: Time Sensitive Systems Perspective

Conclusion

Implementing GVA/NGVA with a system-wide DDS-enabled TSN fabric delivers a range of benefits beyond the more dependable and flexible communication:

SWAP-C: Reduced network topology and infrastructure eliminate the need to install multiple networks to ensure data availability within the required latency boundaries.

Scalability: Relatively simple migration to 10GE to support increased application bandwidth needs, for example, an increased number of higher-resolution video feeds. Easier insertion of other technologies.

Open: TSN is an IEEE specification while DDS is an open standard managed by the Object Management Group® (OMG®).

Modular: The ability to decouple component elements is fundamental to the SOSA™ approach.