Ethernet TSN heralds a new era of industrial communication

For the first time in the more than 40-year history of Ethernet, Ethernet TSN allows a time-controlled and deterministic transmission of real-time-critical messages via standard hardware. A time slot method, which Sercos has been using for real-time communication for over 25 years, is used for this purpose. With TSN, the application spectrum of Ethernet is extended to real-time applications, e.g. in the automotive or in industrial plants. This is the beginning of a new era in industrial communication.

The benefits of using Ethernet TSN are obvious: standard hardware with integrated real-time capability can be used, resulting in low cost and broad vendor and product offerings. In addition, the TSN standard allows the convergence of production and IT networks, that is, real-time communication and normal Ethernet communication can be transmitted over a uniform network standard. This is an ideal basis for the implementation of Industry 4.0 and IIoT concepts.

Evolution of fieldbus systems

With the availability of Ethernet TSN, the evolution of the fieldbus systems continues.

Generation 1 fieldbuses were designed for dedicated purposes. Sercos®, for example, was developed as a drive bus in order to replace the analogue ± 10 V drive interface. In parallel, Profibus, Interbus or DeviceNet were developed as fieldbuses for I/O communication. At that time, Ethernet was not used at all at the field level but only when machines need to be integrated and connected to superior IT systems.

Fieldbus systems of the second generation are characterized by the fact that they are all based on Ethernet and therefore have a much higher bandwidth available. However, they need a special hardware support for functioning correctly and for achieving a corresponding transmission and real-time performance. As a result, these systems are not compliant with the IEEE 802.1 and 802.3 standards, which means that vertical and horizontal integration with Ethernet cannot be optimally implemented. Another complicating factor is that most real-time Ethernet protocols cannot coexist in a common network infrastructure without compromising performance and real-time performance. Various real-time Ethernet solutions even use the network infrastructure
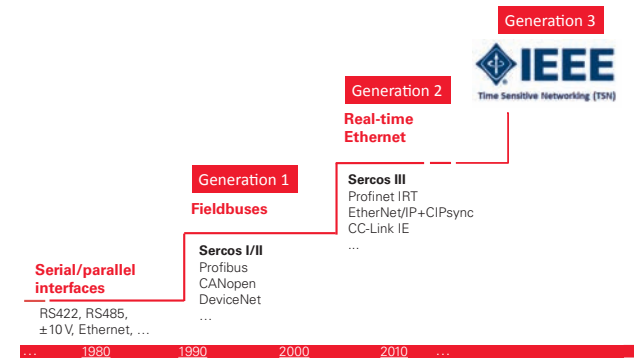
exclusively, so that other protocols must be tunneled via the underlying real-time protocol (see figure 2a). However, this requires a fully-functioning real-time protocol to communicate with the devices at all. Another approach is to use real-time Ethernet solutions that support coexistence with other Ethernet protocols. In such an approach, other protocols can be used both with and without the respective real-time protocol (see figure 2b). Representatives of these real-time Ethernet solutions are e.g. Sercos III and Profinet IRT.

Ethernet TSN is now ringing in the third generation of fieldbuses, since this technology allows a time-controlled and deterministic transmission of real-time-critical messages via standard Ethernet hardware for the first time in the over 40-year history of Ethernet (figure 2c). Ethernet TSN uses the principle of a time slot method, which Sercos has been using for real-time communication for over 25 years. As Ethernet TSN allows real-time communication and normal Ethernet communication to be transmitted over a uniform network standard, future-oriented solutions can be implemented that facilitate the convergence of production and IT networks.
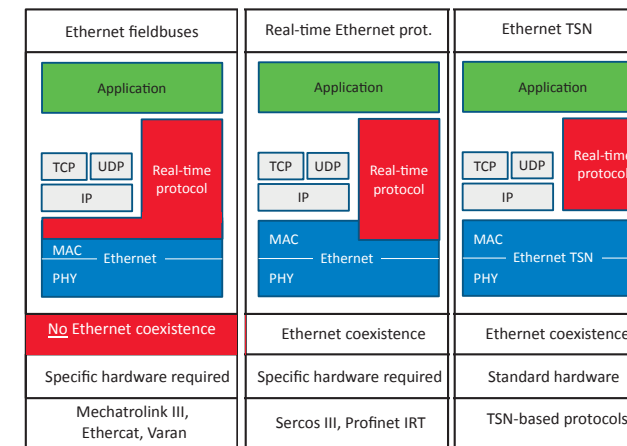

Figure 2a   Figure 2b   Figure 2c

Sercos III in the context of Ethernet TSN

The Sercos' transmission method has been based on a time slot method and cyclic communication since the introduction of the first generation (Sercos I). Sercos III not only supports the transmission of real-time telegrams in the so-called real-time channel, but also allows the transmission of any other Ethernet protocols in the so-called UC channel (see figure 3 below).

Ethernet TSN has all the features and mechanisms to implement or replicate the Sercos transmission process with standard Ethernet hardware. The basis of Ethernet TSN is the IEEE 802.1Q standard, which specifies the division of physical networks into several logically separated, prioritized virtual networks. With various substandards, additional features are specified, which are explained in the following and are brought into the context of the transmission method of Sercos (see figure 3 below).

Time synchronization: All connected network nodes have a common understanding of time. To this end, Ethernet TSN relies on IEEE 802.1ASrev and IEEE 1588 mechanisms. The protocol for time synchronization (PTP = Precision Time Protocol) described therein defines how spatially distributed real-time clocks are synchronized among themselves.

Time slot method: Synchronous time slots allow the transmission of different traffic classes and a time-controlled data transmission. Ethernet TSN uses the IEEE 802.1Qbv substandard (enhancements for scheduled traffic).

Scheduling and traffic shaping: All connected devices use the same rules to process and forward network packets. For this purpose, Ethernet TSN uses the substandard IEEE 802.1Qcc (stream reservation).

Frame preemption: Telegrams can be interrupted and continued later. Ethernet uses the IEEE 802.1Qbu (frame preemption) substandard.

For real-time Ethernet protocols of the second fieldbus generation, interesting migration concepts for TSN-based networks exist. A Sercos TSN demonstrator was presented at SPS IPC Drives in November 2016 in which Sercos III devices and Ethernet devices are operated in a common TSN-based network infrastructure without impairing the real-time performance of Sercos III.

With such an approach, a Sercos-driven machine can be connected to a TSN network infrastructure (factory network) and is remote-controlled by a TSN-based Sercos master that can be freely positioned in the TSN network ("edge cloud") to control the machine and at the same time interfacing to the connected IT systems.
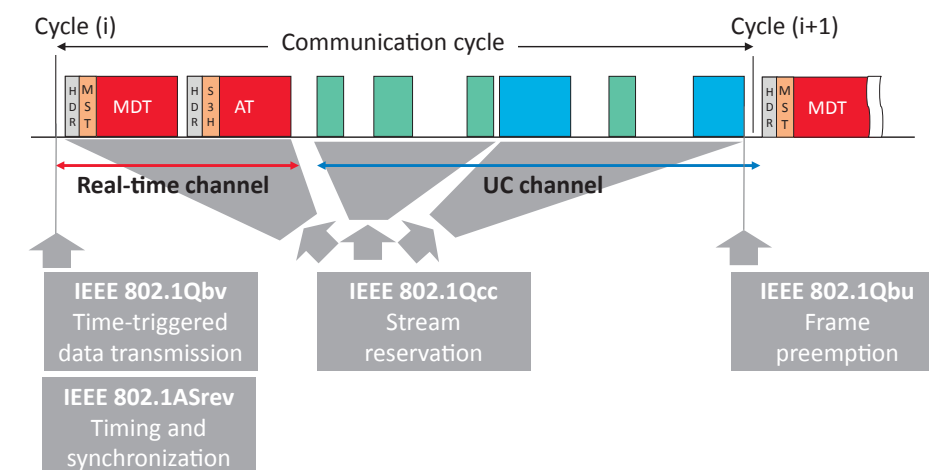

Figure 3: Transmission method of Sercos III in the context of Ethernet TSN