Time-Triggered Ethernet for Aerospace Applications

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Aerospace Applications

- More than 4,000 aircraft built yearly $115 Billion
- Electronic fly-by-wire used for all airliners and high performance aircraft
- Avionics control systems
- Communication systems
- Sensing networks
Aerospace Network Goals

- Safety/reliability is critical
- Less weight
- Lower cost
- Shared networks
- Reduce wiring
- High/extreme environmental requirements
- Commercial off-the-shelf (COTS)
Key Communication Networks Reviewed

- **SpaceWire**
  - Based on IEEE 1355 (simple, low cost switched network with point to point links)
  - Connected using low-latency, full-duplex point to point serial links and packet switching
  - Low cost, error rates, deterministic, simple electronics, reliable
  - Asynchronous communication 2-400 Mbit/s
  - Used European Space Agency, NASA
Key Communication Networks Reviewed

- MIL-STD-1553
  - Multiplex data bus using a bus controller controlling multiple remote terminals
  - Can provide multiple data paths
  - Fault tolerant
  - High availability
  - Deterministic
  - 1 Mbit/s bus
  - Proven military bus
Key Communication Networks Reviewed

- IEEE 1394b
  - Serial Bus for high speed data transfer 3200 Mbit/s with optical links
  - Plug and play with hot swapping
  - Connect in tree or daisy-chain
Key Communication Networks Reviewed

- Avionics Full-Duplex Switched Ethernet (AFDX)
  - Based on IEEE 802.3 specific implementation of ARINC 664 (Deterministic Ethernet avionic data bus)
  - Uses cascaded star topology to reduce wire runs and weight
  - Dual link redundancy and QoS
  - 100 Mbit/s
  - Extends Ethernet to provide deterministic timing
  - Used on Airbus A380, Boeing B787 Dreamliner
Other Communication Networks Reviewed

- FlexRay
- CAN bus (Controller area network)
- LIN (Local interconnect network)
- MOST bus (Media Oriented Systems Transport)
- ARINC 429 (Aeronautical Radio, Incorporated, data bus)
Time-Triggered Ethernet

- IEEE 802.3, IEEE 1588 (hierarchical architecture clock distribution), ARINC 664 (AFDX) compatible
- Open, published as SAE AS6802 with IEEE standardization progressing
- Layer 2 Ethernet switch extension providing a unified deterministic network
- Supports all physical switched Ethernet layers even those with different bandwidths 10/100/1000 Mbits/s
- Integrates with Ethernet network components
Time-Triggered Ethernet

- Provides deterministic real-time and TCP/IP Ethernet Communication on same network in parallel
- Provides redundancy management, fault tolerance and isolation
- Synchronous startup and recovery
- Fault tolerant synchronized distributed clock with security
Time-Triggered Ethernet

- Time-triggered
  - For time-triggered systems control signals are only in the computer system
- Event-triggered
  - For event-triggered systems control signals can come from the computer system and outside causing unpredictable non-deterministic behavior
QoS is provided with three message types:

- Time-triggered take priority over other message types and are sent at predefined times providing set delivery for critical applications such as aerospace fly-by-wire.
- Rate-constrained have bandwidth guarantees but are not system synchronized that may increase jitter but could be acceptable for less critical applications such as video.
- Best-effort uses remaining bandwidth with no transmission, delay, or reception time guarantees for Ethernet traffic with limited quality of service requirement such as non-critical monitoring.
Time-Triggered Ethernet

- Significant Aerospace applications
  - Boeing 787 Dreamliner power & pressure systems
  - Airbus A380 pressure systems
  - NASA Orion vehicle communications network
  - Bombardier C Series flight control
Any Questions