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JAS Interconnect Requirement Analysis and Background

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Protocols Reviewed

Advanced TCA	Packet Switched Backplane
ASI (advanced switching interface) using PCIe physical layer	Parallel RapidIO
ATM	PCI Express (PCIe) and Compact PCI Express (cPCIe)
Aurora	PCI/PCI-X
CAN	Raceway (VME Extension)
CEI 2.0/SPI-S 1.0	RapidIO (serial)
cPCI	RS422
Display Port	Serial ATA
Ethernet (802.3***-2005), 10Gbps	Sonet/SDH
Ethernet (802.3***-2005), 1Gbps	Spaceborne Fiber-Optic Data Bus (IEEE 1393)
Fibre Channel 4 GFC	SpaceFiber
Fibre Channel 10GFC	SpaceWire
FireWire (IEEE 1394b)	SPI/SPF/CEI 4.2
HDMI	SPI-S 1.0 (Link Layer Overlay)
HyperTransport 3.0	StarFabric
IEEE 802.3ae/SPI-S	USB 2.0
Infiniband	VME
MIL-STD-1553	

MUST Objectives

- Technology is based on a **serial interface**
- Technology supports a floor or minimum **bandwidth**
- Technology is **widely accepted, openly available, and viable**
- Technology overview indicates that it will subjectively **support the intended application**

Down Select Protocols

ASI (advanced switching interface) using PCIe physical layer	HyperTransport 3.0
ATM	IEEE 802.3ae/SPI-S 1.0
CEI 2.0/SPI-S 1.0	Infiniband
Ethernet (802.3***-2005), 10Gbps	PCI Express and Compact PCI Express
Ethernet (802.3***-2005), 1Gbps	RapidIO (serial)
Fibre Channel 4GFC	SFODB – IEEE 1393
Fibre Channel 10GFC	SpaceWire
FireWire (IEEE 1394b)	USB 2.0

WANT Objectives

Project Constraints

- Minimum cost
- Minimum power
- Minimum size
- Minimum weight
  - ❖ Maximum availability of commercial ASIC support circuits
  - ❖ Minimum link spans necessary to achieve data path bandwidth
  - ❖ Minimum processing overhead
  - ❖ Availability of "Intellectual Property"
  - ❖ Availability of design tools

Performance Requirements

- Minimum transmission latency
- Bandwidth available
- Provides Quality of Service (QoS) capability
- Provides routing without deadlocks
- Link span transmission distance
- Maximum transfer rate
- Packet overhead or efficiency

Design, Operations, Maintenance

- Space legacy or qualification
- Designer or programmatic preference
- Fault detection and recovery
- Implementation complexity (examples: pin count, board design)
- Simple redundancy
- Fault recovery and reliability
- Network fabric peering
- Built-in error coding and correction
- Preference for hardware solution

Flexibility and Adaptability

- Self-Configuration or Recognition
- Common physical layer/network support
- Dynamically reconfigurable architecture
- Scalable
- Topology independence
- Transfer rate spread
- Protocol span of OSI stack layers
- Path forward

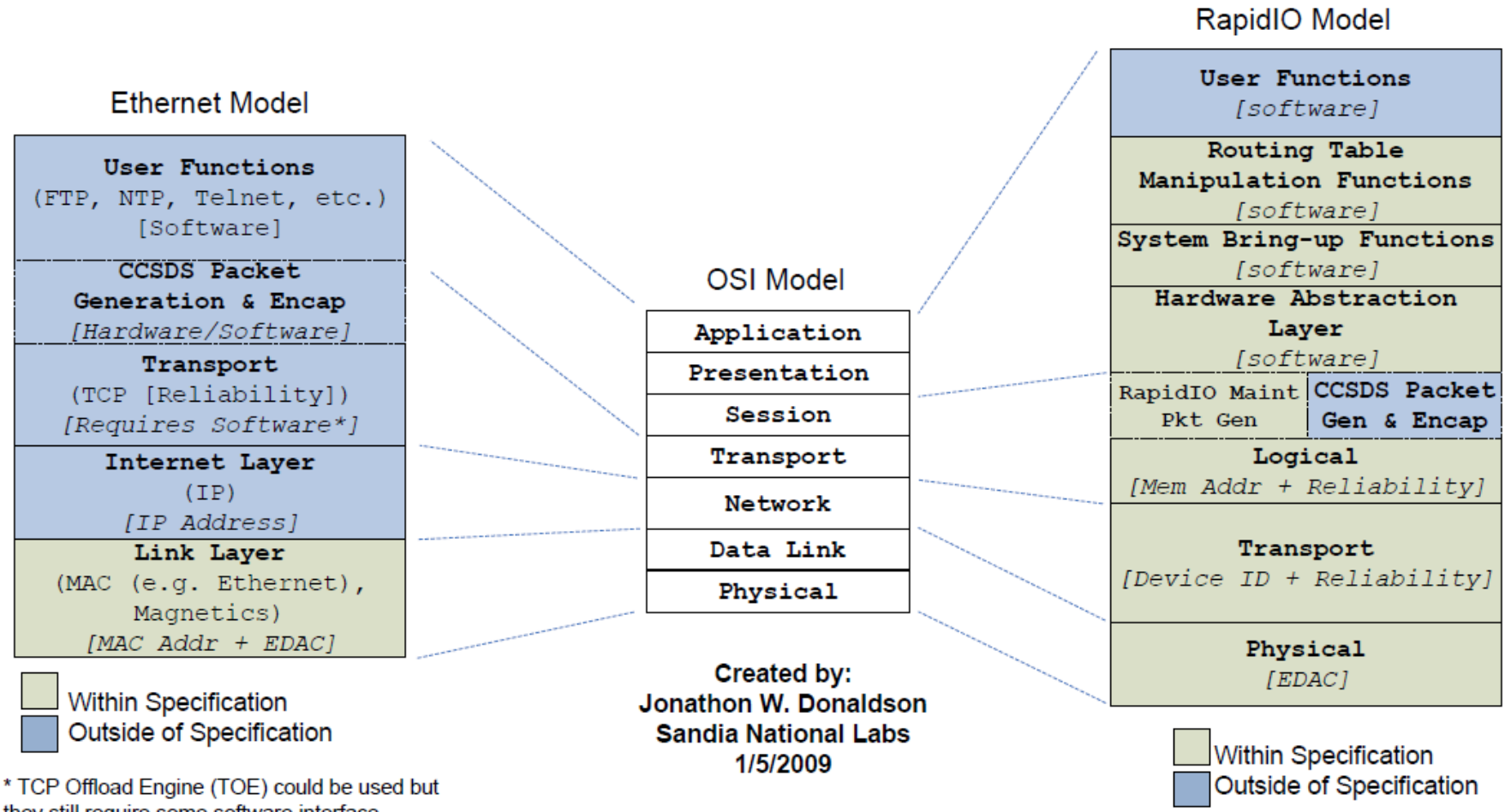
Specific Technical Requirements

- **Precision Time**
  - **The Architecture shall enable connectivity and interoperability between the host platform and payload subsystem elements tasked with acquiring and maintaining precision time for time-tagging event data.**
- **Inter-element messaging Data Rates**
  - **The Architecture shall support inter-element message information transfer rates (overhead not included) from 10 kbps up to 10 gigabits/second.**
- **Inter-element messaging Latencies**
  - **The Architecture shall support applications requiring inter-element message latencies as short as 1.0 microsecond not including any cable propagation delays.**
- **Inter-element messaging Error Rates**
  - **The Architecture shall support applications requiring bit error rates ranging from 10^{-6} to 10^{-12} for distances up to 10 meters.**
- **Modularity**
  - **The Architecture's design shall be based on a modular structure, which is extensible and configurable without changing its basic structure.**
- **Scalability**
  - **The Architecture shall be vertically (single node) and horizontally (multiple node) scalable.**
- **Topology Independence**
  - **The Architecture shall support a wide range of topologies.**
- **Protocol Independence**
  - **The Architecture physical layer shall be capable of supporting a range of standard protocols.**

Protocol Comparison

SpaceWire	Serial RapidIO	Ethernet
•Space Use Qualified. •Possible bandwidth path forward with SpaceFiber. •“IP” is available for switch, router, and link. •Flexible link rates with operation over a range of bandwidths (2 Mbps to 400 Mbps). •Topology independent with good routing support.	•Very good communication capabilities. •“IP” is available for endpoint node and switch. •Flexibility for use with other satellite designs. •Very good capability for protocol encapsulation. •Built-in support for shared memory and DMA data transfer. •Built-in transport and routing capabilities. •Provides deterministic data delivery. (Timing, QoS, …) •Standard 1x data rates are in excess of what is required for some applications. (1.25, 2.5, 3.125 Gbps) •Topology independent.	•Very good and robust development tools and design environment. •Incrementally add capability. •“IP” is available for MAC, Internet Protocol, UDP. •Operation is possible over a range of bandwidths (10/100/1000/10000 Mbps) (with different physical layers). •Minimal complexity to implement for a point-to-point link. •Link and bus centric. •Requires support protocols to function as desired for routing, reliable transport, etc. •Stable and long lasting communication standard. •Performance under congestion. (At links utilization above ~80% the lack of built-in end-to-end flow control begins to limit data transfer.)

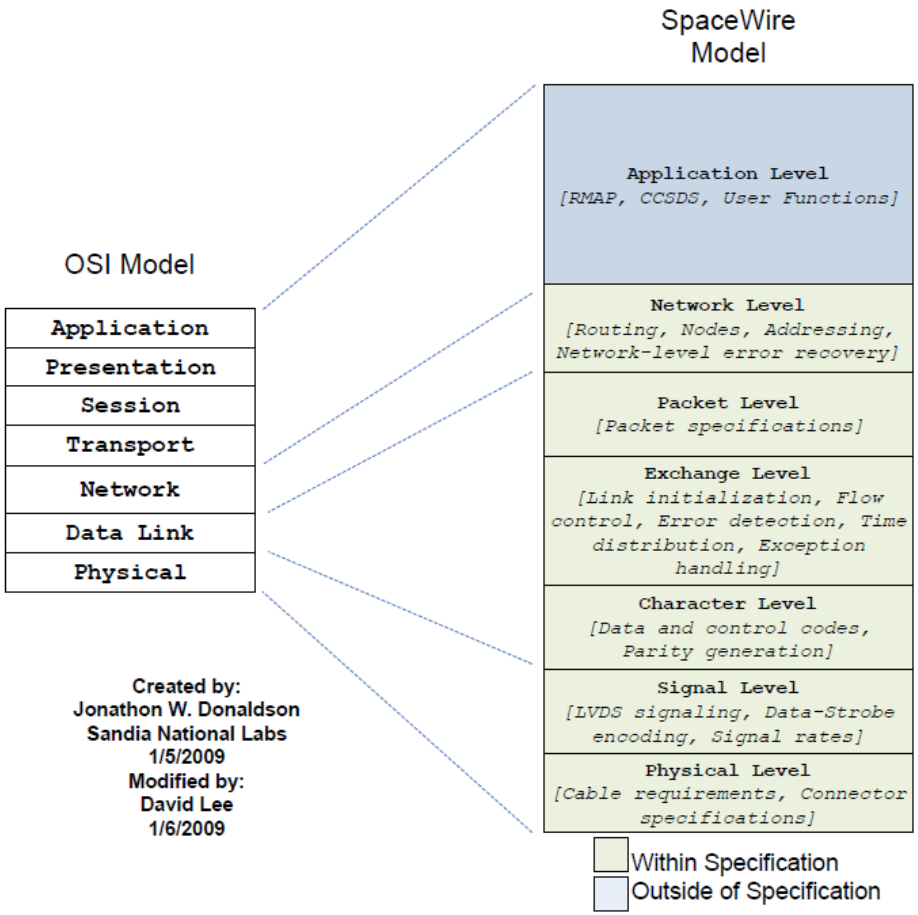
OSI - Ethernet vs. Serial RapidIO

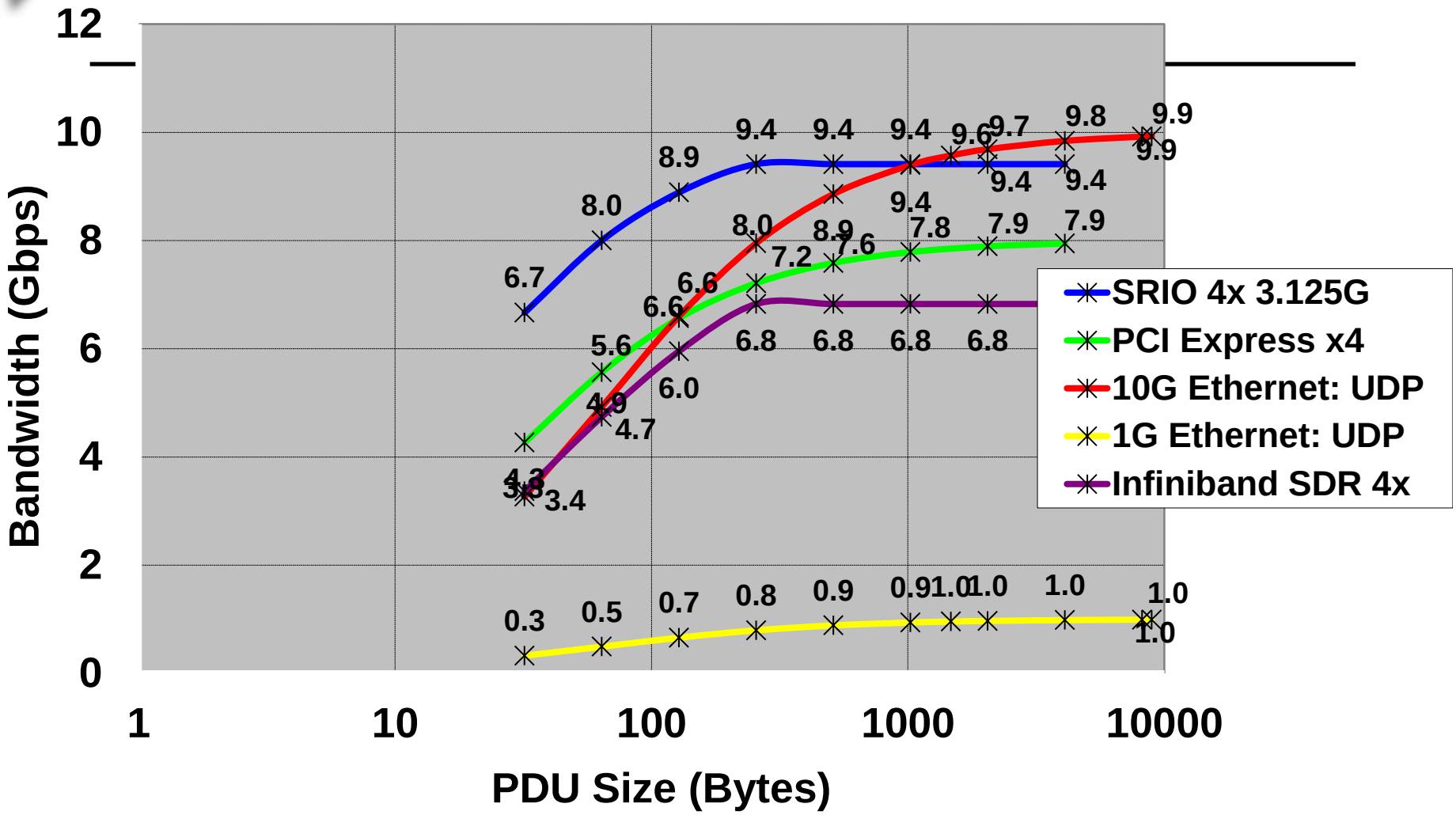


* TCP Offload Engine (TOE) could be used but they still require some software interface.

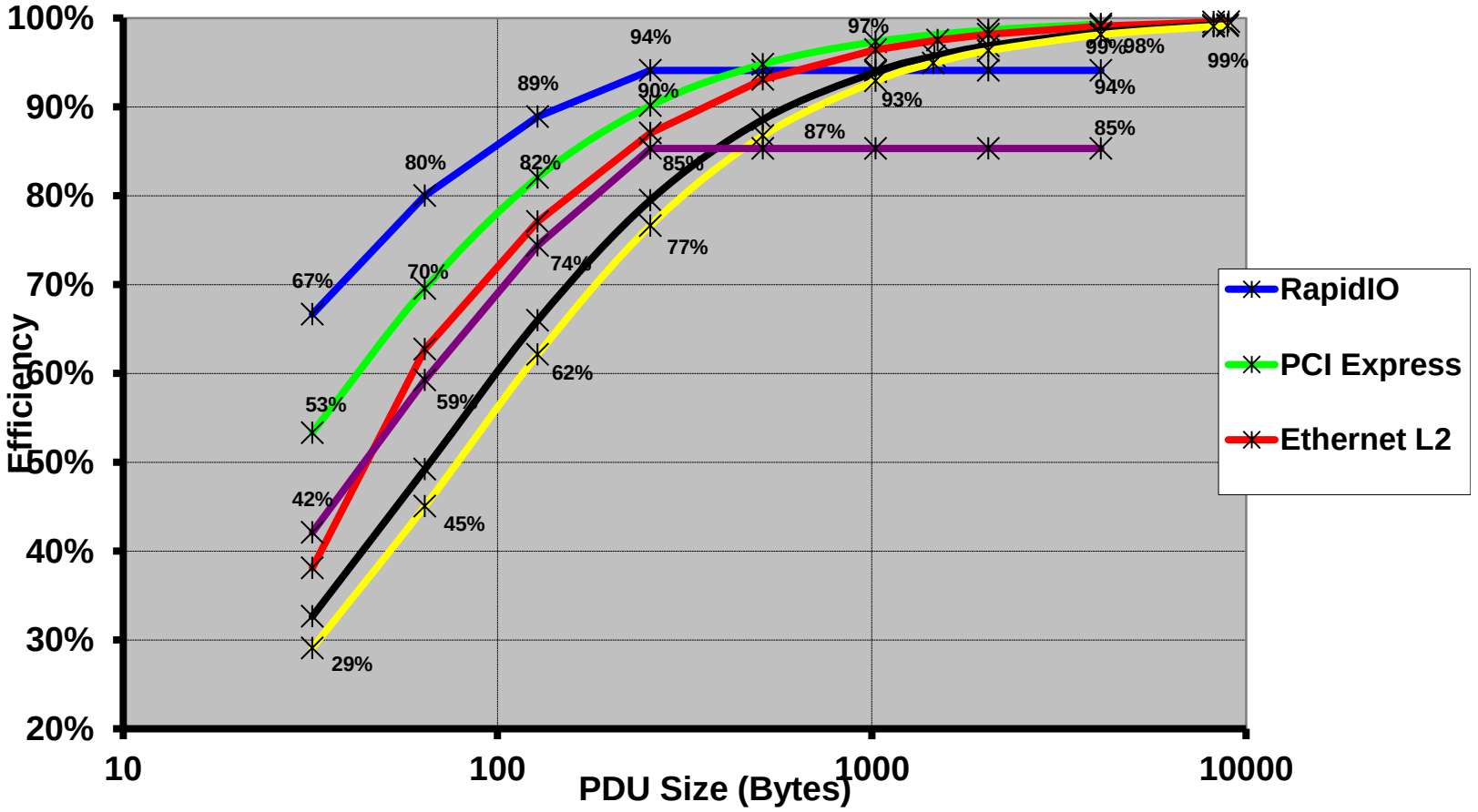
* UDP could also be used provided the application layer protocol provides the reliability (e.g. TFTP)

OSI - Spacewire





Courtesy: Freescale



Courtesy: Freescale

Conclusion

- **Sandia has completed internal protocol studies, topology studies, and begun developing hardware (include rad testing).**
- **We have found that a combination of low bandwidth Spacewire link for low speed data and command and control coupled with a high speed reliable link like SRIO to be an excellent spacecraft solution.**