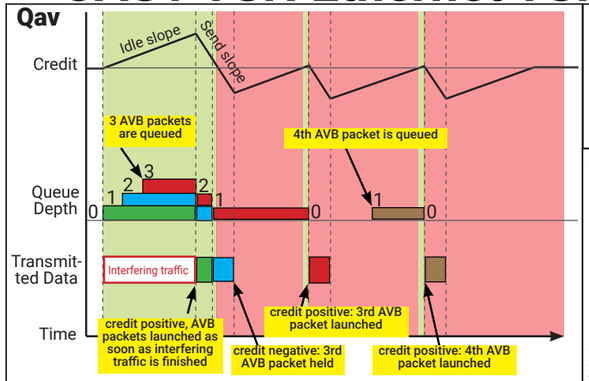
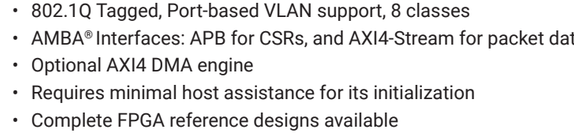
CAST TSN Ethernet TSN Ethernet Reference Sheet- Time-Sensitive Networking for Real-Time Applications

Qav



802.1Qav Credit-based shaper (CBS)
Class A: highest priority, transmission period of 125 µs, 2ms latency
Class B: lower priority, Tx period of 250 µs max, 50ms latency
Control: lowest priority, includes gPTP and SRP traffic.
Traffic classes shall not exceed the preconfigured max bandwidth.
The maximum number of hops is 7

Qbv

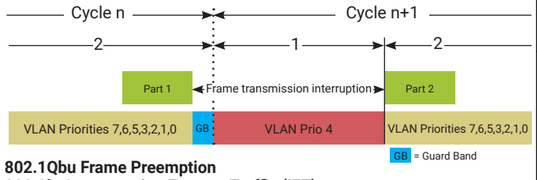


802.1Qbv Time-Aware Scheduler (TAS)
Class CDT: highest priority over classes A, B, and Control of Qav (CBS)
Worst-case latency: 100 µs over 5 hops
Maximum transmission period of 0.5 ms
For realtime control data (sensors and actuators)

Qci

802.1Qci Per-Stream Filtering and Policing (PSFP)
Filters individual traffic streams and prevents traffic overload conditions. Allows frames with specified stream IDs and priority levels. Applies policy actions to other streams. All streams are coordinated at their gates. Applies predefined bandwidth profiles to each stream.

Qbu/br

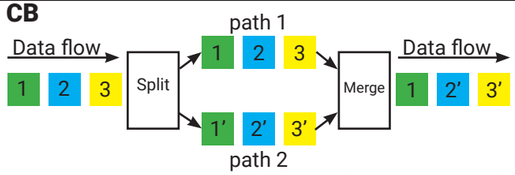


802.1Qbu Frame Preemption
802.3br Interspersing Express Traffic (IET)
Two MAC services for an egress port: preemptable MAC (pMAC) and express MAC (eMAC). Express frames can interrupt transmission of preemptable frames. On resume, MAC merge sublayer re-assembles frame fragments in the next bridge.

Common EtherTypes

0x0800	Internet Protocol version 4 (IPv4)
0x0806	Address Resolution Protocol (ARP)
0x0842	Wake-on-LAN
0x22EA	Stream Reservation Protocol
0x22F0	Audio Video Transport Protocol (AVTP)
0x8100	VLAN-tagged frame (IEEE 802.1Q)
0x8102	Simple Loop Prevention Protocol (SLPP)
0x86DD	Internet Protocol Version 6 (IPv6)
0x8808	Ethernet flow control
0x8892	PROFINET Protocol
0x88A4	EtherCAT Protocol
0x88A8	Service VLAN tag identifier (S-Tag) on Q-in-Q tunnel
0x88CC	Link Layer Discovery Protocol (LLDP)
0x88E5	IEEE 802.1AE MAC security (MACsec)
0x88F7	Precision Time Protocol (PTP) over IEEE 802.3
0xF1C1	IEEE 802.1CB FRER

CB

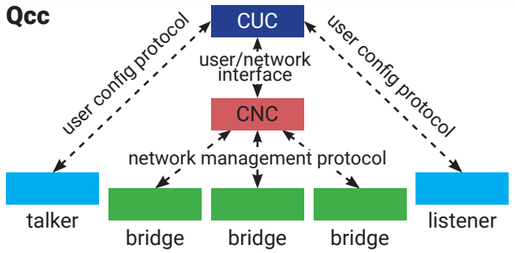


802.1CB Frame Replication and Elimination for Reliability (FRER)
Seamless redundancy by frame duplication over multiple paths.

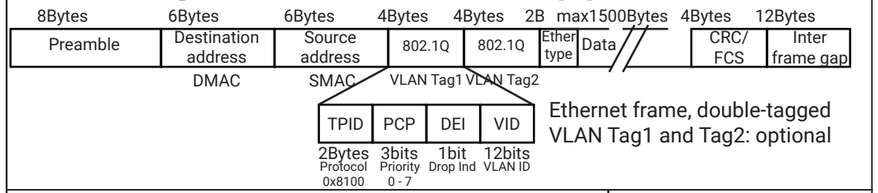
Qca

802.1Qca Path Control and Reservation (PCR)
Intermediate Station to Intermediate Station (IS-IS) configuration protocol in multiple paths bridged networks. Explicit forwarding path definition, bandwidth reservation, data protection, redundancy flow distribution. Derived from ECT, MSTI , IST and ET protocols.

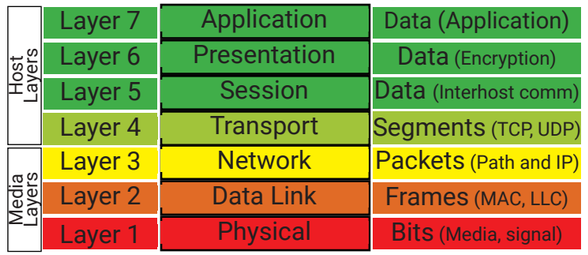
Qcc



CUC: Centralized User Configuration
CNC: Centralized Network Configuration
802.1Qcc Enhancements to SRP
Replaces 802.1Qat
Reduces size of reservation messages and redefines timers to trigger only when link state or reservation have changed.



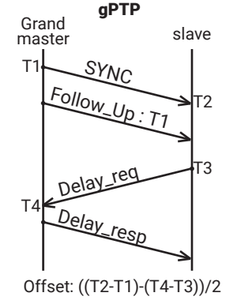
OSI Network Model



CAST TSN cores support:

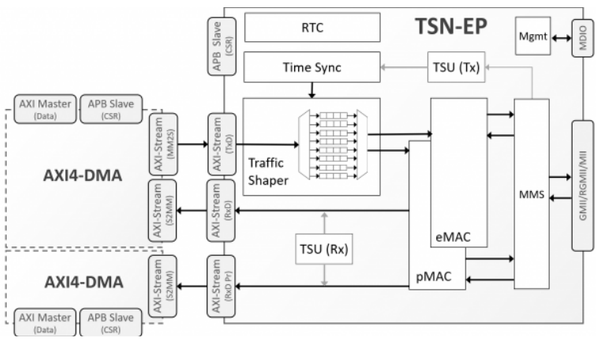
802.1AS-2020: gPTP
802.1Qav: Credit-based shaper/scheduler (CBS)
802.1Qbv: Time-Aware Shaper/scheduler (TAS)
802.1Qbu: Frame preemption
802.3br: Interspersing Express Traffic (IET)
802.1Qci: Per-Stream Filtering and Policing (PSFP)
802.1CB: Frame Replication and Elimination for Reliability (FRER)
802.1Qcc: Stream Reservation Protocol (SRP)
802.1Qca: Path Control and Reservation (PCR)

gPTP



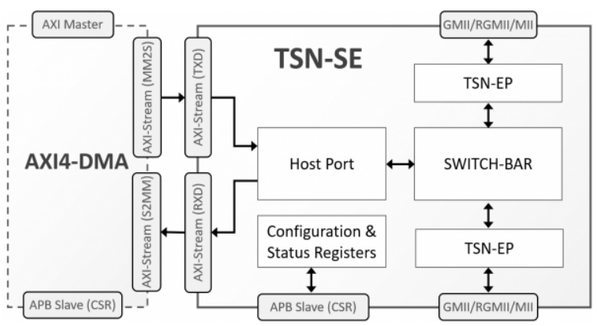
gPTP sync process
1. GM sends a SYNC at T1
2. Slave receives it at T2
3. GM sends a Follow_Up containing T1
4. Slave sends a Delay_req at T3
5. GM receives Delay_req at T4
6. GM sends the Delay_resp to Slave containing T4

TSN-EP (Endpoint)



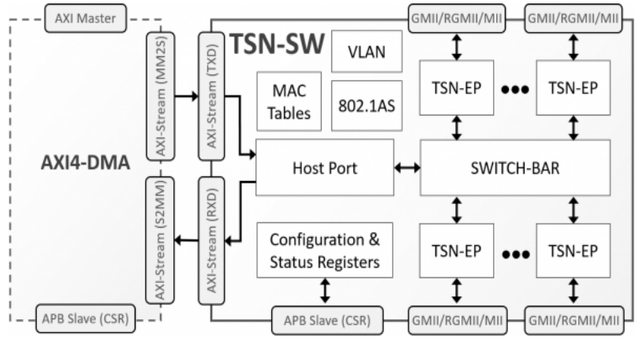
- One Ethernet port & one host processor port
- Suitable for star-topology networks
- Low latency
- Grandmaster or Slave functionality
- 802.1Q Tagged, Port-based VLAN support, 8 classes
- AMBA® Interfaces: APB for CSRs, and AXI4-Stream for packet data
- Optional AXI4 DMA engine
- Requires minimal host assistance for its initialization
- Complete FPGA reference designs available

TSN-SE (Switched/Bridged Endpoint)



- Two Ethernet ports & one host processor port
- Suitable for daisy-chained/ring networks
- Low-latency Layer 2 Cut-Through Switching
- Run-time switch configuration
- 802.1Q Tagged, Port-based VLAN support, 8 classes
- Configurable VLAN-ID & MAC lookup table
- Untagged ports support
- AMBA® Interfaces: APB for CSRs, and AXI4-Stream for packet data
- Optional AXI4 DMA engine
- Requires minimal host assistance for the PTP stack
- Complete FPGA reference designs available

TSN-SW (3-24 Port Switch)



- 3-24 Ethernet ports & one host processor port
- Low-latency cut-through or robust store-and-forward mode, per port
- Sub-microsecond Layer 2 port-to-port latency, in cut-through mode
- Run-time switch configuration
- 802.1Q Tagged, Port-based VLAN support, 8 classes
- Configurable VLAN-ID & MAC lookup table
- Untagged ports support
- AMBA® Interfaces: APB for CSRs, and AXI4-Stream for packet data
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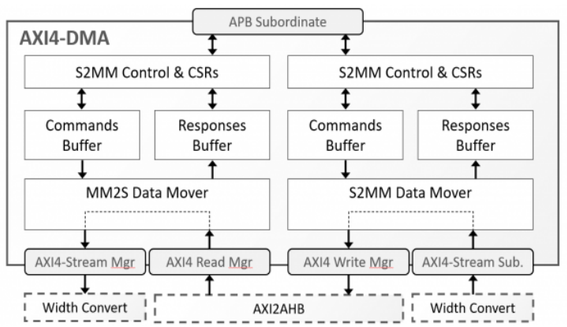
AXI4-DMA Controller



- Memory-Mapped to/from AXI-Stream DMA
- Independent stream-to-memory, and memory-to-stream paths
- AXI4 Manager port used to access data and descriptors
- AXI4-Stream subordinate port for memory-to-stream, and manager port for stream-to-memory
- Synthesis-time configurable data-bus width of 32 or 64 bits
- S2MM channel reports TLAST assertions and transfer length
- AXI4-to-AHB bridge can optionally be instantiated

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