Interfacing and Operation of the SpaceWire.Server in the SAVOIR Environment

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T.Pike, E.Weih, M.Staehle, R.Cissou and I.Herrera
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Introduction

- The SpaceWire.Server is a new PDHU-Memory development at Airbus Defence and Space Electronics which supports SpaceWire payload architectures of new generation satellites in which payload data, telemetry, telecommands and time synchronisation are passed via the same SpaceWire network.

- The presentation focuses on the functional interfacing with both payloads & the OBC together with the capability to handle low speed control & telemetry data with higher & diverse speed instrument data simultaneously.

- In this context several features are discussed:
  - the robustness of the SpaceWire.Server to be resilient against payload failures
  - the merits and drawbacks of a multi-user file system and
  - advanced interface extensions like SpaceWire-D protocol and SpaceFibre.

Examples for high speed SDRAM High Data Rate Recorder & High Capacity NAND Flash Mass Memory Units

SDRAM Technology

Capacity:	2.3 TBit (BoL)
Input Data Rate:	6140 Mbps
Output Data Rate:	800 Mbps
Mass:	34 kg
Max. Power:	132 W

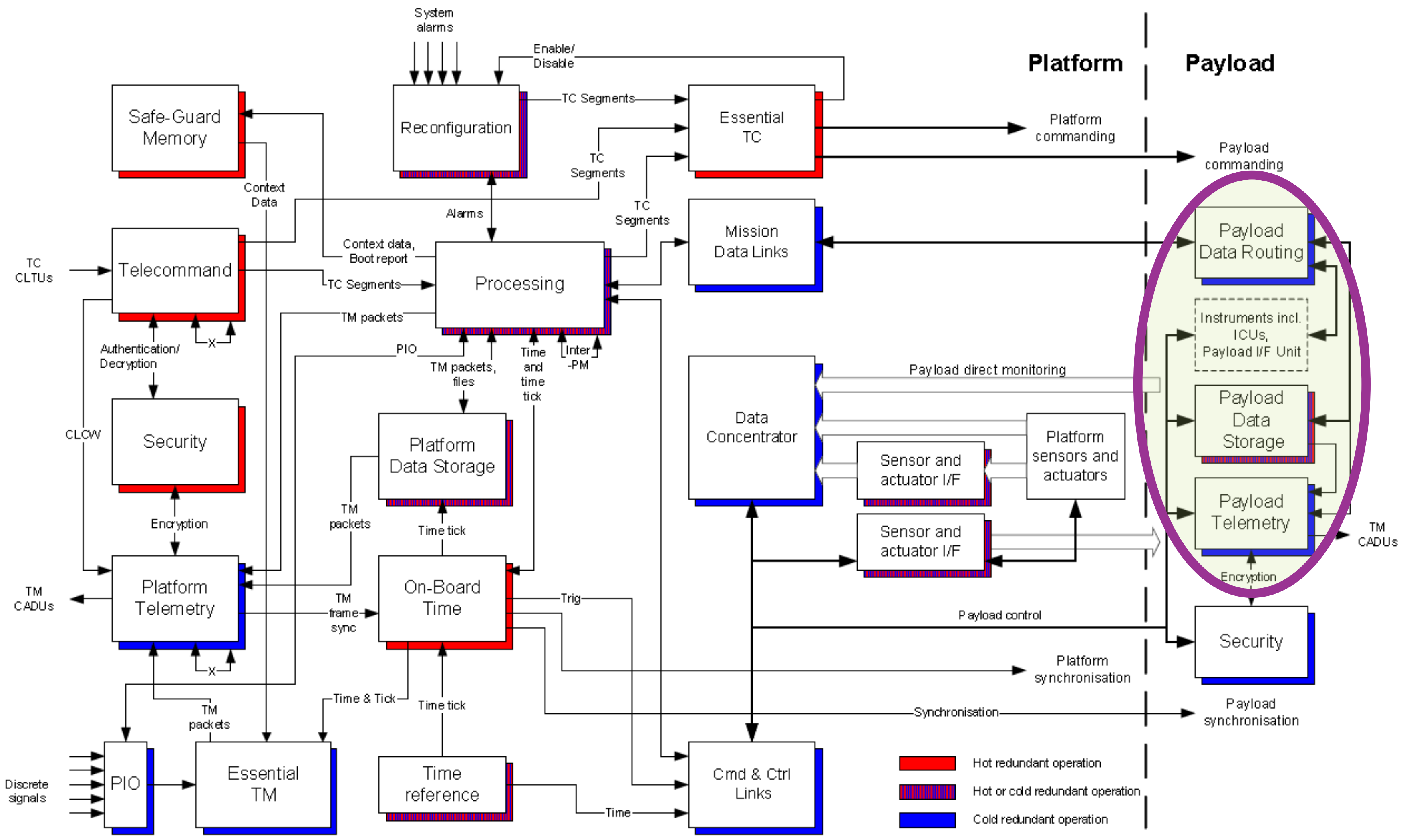
- Simultaneous record and replay
- Management of multiple files in parallel.
- CCSDS conform output Data Formatting

NAND Flash Technology

Capacity:	6 TBit (BoL)
Input Data Rate:	2*560 Mbps
Output Data Rate:	3*280 Mbit/s
Mass:	14 kg
Max. Power:	34 W

- Simultaneous record and replay
- Flexible real-time SW based embedded File Management System with PUS services.
- CCSDS conform output Data Formatting

Mass Memory Unit in the Savoir Environment



Features of future Mass Memory Systems

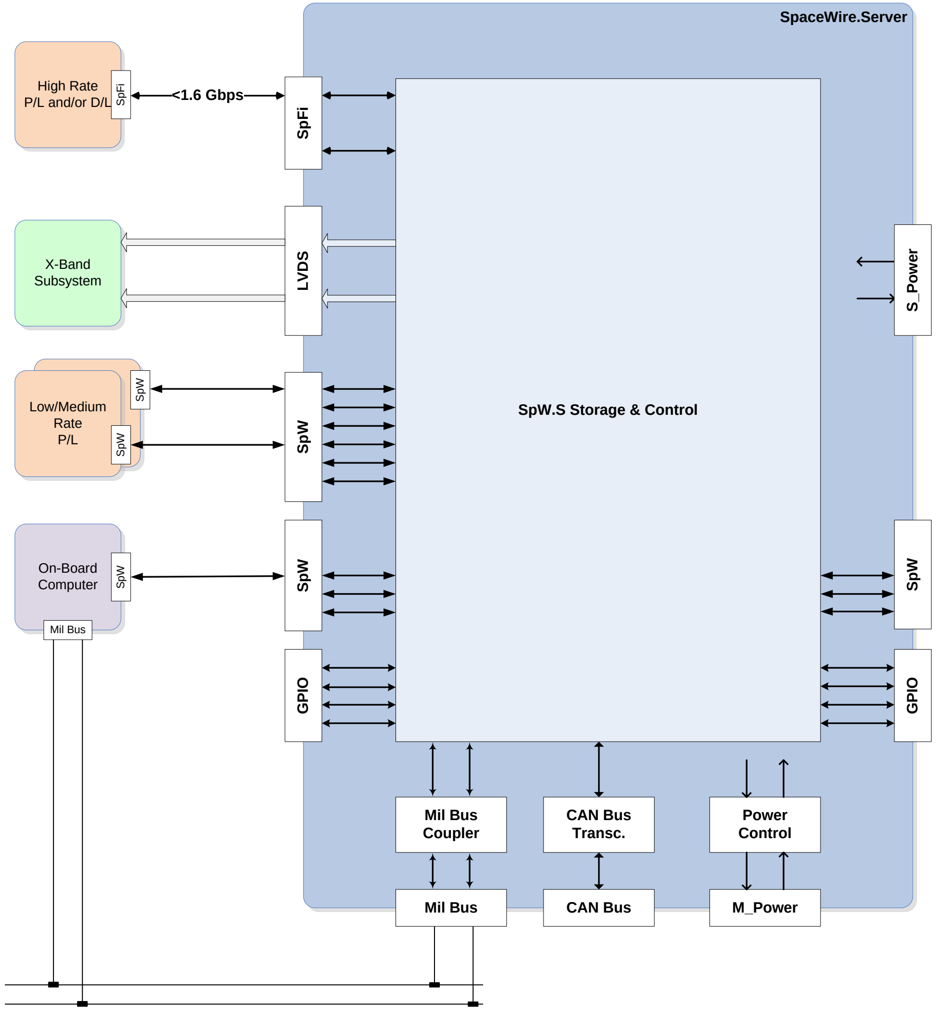
- Interface Architecture which fits to SAVOIR (Space Avionics Open Interface Architecture)
- Standard Onboard Interfaces for File System and Packet Store Handling
  (SOIS – Spacecraft Onboard Interface Services)
- CFDP for reliable Downlink
- SpFi for high speed communication
- SpW to SpFi Bridge
- **SpW Routing Networks**
- **New protocols for onboard communication => e.g. SpaceWire D**

“SpW.Server” the future Mass Memory Solution

- Compact Mass Memory System
- Input Data Rate up to 600 Mbps
- Output Data Rate up to 600 Mbps
- 6 SpW Interfaces for Instruments
- Redundant OBC SpW Interface
- Mil Bus Interface
- CAN Bus Interface
- Redundant Power Interface
- High Speed SpFi Interface
- Parallel LVDS Downlink Interface
- Storage Capacity: 1Tbit (NAND Flash)
- Large SDRAM Buffer (8 Gbit)
- SpW Network with Concentrator

- SOIS Packet Store and File Management
- No. of open Packet Stores / Files: 32
- CFDP Support

- Mass: < 10Kg
- Power: < 25W
- Half Volume of comparable systems



SpaceWire Networks and Interfaces from Mass Memory Systems Point of View

- A SpaceWire network comprises SpaceWire links, nodes and routers.
  - The nodes are functional units that use the onboard communication services to exchange TCs, TMs, and Data.
  - Links are point to point interconnections for medium to high speed communication.
  - Routers allow interconnecting point-to-point links for communication between any node.

⇒ Advantages: Common interface and protocols for all users (e.g. SpW, RMAP).
High performance.
Only one interface technology (no Mil Bus anymore).

⇒ Disadvantage: Control and Data packets share the same network,
but have different communication requirements.

Examples for typical requirements:

- TM/TC packets need high priority, low latency, short packets, reliable communication paths, redundancy. In general there is one initiator.
- Broadcast, Time Distribution needs high priority.
- Data packets may need larger packet sizes, high speed, direct access, parallel and independent communication paths for each instruments to mass memory.

SpaceWire Networks and Interfaces from Mass Memory Systems Point of View

Typical Communication Environment

From \ To	Instrument	OBC	Mass Memory Controller	EGSE	Storage Function
Instrument	N/A	HK TM	N/A	yes	Observation TM
OBC	TC, Time Codes	N/A	TC	yes	HK, TC, TM
Mass Memory Controller	N/A	HK TM	N/A	yes	Private Files
EGSE	AIT	AIT	AIT	N/A	AIT

SpaceWire Networks from Mass Memory Unit Point of View

- Typically the Routers of the SpaceWire Networks are located in the MMU.

- The Router Network has to cope with the following main requirements:
  - Connectivity of the Router according to the table on the previous page.
  - Network Routing Implementation shall be redundant.
  - Interfaces shall be redundant and individually configurable without affecting the other links.
  - Routing Network shall be single point failure free.
  - Routing of TC, TM and Data packets; maybe with different protocols.
  - Network nodes shall not be dependent on each other.
    - There shall be no bottleneck for data packets routed from the instruments to the mass memory

      => bandwidth allocation to instrument packets (general)

      => no specific requirement to buffer data in instruments.
    - Guaranteed delivery of TC and TM packets

      => priority allocation to OBC packets.
  - Appropriate handling of network and protocol errors.

SpaceWire Networks from Mass Memory Unit Point of View

- Solution for Priority and Bandwidth Allocation:
  - SpaceWire-D:
    - Allows deterministic delivery of SpaceWire Packets over existing SpW networks.
    - Method: Time Division Multiplexing
    - Initiator (OBC) determines and controls network access and traffic.
    - RMAP protocol to “write” commands and to “read” telemetry.
    - Allows one or more initiators.
    - Performance reduction due to protocol overhead and response delays.
    - Works properly for communication between OBC and instruments to exchange TC and TM packets.
  - Concentrator:
    - Similar to an SpW to SpFi Bridge
    - Allows direct access to the mass memory node for delivery of data packets.
    - Method: Direct access via direct point-to-point path.
    - Each instrument can send data independently.
    - No specific protocol necessary.
    - No performance reduction.
    - Bandwidth depends on the receiving Mass Memory node only.
    - Works properly for communication between Instruments/OBC and Mass Memory to exchange data packets.

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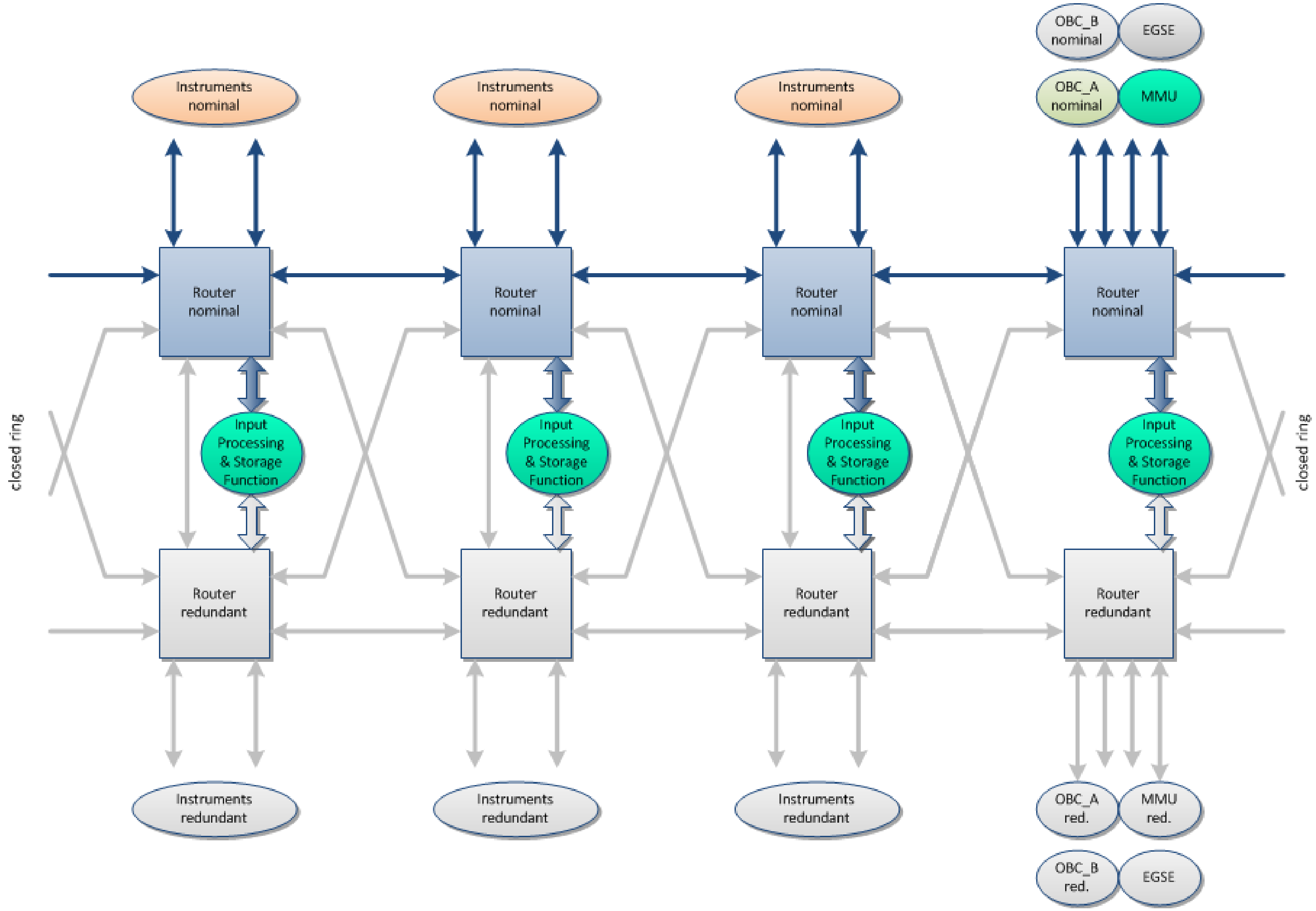
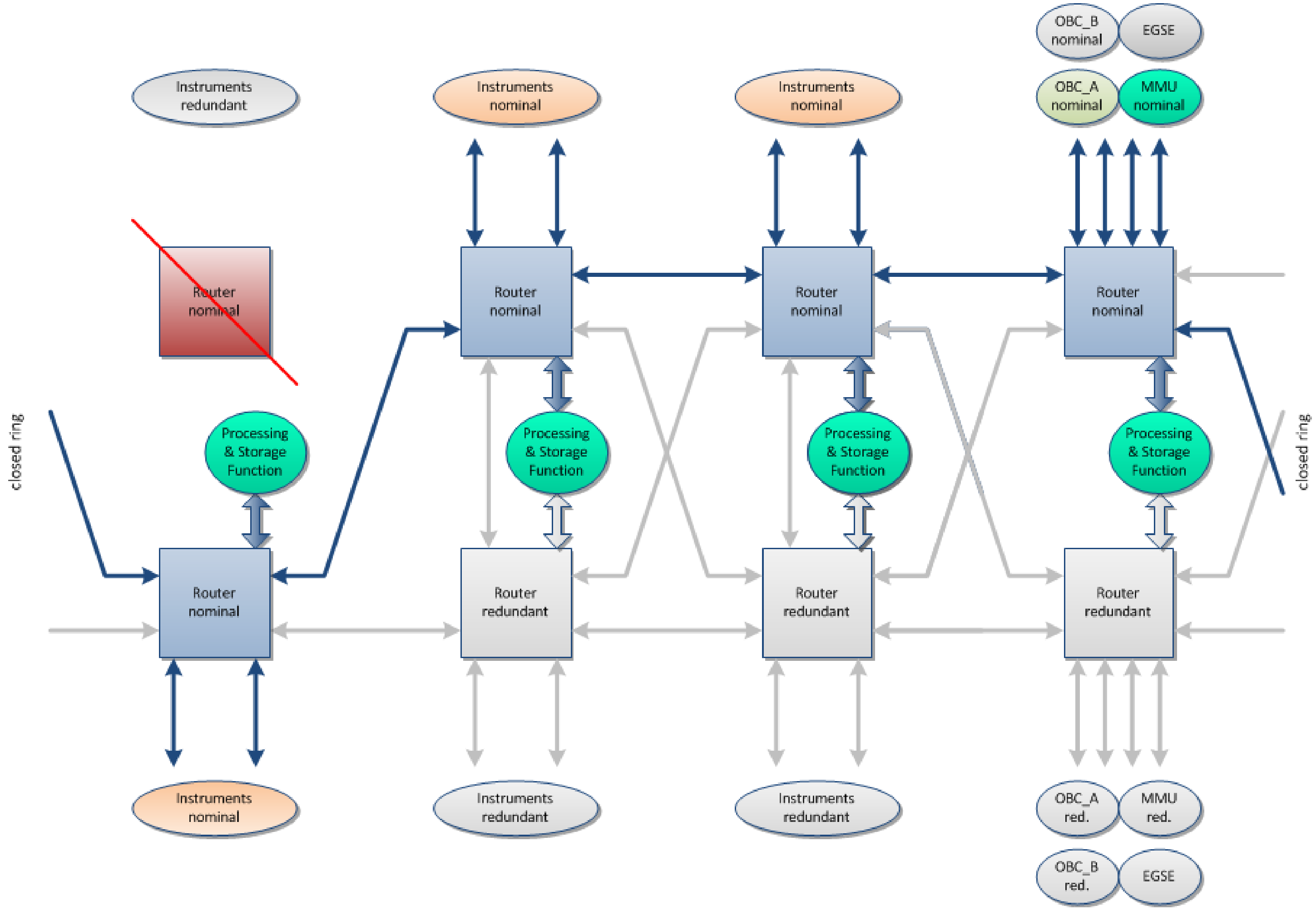
Redundant Network Topology with Router Devices

- Example for a network with two Instruments per Router
- High number of Router Devices to achieve Redundancy on Interface Level
- Router devices need cross-coupled supply voltage.
- Router SpW Links need cold sparing capability.



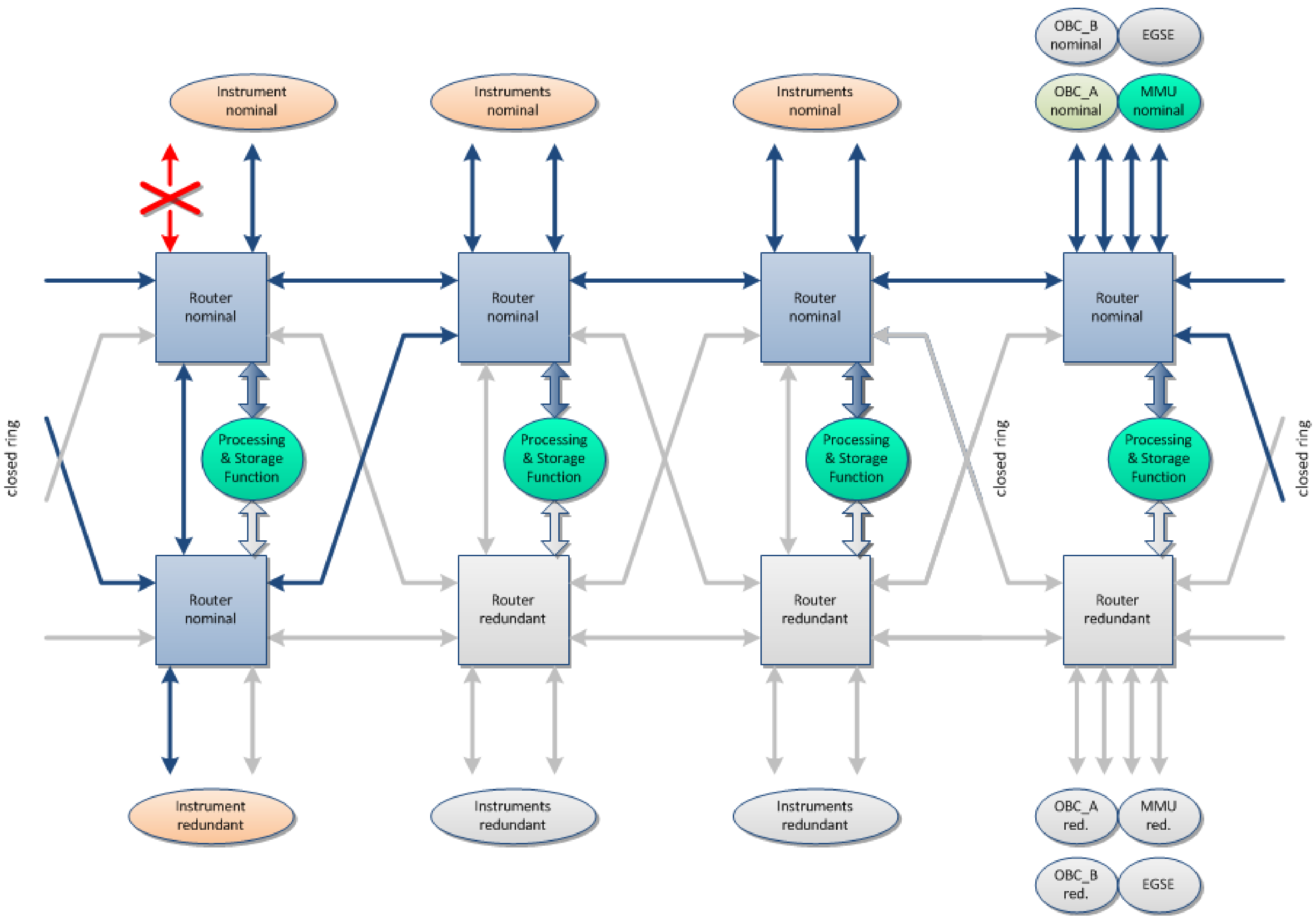
Redundant Network Topology with Router Devices

- Network Reconfiguration in case of a Router Failure.
- Failed device is part of Mass Memory.
- All interconnected links have to be exchanged.



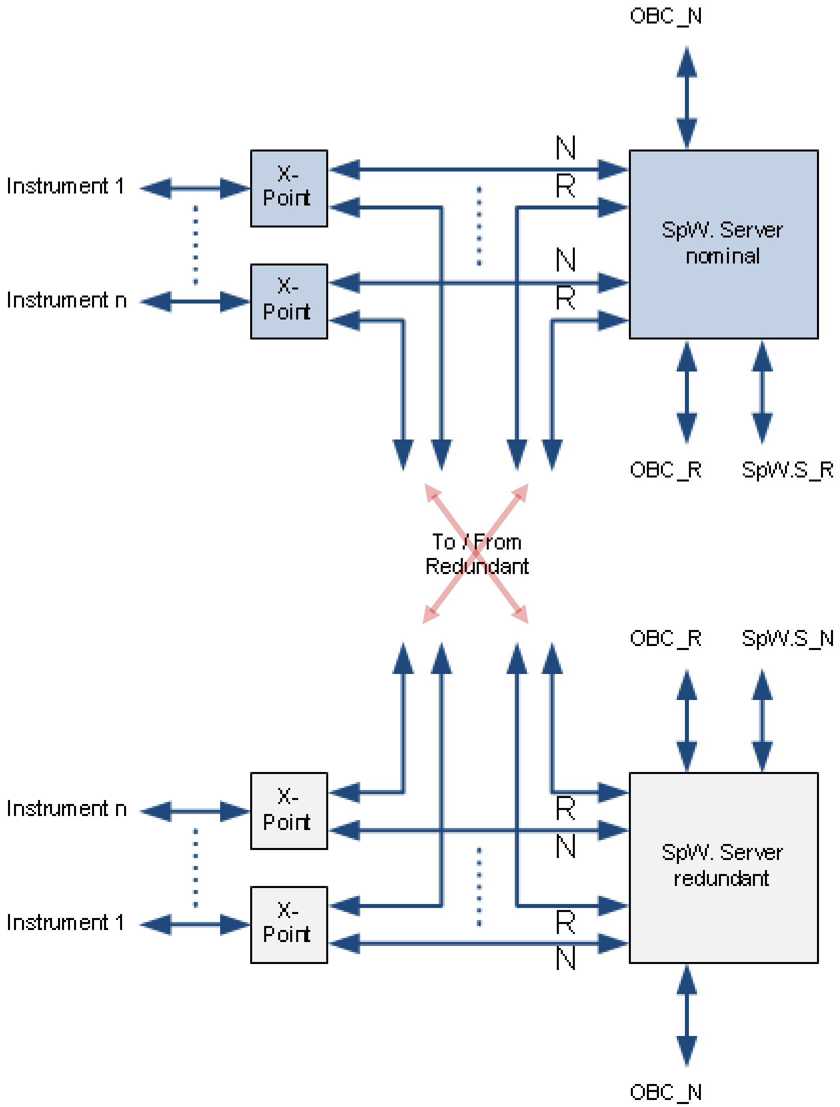
Redundant Network Topology with Router Devices

- Network Reconfiguration in case of an Interface Failure.
- Failure location is part of the instrument.
- Failed interface can be independently reconfigured on the cost of having nominal and redundant Router on power.



Redundant Network Topology with X-Point Switches

- Separation of interface cross-coupling and Routing.
- Number of Router Devices can be reduced at the expense of X-Point Switches.
- Instruments can be individually interconnected to the redundant structure of the MMU with a single link.
- From redundancy allocation point of view, the X-Point Switch is part of the Instrument, but normally realized in the MMU.
- X-Point requires dedicated redundant supply voltage.



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Handling of typical Network Errors

- SpaceWire Network needs various mechanisms for error detection and recovery (no claim to be complete):
  - Hardware Failures
    - Link corruption
    - Router corruption
    - Receiving, sending end corruption
  - Link Errors
    - Disconnection
    - Frequent parity or EEP errors
  - Protocol Errors
    - Address Check
    - Parity Check
    - Packet Length Check
      (e.g. minimum and maximum allowed length, packets with EOP, EEP only)
  - Communication Errors
    - Number of packets check (packet rate observation)
    - Packet travel time (time out from start to end of packet)
    - Removal of circulating packets (in case of closed loop paths)
    - Packets without flow credit
    - Overload protection (at receiving end)

Thinking about the Future: Multi-User (Initiator) Network

- Combination of

  => SpaceWire-D and

  => SpW.Server

  can be extended to a **Multi-Initiator** Network which

  ⇒ allows each user to access the MMU individually by RMAP based read and write commands

  ⇒ provides the capability to OBC to have priority for commanding and monitoring.

  ⇒ no bottlenecks and maximum bandwidth between MMU and users.

  ⇒ note: downlink transmitter may act as a user, too, reading data files.

  - Communication between OBC and User Nodes is scheduled.
  - Communication between User Nodes and MMU is “concentrated”.

- Multi-User environment means
  - **File Access Services** can be directly performed by the user nodes (*open**, *close**, read, write) and
  - **File Management Services** are centrally controlled by the OBC (create, delete, rename, lock, unlock, *open**, *close**, copy, move, etc.)
  - Intelligent users can access files to store data in different files (comparable to APID to Packet Store mapping).
  - Intelligent users can access files to retrieve data for onboard data handling or download.
- Multi-User environment needs the implementation of an enhanced file system in the MMU.

** open and close assigns / frees hardware and software resources. Implementation is application specific.*

Summary

- Concentrator is a building block which eliminates bandwidth limitations of existing solutions.
- X-Point Switches allow individual SpW interface redundancy switching before routing takes place.
- SDRAM and NAND Flash memory partitions are used to buffer and store real-time and file data.
- SpaceWire.Server provides attractive power (< 25 W), mass (<10 kg) and volume budgets at full performance for medium scale systems (<1 Tbit capacity, <1 Gbit/s aggregate data rate).
- SpaceWire.Server is also capable to support multi-user access to files.