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SpaceWire in the Joint Architecture Standard

Leonard Burczyk[1], Justin W. Enderle[2], Daniel Gallegos[2], Paul S. Graham[1], Richard D. Hunt[2], Jeffrey L. Kalb[2], David S. Lee[2], Jacob E. Leemaster[2], John M. Michel[1], and Justin L. Tripp[1]

[1]Los Alamos National Laboratory, Los Alamos NM 87545

[2]Sandia National Laboratories, Albuquerque, NM 87185

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Agenda

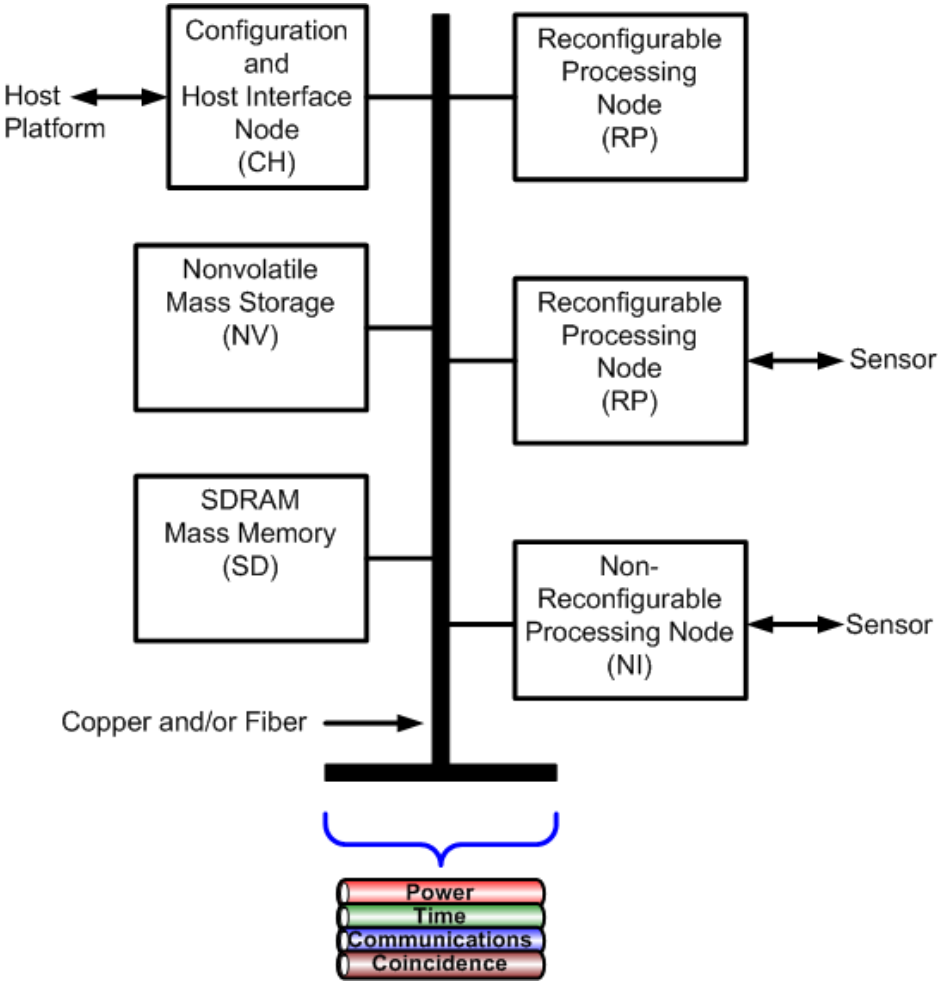
- Background
- Overview of JAS
- Use of SpaceWire in JAS
- JAS SpaceWire Protocols
- JAS Packet Data Formats
- JAS Packet Services

Background

- Joint Architecture Standard (JAS) – Jointly developed by Los Alamos National Laboratories and Sandia National Laboratories
- Common processing and communication infrastructure
- Flexible, scalable and reliable solutions for DOE customers
- Wide range of performance, throughput, reliability, etc.
- Inexpensive environment for rapid prototyping and development of data processing platforms
- SpaceWire provides packet switched serial interconnect backbone

Features of JAS

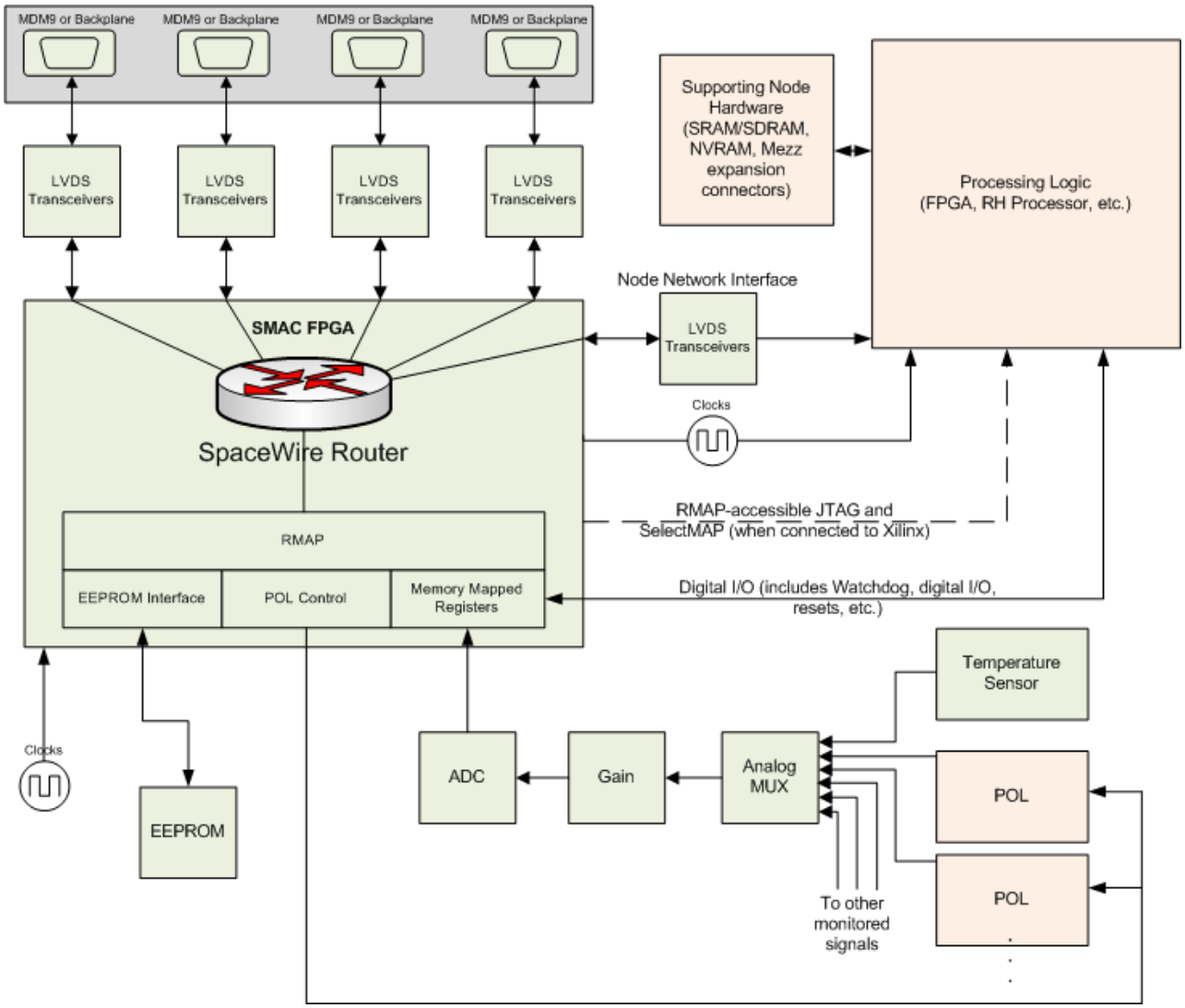
- JAS is a modular, node-based architecture that uses:
  - High-speed serial data interfaces
  - Industry standard protocols
  - Hardware and software building blocks
- Nodes
  - Several processing nodes
  - Mass SDRAM & non-volatile memory nodes
  - Number and type are determined by system requirements
- JAS supports:
  - Rad-hard ASIC processors
  - Reprogrammable FPGAs for HDL algorithm implementations or soft-core processors
- JAS offers COTS-based development and test environment for rapid system demonstration.



Node Overview

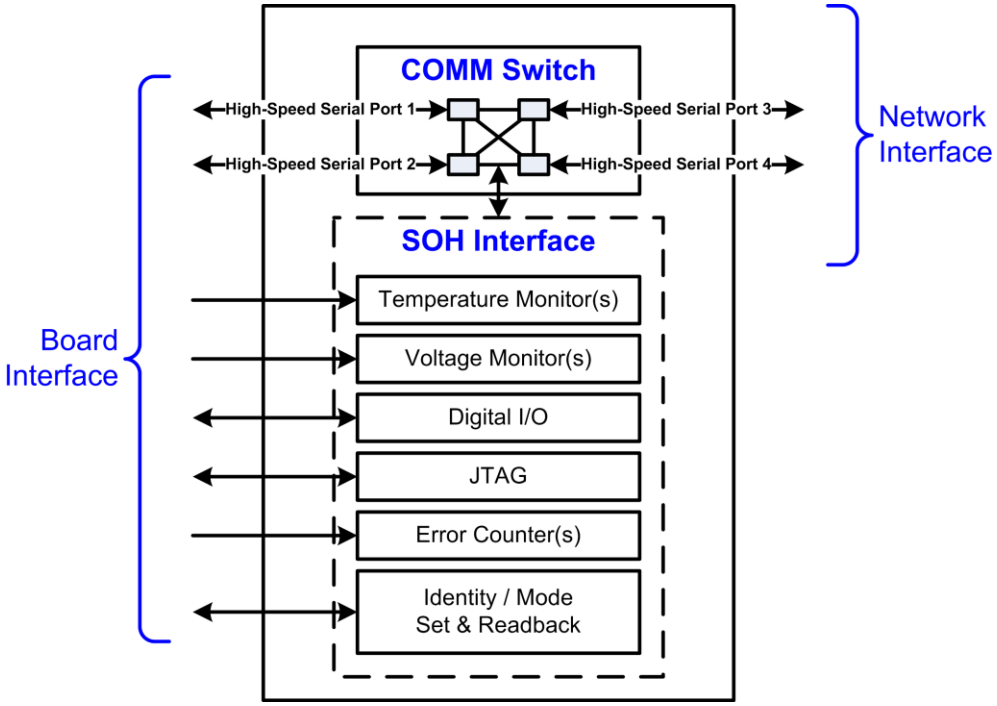
Common node elements:

- System Monitoring and Communications device with SpaceWire router
- Processing Element (FPGA/CPU)
- Local POLs for power conversion
- Supporting Electronics (ADCs, Memories, etc.)



SMAC Device

- **System Monitor and Communication device is a FPGA on each node that provides:**
  - Physical Interfaces
    - SpaceWire Network
    - Serial/Parallel I/O
  - Reusable IP
    - SpW Router (NASA)
    - RMAP
    - SpW Broadcast
    - SelectMAP for Xilinx configuration
    - Remote JTAG over SpaceWire
    - IPMI data for node identification



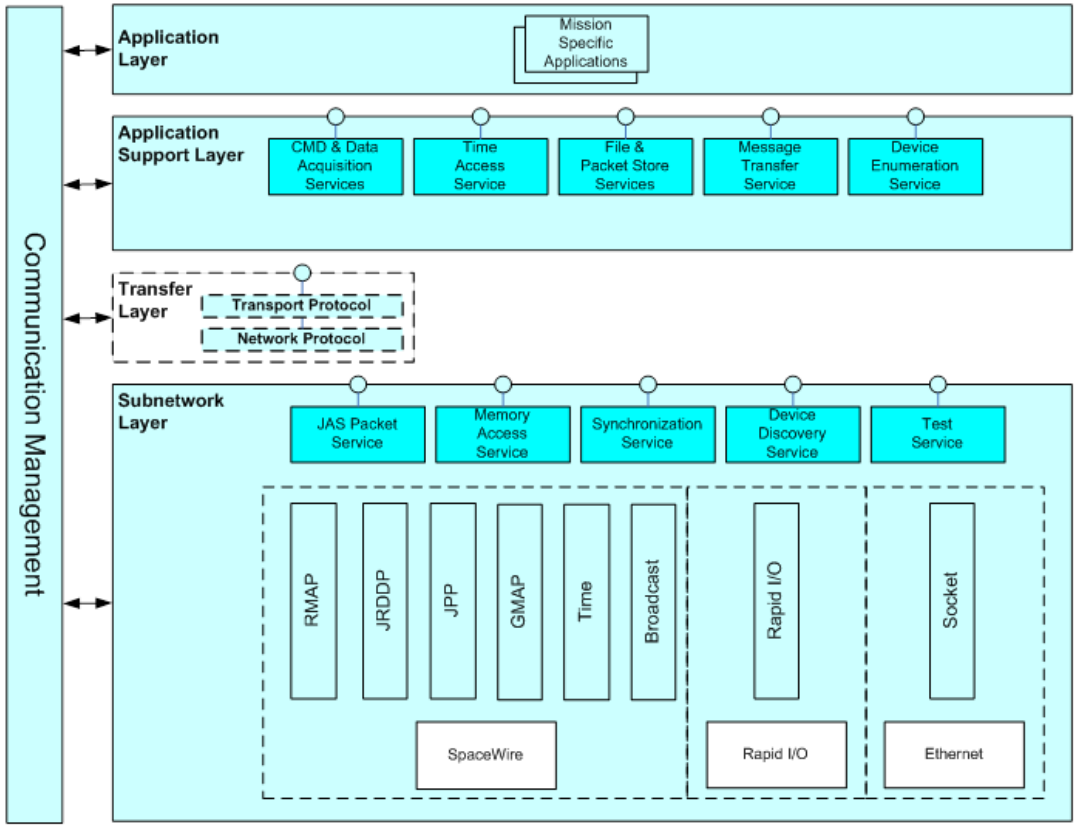
JAS SpaceWire Protocols

Protocol Name	Value
Remote Memory Access Protocol (RMAP)	1
JAS Packet Protocol (JPP)	240
Goddard Memory Access Protocol (GMAP)	241
JAS RDDP (JRDDP)	242
Time Protocol	243
Broadcast	245
Broadcast	246

- RMAP is defined in ECSS Space Engineering Standard (ECSS-E-ST-50-52C)
- JAS has defined a number of project-specific protocols
  - JPP is a “best effort” packet protocol
  - GMAP is used to configure NASA-Goddard SpW Router core
  - JRDDP is a more flexible version of NASA’s “guaranteed delivery” packet protocol RDDP
  - Time Protocol provides 1Hz time synchronization between nodes
  - Broadcast Protocols provide a network broadcast capability

CCSDS SOIS with JAS Protocols

- Applications use a communication stack based on CCSDS Spacecraft Onboard Interface Services Standard (SOIS)
- Subnetwork Layer services can be implemented in software or hardware (VHDL)
- Protocols are implemented in routers and end-points as needed
- Applications use RMAP, JRDDP and JPP to communicate



SpaceWire Regional Addressing

- Implements a subnet capability within the network allowing a significant increase in potential endpoints
- Uses SpaceWire logical routing with a two-byte addressing scheme
  - Regional address routes packet to a particular router and is removed
  - Endpoint address routes packet to final endpoint
- Logical Addresses 32-63 are reserved for endpoints and 64-254 are used for routers
- Route tables can be manually loaded or automatically generated using a network discovery algorithm

JAS Packet Format

- Used for all packet-based communication protocols
- Based on CCSDS Space Packet Protocol and ECSS Packet Utilization Standards
- Specifies command and telemetry packet formats
  - Source and destination APID and Transaction ID fields track communication between applications
  - Service Type and Subtype fields identify packet content

JAS Command Packet Primary Header

Version Number (=0)	Packet Type (=1)	Data Field Header Flag (=1)	Destination Application Process ID	Sequence Flags	Sequence Count	Packet Length
3	1	1	11	2	14	16

JAS Command Packet Secondary Header

CCSDS Secondary Header Flag (=0)	JAS Version Number (=2)	Ack	Service Type	Service Subtype	Source Application Process ID	Transaction ID
1	3	4	8	8	11	13

JAS Command Packet Data & Error Control

Application Data	Packet Error Control
Variable	16

JAS Telemetry Packet Primary Header

Version Number (=0)	Packet Type (=0)	Data Field Header Flag (=1)	Source Application Process ID	Sequence Flags	Sequence Count	Packet Length
3	1	1	11	2	14	16

JAS Telemetry Packet Secondary Header

Spare (=0)	JAS Version Number (=2)	Spare (=0)	Service Type	Service Subtype	Destination Application Process ID	Transaction ID
1	3	4	8	8	11	13

JAS Telemetry Packet Time, Data & Error Control

Time	Application Data	Packet Error Control
56	Variable	16

Packet Services

- Services identify data contents and format
- Based on the ECSS Packet Utilization Standard
- JAS defines additional service types for onboard communication
- Additional services can be added based on program-specific needs

Service Number	Description
128	Device Access Service
129	File Access Service
130	Platform Management Service
131	Time Management Service
132	Sensor X Service
133	Sensor Y Service
134	Test Service

A Service Example

Device Access Service						
Service Type	Service Subtype	Subtype Description	Cmd	Tlm	Service Parameters	Data Types and Description
128	1	Device Parameter Request	X		Device ID, Parameter	Device_ID is an unsigned integer that identifies the device. Parameter is an enumerated value that identifies the parameter to read.
128	2	Device Parameter Report		X	Device ID, Parameter, Value	Device_ID is an unsigned integer that identifies the device. Parameter is an enumerated value that identifies the parameter to read. Value is the parameters value and its type is obtained from a configuration table.

- **Services consists of a set of subtypes that define the packet data content**
- **Each subtype translates to a specific JAS command or telemetry packet**
- **Service parameters define the content and can be parsed based on standard data types (char, int, float, …)**

SNL/LANL Interoperability Demo

- Nodes from both LANL and SNL have been combined and interconnected with SpaceWire for the command and control network
- Hardware was based on a combination of Xilinx evaluation boards (ML-507, ML-605) and JAS prototype nodes
- Software was independently implemented by each lab based on the JAS Communication Specification