

Time-Sensitive Networking for Real-Time Applications

The Time-Sensitive Networking (TSN) standard facilitates delivery of real-time information from streaming multimedia to synchronizing power microgrids.

Crafted by the Time-Sensitive Networking Task Group, the Time-Sensitive Networking (TSN) standard helps to deliver real-time information, from streaming multimedia to synchronizing power microgrids (Fig. 1). The group, originally called the Audio/Video Bridging (AVB) Task Group, defines extensions to the 802.1Q virtual LAN (VLAN) standard, implementing very low latency and supporting high-availability applications.

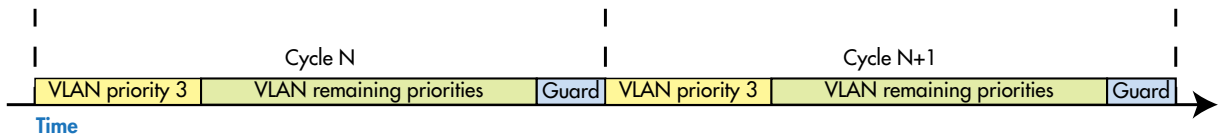
TSN implements a time-division multiple-access (TDMA) scheme (Fig. 2) to define fixed-priority VLAN slots for transmission. The approach can be used with strict priority schedulers via IEEE 802.1Q, or new processing methods like the TSN IEEE 802.1Qbv time-aware traffic scheduler.

The approach requires cooperation at the hardware level with time-synchronized devices, including network switches. Time synchronization is usually maintained using the IEEE 1588 protocol (see “What’s Behind The IEEE 1588 Protocol?”). This cooperation is necessary to maintain synchronization and make sure the priority of critical data is maintained.

The VLAN priorities provide quality-of-service (QoS) support by reserving bandwidth at specific points in a cycle. It’s possible to use multiple priorities for time-sensitive applications on the same network that may have different requirements. Of course, the applications can’t exceed the guaranteed bandwidth, but these are typically embedded applications where the requirements are known and the



1. National Instruments uses time-sensitive networking to manage its power microgrid.



2. Fixed-priority scheduling using a TDMA scheme enables applications to guarantee access to the transmission medium.

system is designed to handle these requirements.

The system allows non-time-critical applications to coexist on the network, but without the guarantees. As a result, operations like file copies may not be time-critical to utilize the remaining bandwidth; however, they will not affect the reserved, real-time bandwidth. Likewise, an application may utilize both types of connections for different purposes.

TSN does guarantee delivery of data at Open System Interconnection (OSI) model Layer 2 instead of Layer 4. This is how it can provide low latency that otherwise would not be possible if the support was in Layer 4.

APPLYING TSN

Wind River’s Industrial Internet of Things (IIoT) platform, called Titanium Control (*see “Wind River Virtualizes the IIoT”*), takes advantage of TSN to link control applications running on virtual machines (VMs) in a server with networked control systems. This essentially lets designers implement soft programmed logic controllers (PLCs) that have the logic running in a VM, while a network device samples data and executes the PLC’s actions.

Broadcom’s Quartz BCM53570 is an example of a fully compliant TSN Ethernet switch chip. It implements multiple 802.1 standards: 802.1Qca path control and reservation; 802.1Qbv time aware shaper; 802.1Qbu/ 802.3br frame preemption; 802.1Qch cyclic queuing and forwarding (peristaltic shaper); 802.1AS-Rev, 1588 v2 timing and synchronization; 802.1Qcc stream reservation protocol enhancement; 802.1Qci time based ingress policer; 802.1CB frame replication and elimination for reliability; and 802.1CM front-haul network profile.

TSN will likely replace or coexist in systems that currently utilize one or more of the many industrial Ethernet implementations like EtherCAT (*see “Industrial Automation Relies On Ethernet”*). TSN is already being used in National Instruments’ power microgrid test bed. This platform incorporates hardware and software from Bosch Rexroth, Cisco, Intel, KUKA, Schneider Electric, and TTTech. Essentially it used TSN to synchronize and manage power distribution between power grids, much like the microgrids in the system that are linked to various power sources (e.g., wind and solar) and distribution systems including the main power grid.

Normally ac power grids need to maintain synchronization so that everything runs at the same frequency and phase.

Setting up and tearing down the connections can be slow, cumbersome, and potentially hazardous. A TSN-based system can do it faster, as well as be more efficient and potentially safer. Much of this is still in the works, but eventually it could transform power-grid operation. The use of a networked solution also means that additional IIoT information can be exchanged on the same network.