NASA
SpaceWire Architectures: Present & Future

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Current SpaceWire Architectures: Swift Data Flow

- **SpaceWire point-to-point links**
  - 16 links from segmented detector array & readout Electronics to Instrument CDH
    - Science Data & Commands

- **PCI**
  - Instrument CDH to Memory
    - Memory to DSP
  - MIL-STD-1553
    - CMD bus to Spacecraft
Current SpaceWire Architectures: LRO Data Flow

• Routed SpaceWire traffic
  • End-node routers on C&DH boards
    – Used as Serial backplane
      » Single Board Computer Board
      » Instrument Interface Board
      » S-Band Communication Board
      » Ka-Band Communications Board
  • Interface to moderate rate instruments
  • Not memory mapped like RMAP or GAP
  • Side band signaling using Time-Codes
    – 1pps
    – Barker code detect – uplink
    – Upper level flow control on downlink frames

• MIL-STD-1553
  • Interface to spacecraft subsystem
  • Used for low-rate heritage instruments
Current SpaceWire Architectures: JWST Data Flow
Current SpaceWire Architectures

- **JWST**
  - Routed SpaceWire traffic
    - From 4 instruments to local router to end node router (Instrument C&DH [IC&DH]) (cable)
    - ICDH end node router to hardware processors (same box over backplane)
    - Hardware processors to compression engine (same box over backplane)
    - Compression engine to recorder (cable)

- **GOES-R** – Point-to-point links
  - Instrument - C&DH with Reliable Data Delivery Protocol
- Different physical interfaces using different protocols that require unique hardware and software to bridge between them.
- Serial interface at one point per enclosure @ NIC.
- Extra board area and more power for multiple interfaces.
- Only boards in same enclosure have memory mapped access via arbitration.
- Enclosures represent limited access.
- Reuse & reconfigurability limited.

**Legend:**

- **Red** – High-speed interface
- **Black** – Discrete sync pulse
- **Blue** – TDMA low rate bus (MIL_STD-1553)
- **Purple** – Parallel Backplane
Future Systems

- Same protocols supported across both physical interfaces: SpaceWire and SpaceFibre
- Bridged by hardware router
- Low-level protocols (RMAP & GAP) for memory mapped DMA or single transactions – no software required & blurs enclosure boundaries
- Plug and Play network mapping and Change-of-Status indication supported in hardware – Coming soon!
- Tunnel higher layer protocols

Legend:

Red – SpaceFibre (optical or copper)
Blue – SpaceWire
Lt Blue – Local port interface (parallel)
Advantages
System Engineer Toolkit

SpaceFiber (cell based virtual channels)
- Long distance
- Isolation
- EMC/EMI
- Bridge to SpW via hardware router

- Full Duplex
- Cmd & Tlm opposite directions

- Dedicated link for low latency

- Multiple SpW local ports to prevent blocking, increase throughput

- Redundant paths

- Redundant cables

- Priority routing

- Time-code expansion
  - Interrupts
  - Polling
  - Multi-TimeCode

- Time-codes
  - Near zero jitter across entire network
  - Synchronization
    - TDMA
    - 1pps

- Router blockage prevention
  - Time-out
  - Max length

Group Adaptive Routing
- Multiple SpW links

- Message sharing
  - Time-critical network
  - Consensus computing

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Conclusions

• Simple protocol that is being developed from bottom up to meet advanced spacecraft applications

• One bus standard can meet requirements
  – Real time control
  – Large data throughput
  – Safety
    • Guaranteed Low latency
    • High reliability

• Reuse & reconfiguration of systems easier with standard interface
  – Modular functions with standard interface
    • Serial interface
      – cable
      – backplane

• Provide system engineers more “tools” for more efficient designs