Spaceborne Fiber Optic Data Bus: A Small Satellite Perspective

By

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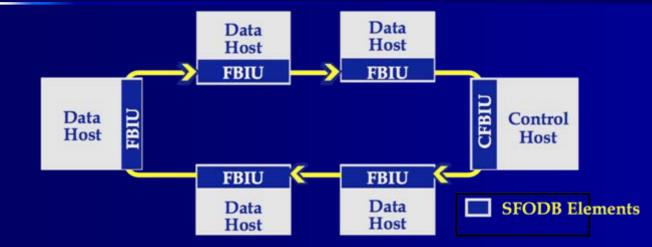Air Force Research Laboratory, Space Vehicles Directorate, Kirtland AFB, N.M
and

Fred Orlando, VP/CTO Space Photonics Inc.

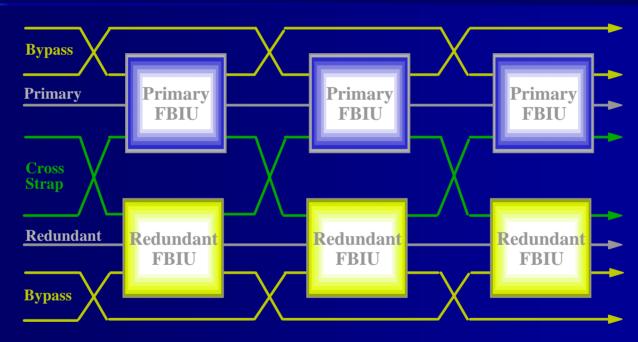# IEEE Standard 1393-1999 Spaceborne Fiber Optic Data Bus

- A Standard Approach to On-board Payload Data Handling Networks

- Joint DoD/NASA funded development
- Only network specifically designed to support realtime payload data handling for aerospace applications
- Soon to be SAE AS-1393

Redundant Ring with Cross-Strap & Bypass Links

- Multifiber Cables and Connectors
- Cross-Strapping and Node Bypass for Maximum Reliability
- Ring Can Accommodate up to 127 Nodes
- Nodes Can be Powered Down and Bypassed Through Consistent System Design
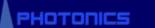
SFODB Communication Config

- Dedicated Transmit Slot Method
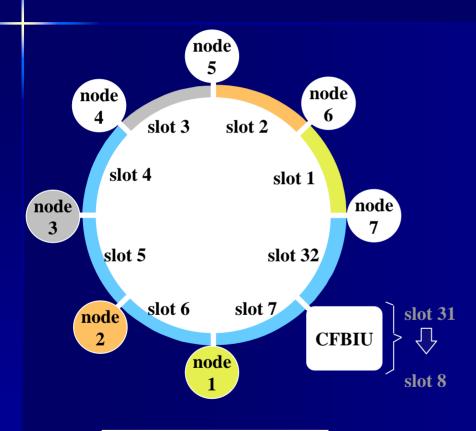
- Token Arbitrated Transmit Method

- Dedicated Receive Slot Method

- ATM Header Address Method
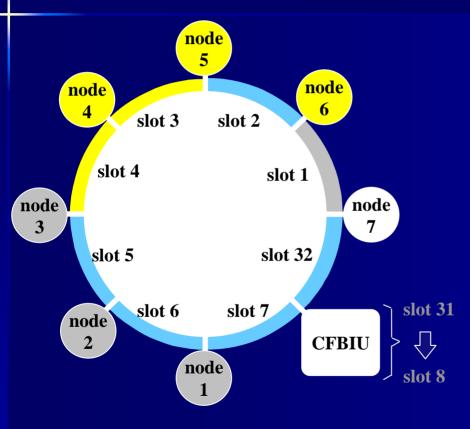
Dedicated Transmit Slot Method

- slot 1 dedicated to node 1
- slot 2 dedicated to node 2
- slot 3 dedicated to node 3

■ CFBIU Allocates Dedicated Network Bandwidth to Selected FBIUs

– CFBIU Assigns Slots by Number to Selected FBIUs

– Each Selected FBIU Writes into All Assigned Slots

■ Bandwidth Reuse Feature

– CFBIU Assigns the Same Slots to Multiple FBIUs

– Each FBIU will Overwrite Any Previous Data in the Assigned Slots

Token Arbitrated Transmit Method

node 5
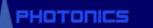node 4
node 6
node 3
node 7
node 2
node 1

slot 3
slot 2
slot 4
slot 1
slot 5
slot 32
slot 6
slot 7

CFBIU

slot 31
⇩
slot 8

- nodes 1, 2 & 3 share slot 1
- nodes 4, 5 & 6 share slots 3 & 4

■ CFBIU Allocates Shared Network Bandwidth to Selected FBIUs

– CFBIU Assigns Shared Slots by Number to Each FBIU
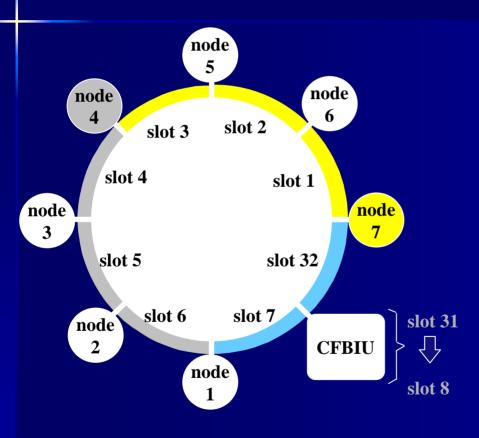
– The Tokens are Used to Control Access to the Shared Slots

■ Token Group Feature

– A Token May Control a Group of Selected Slots

– The Network Can Support Up to 4 Independent Token Groups
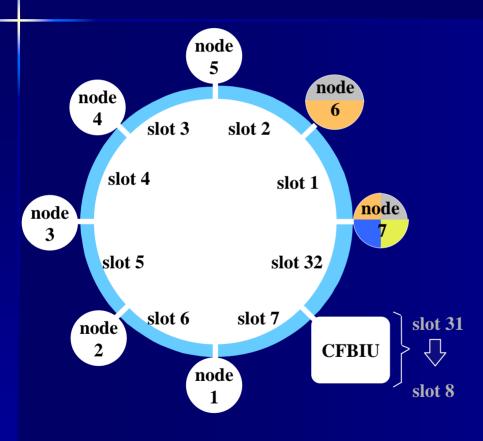
Dedicated Receive Slot Method

- CFBIU Assigns Dedicated Receive Slots to Selected FBIUs
  - Each FBIU will Accept All ATM Cells from Its Assigned Slots
  - Empty Cells Can Be Selectively Deleted

- node 7 receives from slots 1, 2 & 3
- node 4 receives from slots 4, 5 & 6

ATM Header Address Method

node 5
node 6
node 4
slot 3   slot 2
slot 4   slot 1
node 3
slot 5   slot 32
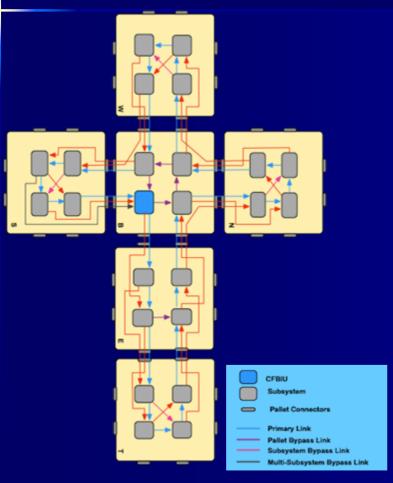slot 6   slot 7
node 2
node 1
node 7

CFBIU
slot 31
slot 8

- CFBIU Assigns Selected Nodes a Set of ATM Cells to Accept Based on VPI or VCI Fields
  - The CFBIU Loads a Table of VPI or VCI Headers into Each FBIU
  - Each FBIU will Accept Only Valid ATM Cells with Matching VPI or VCI Fields

- node 6 assigned to receive VPI a & b
- node 7 assigned to receive VPI a, b. c & d

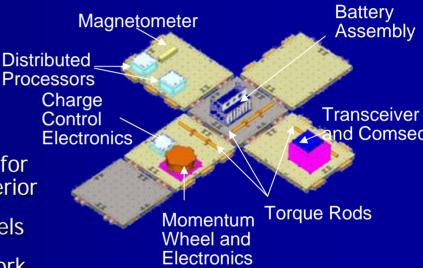# 1393 Graceful Degradation Fiber Optic Cable Routing

Notes:

1. CFBIU can be any node on any pallet.

2. All pallets can be operated and verified independently with DAVS connected across pallet connectors.

3. Active link selection and data routing will be automated.

4. Autonomous fault detection and correction processes will be implemented.

5. Multi-Subsystem Bypass Links only used for the 3rd CFBIU input in this illustration.

6. Subsystem and Multi-Subsystem Bypass Links used for both fault recovery and power management.

Legend:
- CFBIU
- Subsystem
- Pallet Connectors
- Primary Link
- Pallet Bypass Link
- Subsystem Bypass Link
- Multi-Subsystem Bypass Link

Plug-and-Play Spacecraft: A small Satellite Example

- Modular structure incorporates

  - Locking hinge joints allow panels to rotate about hinge line for easy access

  - Standardized mounting grid (5cm oc)

  - SPA mechanical and electrical interfaces for 48 components/payloads on interior/exterior

  - Connectors and harness recessed in panels

  - Inter-panel harness keep electrical network intact throughout assembly and I&T

- Higher performance PnP components incorporated in successive upgrades

- Payloads will be STP experiments that match bus capability

- Planned launch in Oct 2009 as co-manifest on with SIV-1 on Minotaur IV

- Spacecraft configuration to be frozen ~6 months prior to launch to complete final I&T
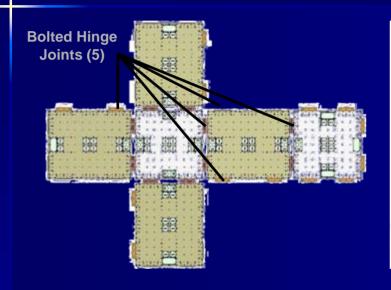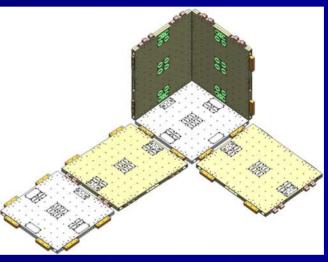
Pnp Sat Desgin Drivers for SFODB

- Hinged Joint Panel Concept for SFODB

- Component and Experiment Accommodations
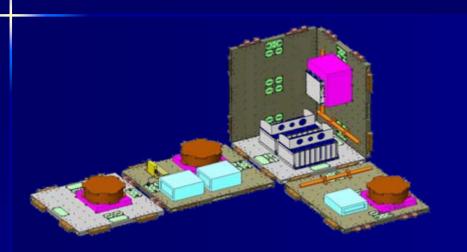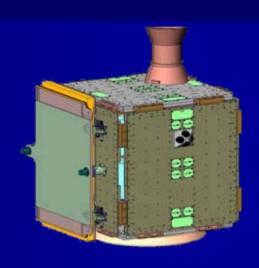
Hinged Joint Panel Concept for SFODB

Bolted Hinge Joints (5)

- 1393 Capability to run panels stand alone
- Panel-to-panel bridge connectors for power and network distribution

Component and Experiment Accommodations

- SPA-U or SPA-S for payload identification
- 1393 for the high speed network

Small Satellite Advantanges of SFOBD

- Simultaneous use of different Methods
- Flexible Speed (200Mbps – 1Gbps)
- Decreased Design Time
- Reduced Design Cost
- NO RFI or EMI

Conclusion

- robust, high-speed network
- compact design
- PnPSat is just one example of the applications
- ideal for small satellites