SpaceWire networks and protocols

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All the space you need

EADS astrium

Summary

- Background experience
  - How we get there
- Identification of advantages and drawbacks
  - How to state the obvious
- Identification of possible ways for improvement
  - SpaceWire standard, devices, protocols and tools - the wish list
- Conclusion

SpaceWire experience – CODEC IP Core

- Development of a SpaceWire codec IP core.
- The codec is available and distributed by ESA.
- It has been used in many studies and projects.
- Thanks to experience acquired, ameliorations have been identified for better performance and ease of use.
- The new version is currently under development and will be integrated in new Astrium products (as SCOC3).

SpaceWire experience – A3M

- An ESA study that aimed to investigate a distributed approach for space system architectures.
- Use of point-to-point communication between three Leon based computers to implement and validate a safe and reliable distribution system.
- As an additional result, A3M has shown that SpaceWire disconnection detection can be used to implement fast failure detectors.

SpaceWire experience – GAMMA

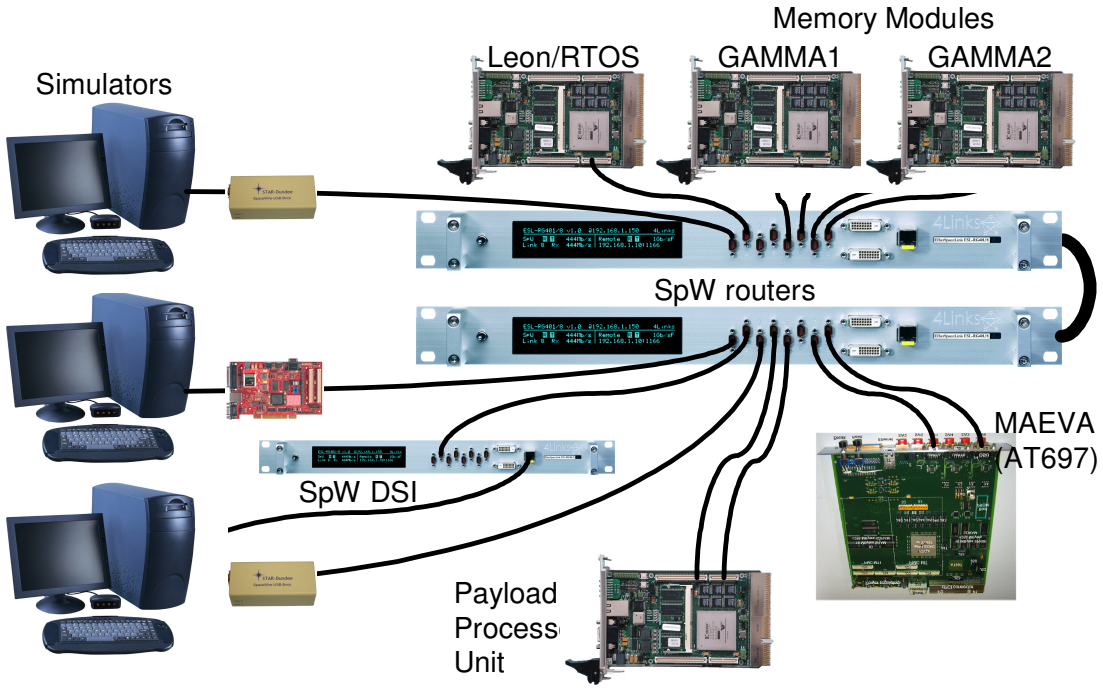
- GAMMA aimed to define, implement and validate a distributed architecture for mass memories.
- Multiple threads on multiple users can access one or several mass memory modules simultaneously through a SpaceWire network from block level to file system level.

SpaceWire experience - PADAPAR

- PADAPAR aims to define a generic architecture for future payloads that can match mid-term needs while optimizing the development process through standard building blocks definition.

BUILDING BLOCKS

- ACQUISITION
- FRONT PROCESSING
- STORAGE
- DATA TRANSFER
- DATA TRANSMISSION TO GROUND
- PAYLOAD DATA HANDLING

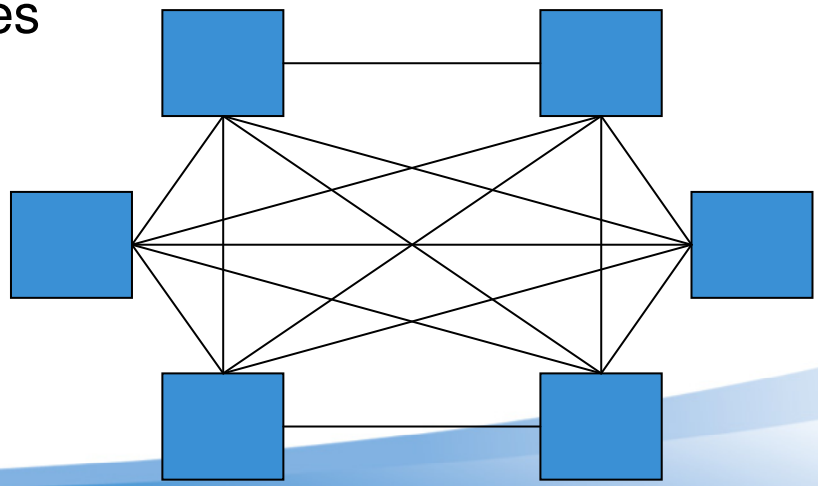


In the beginning

- SpaceWire is simple
  - SpaceWire codec simple to implement
  - SpaceWire interfaces simple to use
- SpaceWire is fast
  - SpaceWire can reach 100 Mbps and more (400 Mbps)
  - SpaceWire is full duplex
- SpaceWire is predictable
  - Direct connections between devices ensure minimum latency and time predictability
- SpaceWire power consumption is low
  - Low consumption on operation

But

- SpaceWire is heavy
  - 80 grams per meter (maximum)
- SpaceWire is point-point
  - One link is required to connect each pair of devices
- Point-to-point connections are not flexible
  - Adding a device may require to add several links and interfaces



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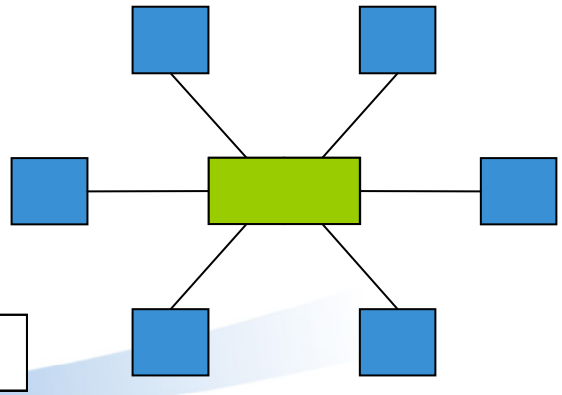
And there was the SpaceWire router

- Minimize the number of links
  - From point to point connections to packet switching network
- Minimize the length of the links
  - By placing the router at the most appropriate location
- Add great flexibility and scalability
  - Adding new devices has never been so simple to
    - Increase the number of instruments
    - Increase the total data capacity
    - Increase the data processing capability
- And mass decreases



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But timing problems began

- Data throughput is limited
  - During a transaction, the complete path runs at the speed of the slowest device.
- Latency is increased by a fixed value
  - A fixed small latency is introduced by the routing mechanism.
- Latency is increased by a variable value
  - A variable latency may be introduced by the routing mechanism when output port is used. This latency depends on the number and size of messages that are waiting for the port as well as the data throughput used.
- Increasing link speed does not solve the problem
  - But pushes back the limits.

Proposition for improvements

- Need for a more predictable SpaceWire network
  - Required for real-time critical systems.
- Need for a more reliable SpaceWire network
  - Critical messages must not be blocked by no-critical ones.
- Need for analysis tools
  - To support the definition of systems.
- Need for test and validation tools
  - This topic is very well covered by the present conference.
- All these improvements must be supported by standards

Better devices

- Support other routing policies
  - The implementation of the arbitration policy is generally limited to round-robin.
  - Priority based should ease predictability and should be easy to implement, EDF is interesting but too complex to implement.
- Support broadcast and multicast
  - Defined in standard but not implemented.
  - Support safe and distributed systems.
- Supporting traffic control
  - Configurable quota checking of all transactions will make the system safer and should be simple to implement.
- Multiplexers
  - Concentrate data traffic and minimize links => Space Fibre

Standards and protocols evolution

- Ensure respect of timing constraints
  - Higher-level protocol could be implemented on SpaceWire:
    - Time-triggered protocol (TTP)
    - FlexRay
    - AFDX adaptations
    - Asynchronous protocols (UCS/UCN) as in A3M
    - …
- While respecting standards
  - SpaceWire standard
  - CCSDS SOIS standards
- That must continue to focus on space needs.

Tools for all steps

- System definition analysis
  - Must support standards
  - Must support protocols
  - Must support device implementations
  - Possibility to mix simulation and real Hardware is an asset
- Device tests and validation
  - Many tools are presented during the conference
- System integration, tests and validation
  - Networking monitoring
  - TopNet SpaceWire IP Tunnel
  - …

Conclusion

Recommendations for further SpaceWire developments:

- Keep standard simple and efficient,
- Keep implementation simple and reliable,
- Higher-level protocols need to be defined,
- Tools are required for systems analysis and design

to extend the domain of SpaceWire applications.