Assessment of SpaceFibre with respect to OSRA-NET requirements

Alessandro Leoni

October, 2017

Outline

- SpaceFibre introduction
- OSRA-NET requirements under study
  - Traffic classes
  - Time distribution and interrupt mechanisms
  - Quality of Service (Reliability)
  - Redundancy
- SpaceFibre applied to a “JUICE-like” router
- Conclusions

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SpaceFibre Introduction

SpaceFibre Introduction

SpaceFibre is the forthcoming technology for on-board satellite networks

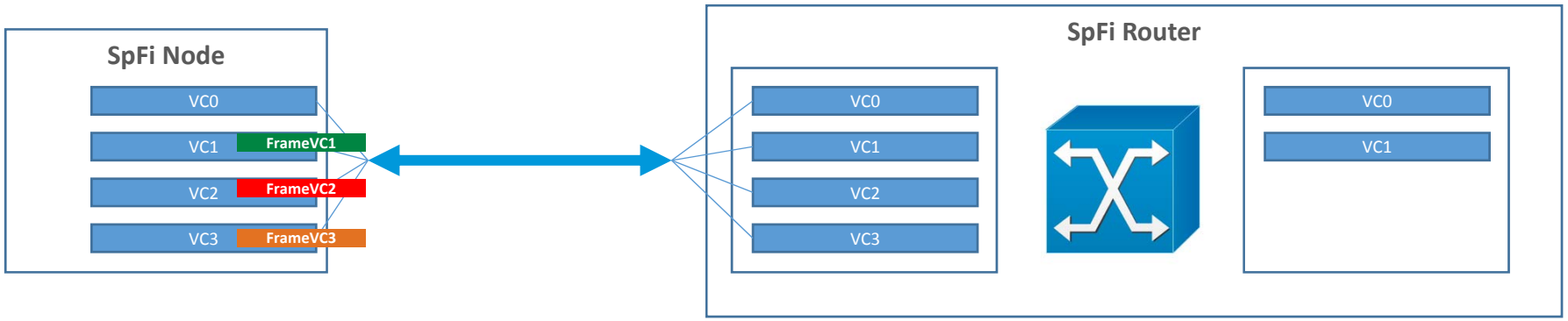
Facts for SpaceFibre link:

- Quality of Service (QoS)
- Integrated Fault Detection Isolation and Recovery (FDIR), with data retransmission in case of errors
- Very high data rates (up to 6.25 Gbps per lane)
- A general *Broadcast* service
- Reduction of harness mass compared to SpaceWire (33% on copper, 50% on optical fiber, > 90% when comparing per bit transferred)

SpaceFibre Introduction

SpaceFibre Quality of Service implemented through *Hardware Virtual Channels*

The data stream is fragmented in ***frames*** (64-words), interleaved among the VCs to achieve the desired QoS



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SpaceFibre Introduction

Each Virtual Channel can be configured using:

- **Time slots:** a VC can transmit only during the time slots allocated to it
- **Priority:** each VC has a priority level. Only the highest priority VC is allowed to transmit the next frame
- **Bandwidth allocation:** each VC can use up to the percentage of the link allocated to it. If it uses more, the babbling protection limits its link usage

QoS precedence: Time slot → priority level → bandwidth allocation

Quality of Service is completely managed in hardware by the port, no need of upper layers

OSRA-NET requirements under study

OSRA-NET Requirements AL2 DT3

Requirements groups		Comments
COMMUNICATION SYSTEM CAPABILITIES REQUIREMENTS	Generic Capabilities	Three traffic classes: • Synchronous time-critical data • Asynchronous time-critical data • Non-time critical data
		Time distribution mechanism
		Interrupt mechanism
	Quality of Service requirements	QoS (Reliability) classes: • At most once • At least once • Exactly once
	Class of communication requirements	Frequency/latency/jitter/QoS requirements for common communication classes
COMMUNICATION INFRASTRUCTURE REQUIREMENTS		Cold, warm and hot redundancy
ERROR HANDLING AND FDIR REQUIREMENTS		Error detection and reporting at datalink, network and transport layer
SYSTEM-LEVEL COMMUNICATION REQUIREMENTS		Presence of a supervisor in the network

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Slide 8

AL2 this is a new slide. on the left two columns there are the names of the chapters of OSRA-NET. in the right column a summary of the main requirements

Alessandro Leoni, 12/10/2017

DT3 ok

Dirk Thurnes, 12/10/2017

Traffic classes

Requirements groups		Comments
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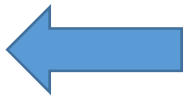

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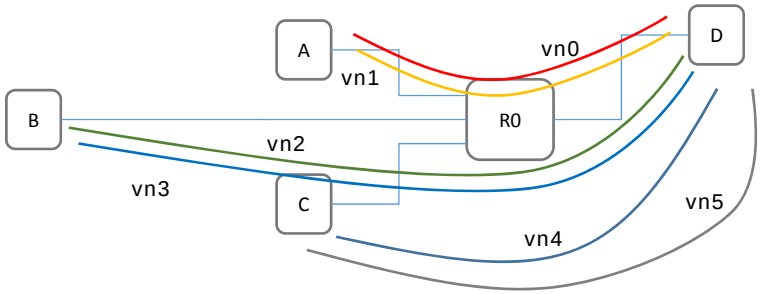
Traffic classes – Virtual Network concept

Each application runs on its own Virtual Network

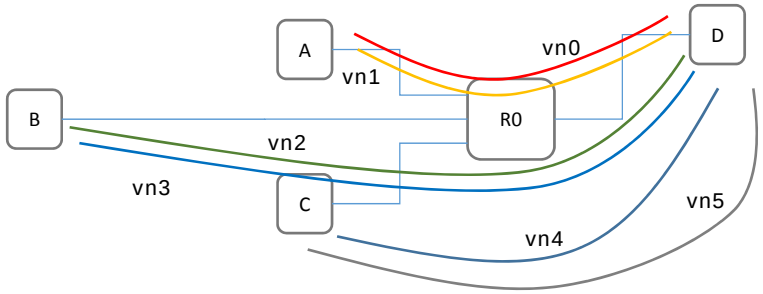


Virtual Network:

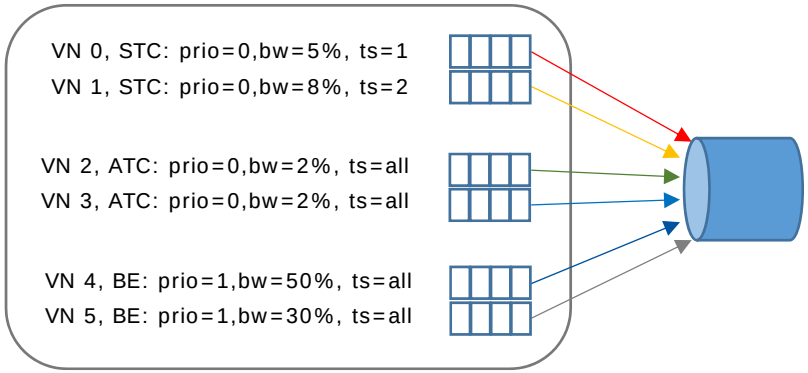
chain of Virtual Channels along the path

Goal: guarantee maximum latency even when another application fails

Traffic classes



Router Output Port



- For **Synchronous Time-Critical Traffic**:
  - High priority
  - Low reserved bandwidth
  - Assigned time slots
- For **Asynchronous Time-Critical Traffic**:
  - High priority
  - Low reserved bandwidth
  - Scheduled in all time slots
- For **Best Effort Traffic**:
  - Low priority
  - Scheduled in all time slots

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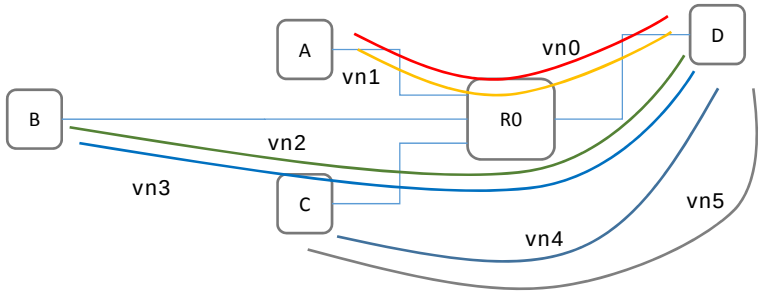
Traffic classes



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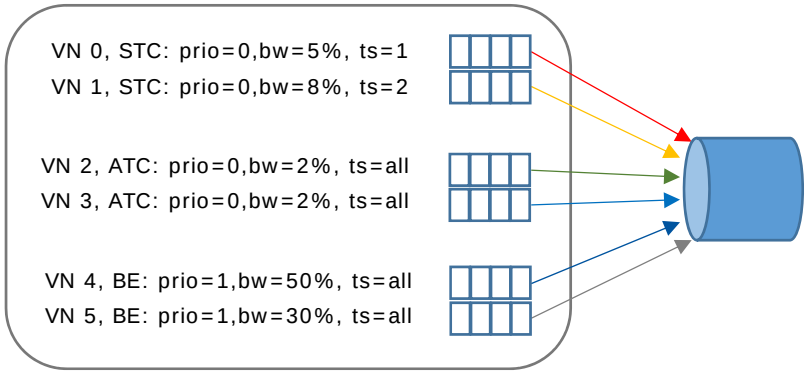

If a fault happens in a **BE** node:

- All other nodes have still their bandwidth guaranteed (low priority)

If a fault happens in a **STC** or **ATC** node:

- Other STC and ATC nodes (same priority) are safe → the **bandwidth reservation mechanism** will immediately privilege them against the babbling node
- BE nodes (lower priority) are shortly penalized at the beginning, then the **babbling protection** kicks in and forces the faulty node not to use more than its allocated bandwidth

Time distribution and interrupt mechanisms

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Time distribution and interrupt mechanisms

SpaceFibre **does not provide** a time distribution and an interrupt mechanism on its own.

However it is possible to use SpaceFibre Broadcast Messages to implement them

Broadcast message

- 8-bytes data field
- Precedence over data traffic
- Automatic loop prevention in the routers
- **Extremely low latency**

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The time distribution and interrupt service will be part of the SpFi transaction layer, which is not part of the SpFI ECSS-E-ST-50-11C standard.

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Quality of Service (Reliability)

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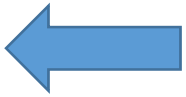

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QoS (Reliability) Requirements

Reliability requirements in terms of SDU (Service Data Unit)

- **At most once**: the emitter must emit an SDU at most one time (the receiver could not receive it)
- **At least once**: the receiver must receive an SDU at least one time (the receiver could receive multiple copies of the same SDU)
- **Exactly one**: the receiver must receive an SDU exactly one time

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They require ack/nack/timeout mechanisms at SDU level

end-to-end point of view =>should be handled on application/ transport layer

... however, SpaceFibre provides a **reliable** link with **point-to-point retransmission** in case of errors

=> needs to be discussed if these requirements are applicable to SpaceFibre networks

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Communication classes

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Redundancy

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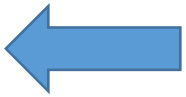

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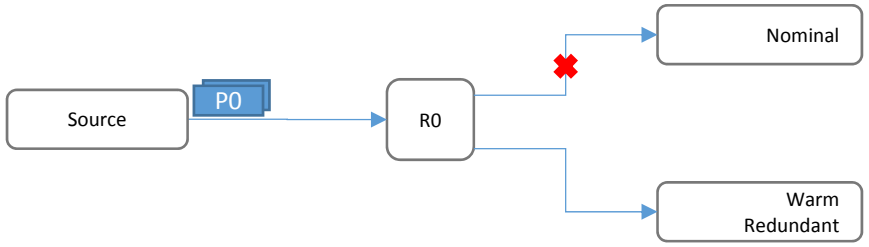
Redundancy

Cold Redundancy

- Always feasible if the network topology supports it

Warm Redundancy

- Can handle it at application level and/or..
- Can use **Group Adaptive Routing**, under the assumption that a failing device stops to accept data



Group Adaptive Routing:

The first free output port in an output port set is chosen to transmit the packet

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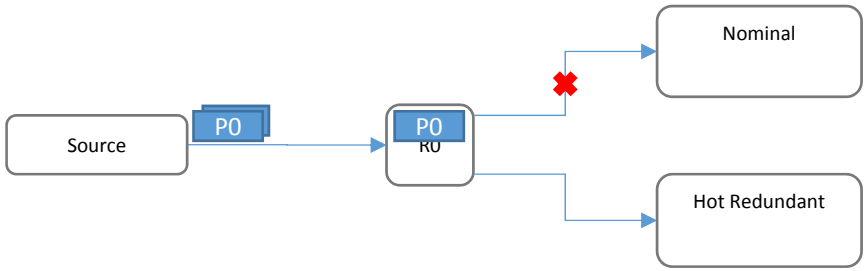
Redundancy

Hot Redundancy

- Can make use of SpaceFibre **Multicast**

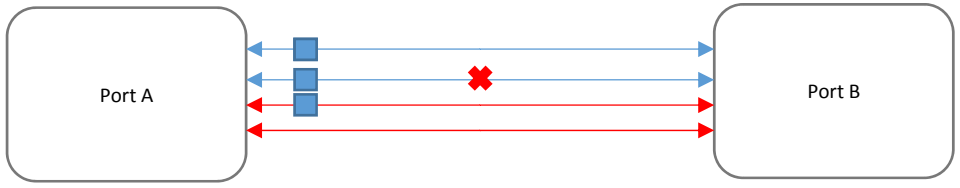


Multicast:

All the output ports in the output set are chosen to transmit the packet

Redundancy

SpaceFibre Multilane: **Hot Redundant Lanes**



Active lane

Hot redundant lane

Hot redundant lanes:

"idle" lanes that are not used to send data but that are ready to be automatically switched on by the port in case one of the nominal lanes fails

- Extremely fast to switch (few clock cycles)
- No data is lost in the process (retry)
- Automatically done by the port

Error detection and reporting

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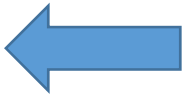

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System-Level Communication Requirements

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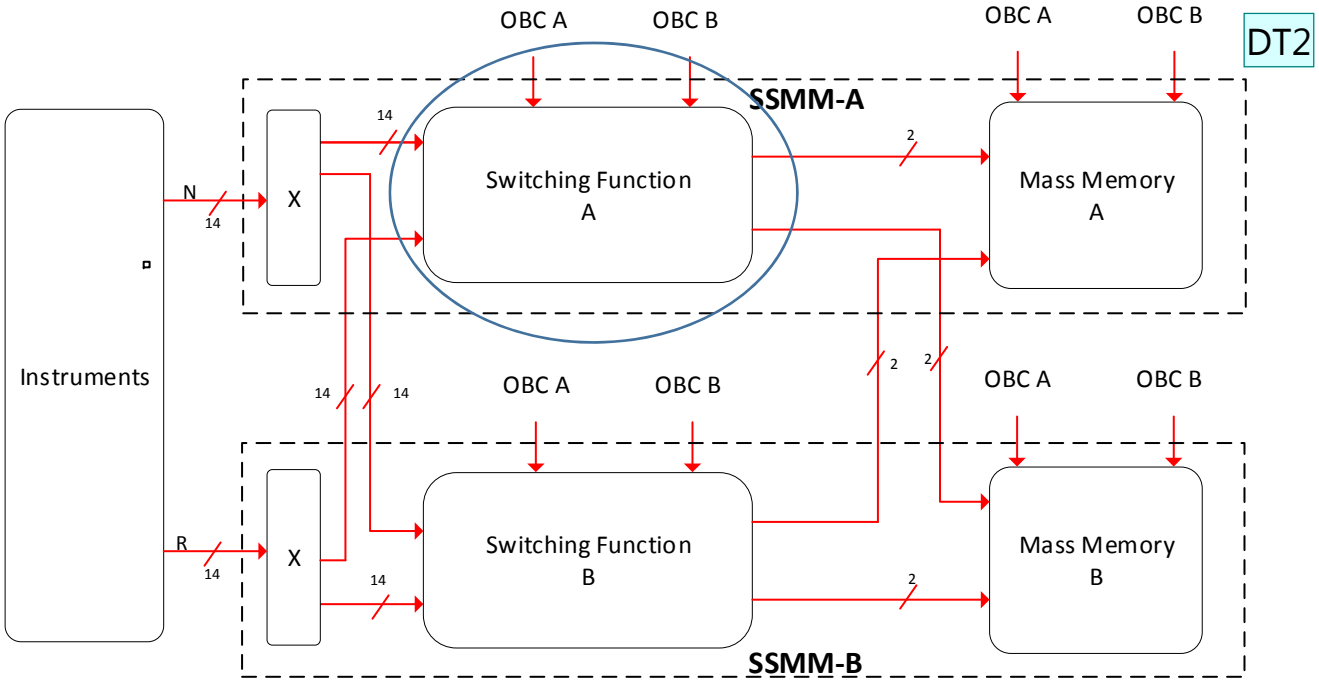
SYSTEM-LEVEL COMMUNICATION REQUIREMENTS		**Presence of a supervisor in the network**

SpaceFibre applied to a “JUICE-like” router

JUICE Payload Simplified Block Diagram

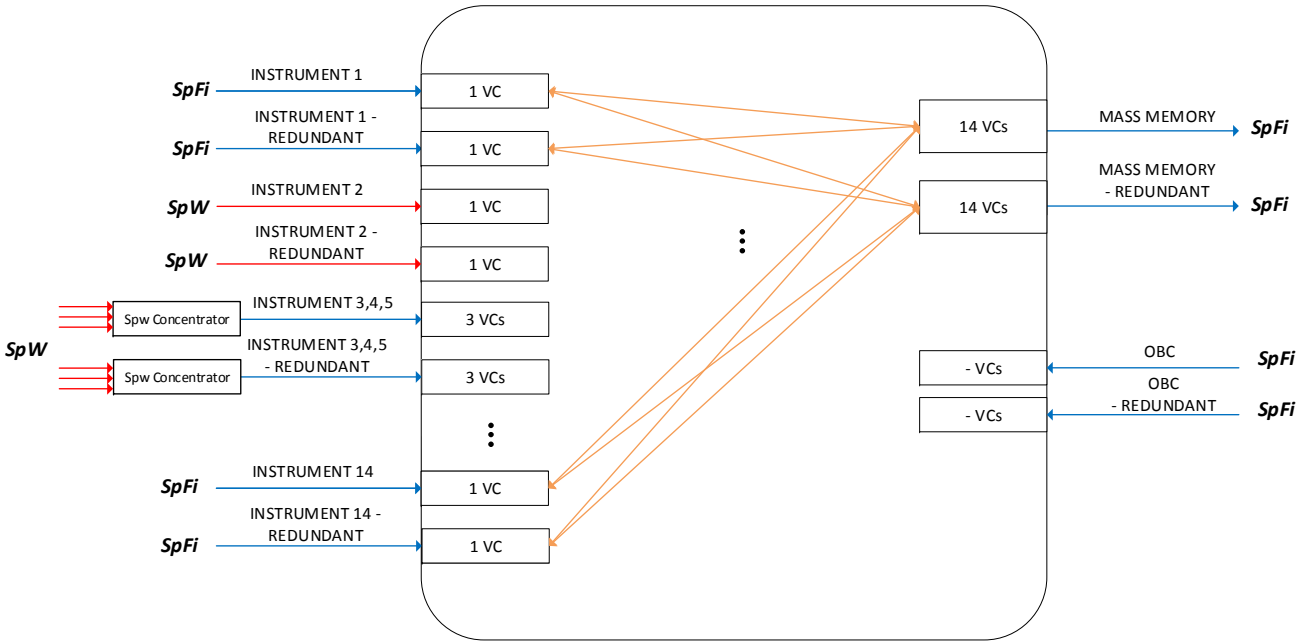


Slide 27

DT2 should say OBC

Dirk Thurnes, 12/10/2017

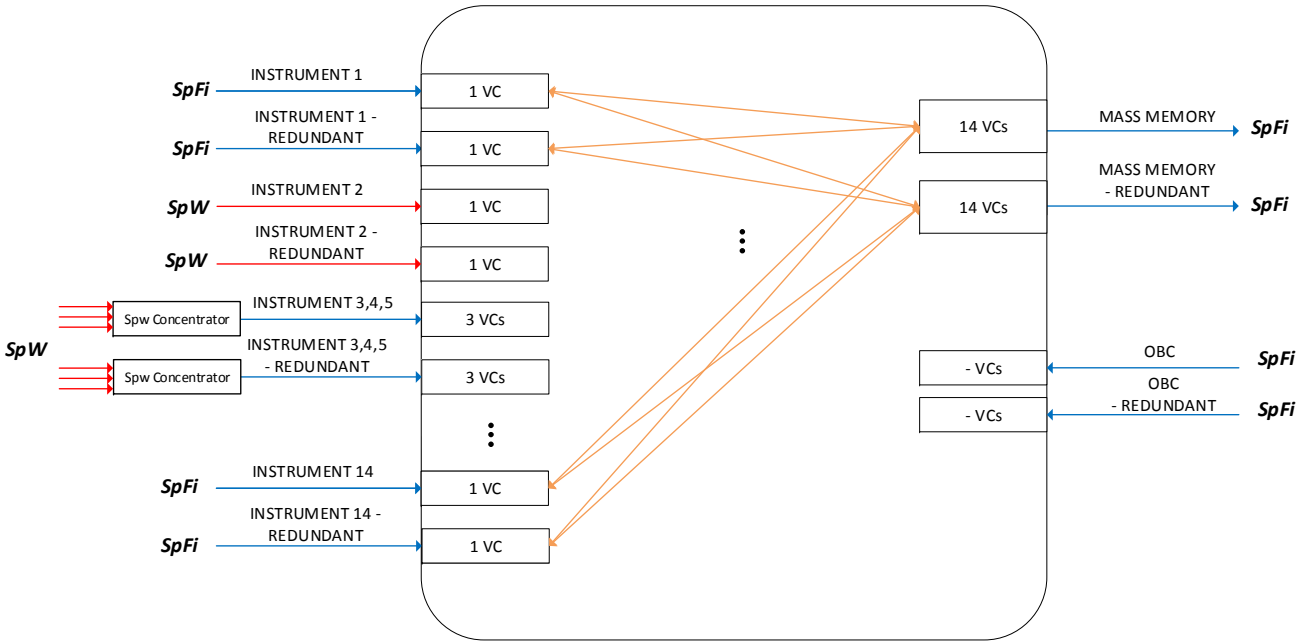
Possible SpaceFibre Router



SpaceWire and SpaceFibre are **compatible** at Network Level

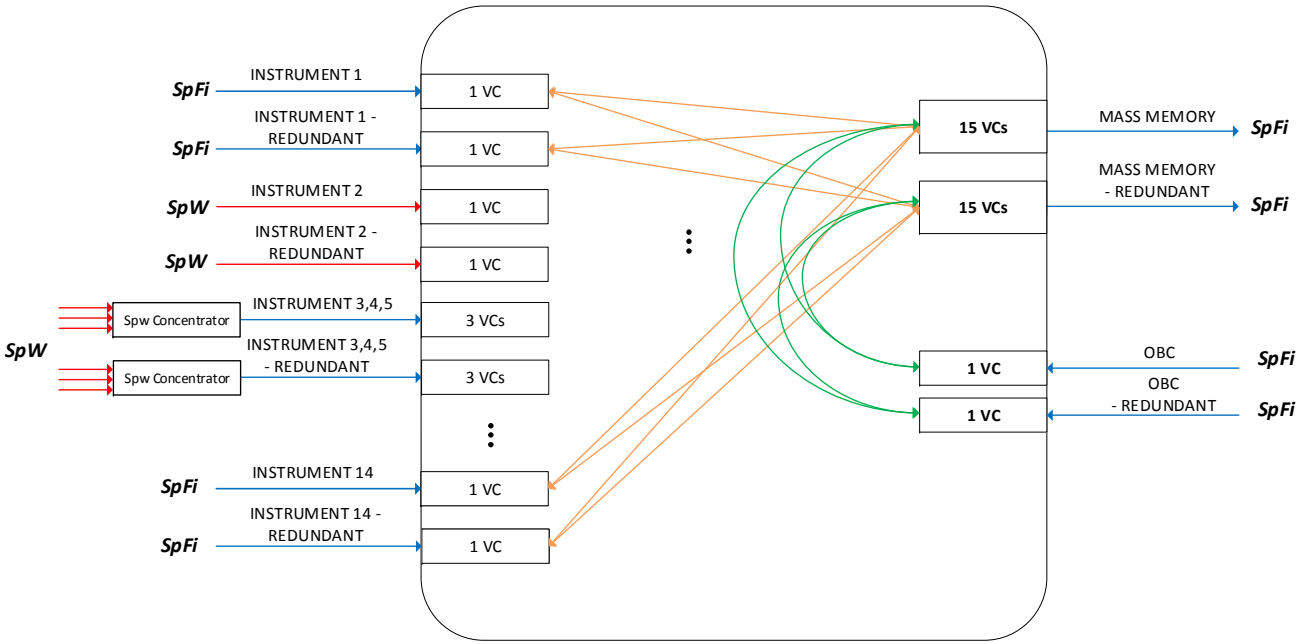
- Possible to directly connect SpaceWire and SpaceFibre devices to the same router
- Possible to concentrate multiple SpaceWire links into Virtual Channels of a single SpaceFibre link → **harness** reduction

Possible SpaceFibre Router



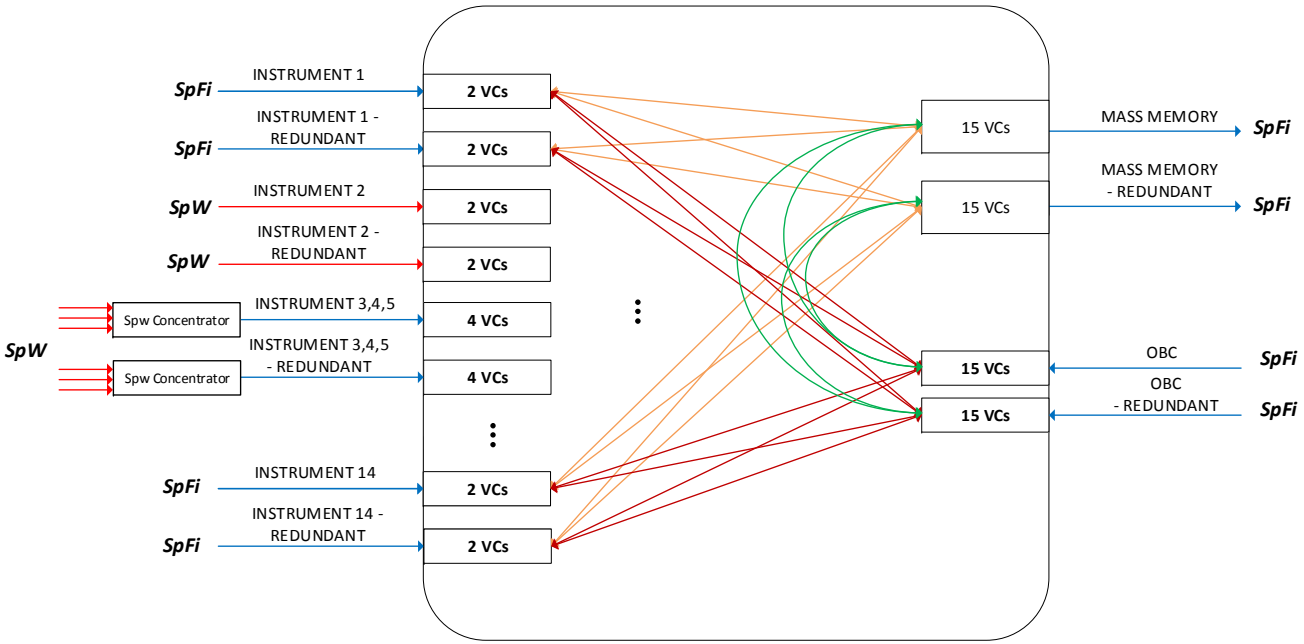
VN	BW	Priority	Timeslots
1	20%	Low(5)	All
2	30%	Low(5)	All
…			
14	15%	Low(5)	All

Possible SpaceFibre Router



VN	BW	Priority	Timeslots
1	20%	Low(5)	All
2	30%	Low(5)	All
…			
14	15%	Low(5)	All
15	5%	High(3)	All

Possible SpaceFibre Router



VN	BW	Priority	Timeslots
1	20%	Low(5)	All
2	30%	Low(5)	All
…			
14	15%	Low(5)	All
15	5%	High(3)	All
16	3%	High(3)	0,1
17	3%	High(3)	2,3
…			

No problem to implement JUICE network with SpaceFibre, adding **Quality of Service** and **FDIR** capabilities

Conclusions

Requirements groups		Comments	Compliance
COMMUNICATION SYSTEM CAPABILITIES REQUIREMENTS	Generic Capabilities	Three traffic classes: • Synchronous time-critical data • Asynchronous time-critical data • Non-time critical data	OK
		Time distribution mechanism	OK/UPPER LAYER
		Interrupt mechanism	OK/UPPER LAYER
	Quality of Service requirements	QoS (Reliability) classes: • At most once • At least once • Exactly once	OK/UPPER LAYER/ NOT NEEDED
	Class of communication requirements	Frequency/latency/jitter/QoS requirements for common communication classes	OK/UPPER LAYER
COMMUNICATION INFRASTRUCTURE REQUIREMENTS		Cold, warm and hot redundancy	OK
ERROR HANDLING AND FDIR REQUIREMENTS		Error detection and reporting at datalink, network and transport layer	OK/UPPER LAYER
SYSTEM-LEVEL COMMUNICATION REQUIREMENTS		Presence of a supervisor in the network	OK (ARCHITECTURAL REQ)

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Conclusions

SpaceFibre:

- implements the **Virtual Network** concept
- allows to handle best effort and time critical data
- provides a low-latency broadcast service
- provides a reliable link
- harness mass reduction

SpaceFibre can be used as communication technology in an OSRA-NET compliant network with a great simplification of upper layers

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