STP-ISS ASSESSMENT IN DETERMINISTIC SPACEWIRE NETWORK WITH MOST SIMULATOR

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OVERVIEW OF STP-ISS TRANSPORT PROTOCOL

OVERVIEW OF STP-ISS

- **Protocol (from Russia)**, created by engineers of the:
  - St. Petersburg State University of Aerospace Instrumentation
  - ISS-Reshetnev
- Lastly updated in 2017: **STP-ISS-14E**
- Why has it been created?
  - SpaceWire network can lead to congestion in some cases.

    example : if a node is emitting permanently, the only solution is to cut it off in the network to be able to take the control back

  - STP-ISS offers a better flexibility to the network by introducing mechanisms

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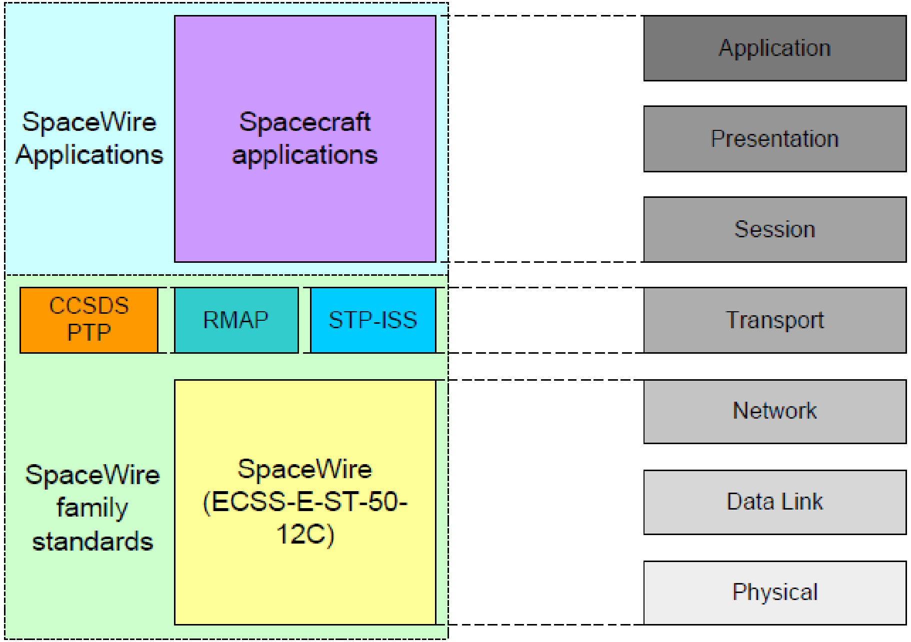
OVERVIEW OF STP-ISS

- **STP-ISS in the OSI model**
  - Transport protocol
  - End-point side
  - Operates over the basic SpaceWire protocols
  - Layer between Application and SpaceWire
  - Specific PID: 252

- **Specificities**
  - Data flow control with Priority QoS
  - Fast transmission with Best Effort QoS
  - Safe transmission with Guaranteed QoS
  - Predictibility with Scheduling QoS
  - Large datas transmission with Connection-Oriented mode



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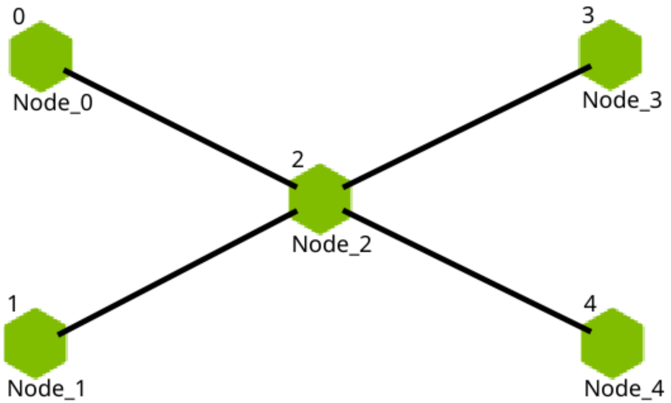
QOS PRESENTATION

- **Priority QoS**

1. Acknowledgement packets, TC acknowledgement packets
2. Control command packets
3. Resent control command packets
4. Connection-oriented mode service packets
5. Credit sync service packets
6. Urgent messages packets
7. Resent urgent messages packets
8. Resent regular messages packets
9. Regular messages packets

- 9 level of priority → maybe too much for space application?
- 9 buffers → impact of FPGA footprint size



Example:
Node 0: req 1, t = 0.1s, Urgent Message
req 2, t = 0.1s, Control Command
req 3, t = 0.1s, Regular Message

Actual order of arbitration:
1) req 2
2) req 1
3) req 3

Advantages: reduces latency of high priority packet

Disadvantages: low priority packet may never be sent

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QOS PRESENTATION

- **Guaranteed QoS**

Emitter sends a packet and starts the resend timer

↙ ↘

Acknowledge received before resend timer expiration
OK (delete from resend buffer)

Acknowledge not received before resend timer expiration

↓

Message resent

↙ ↘

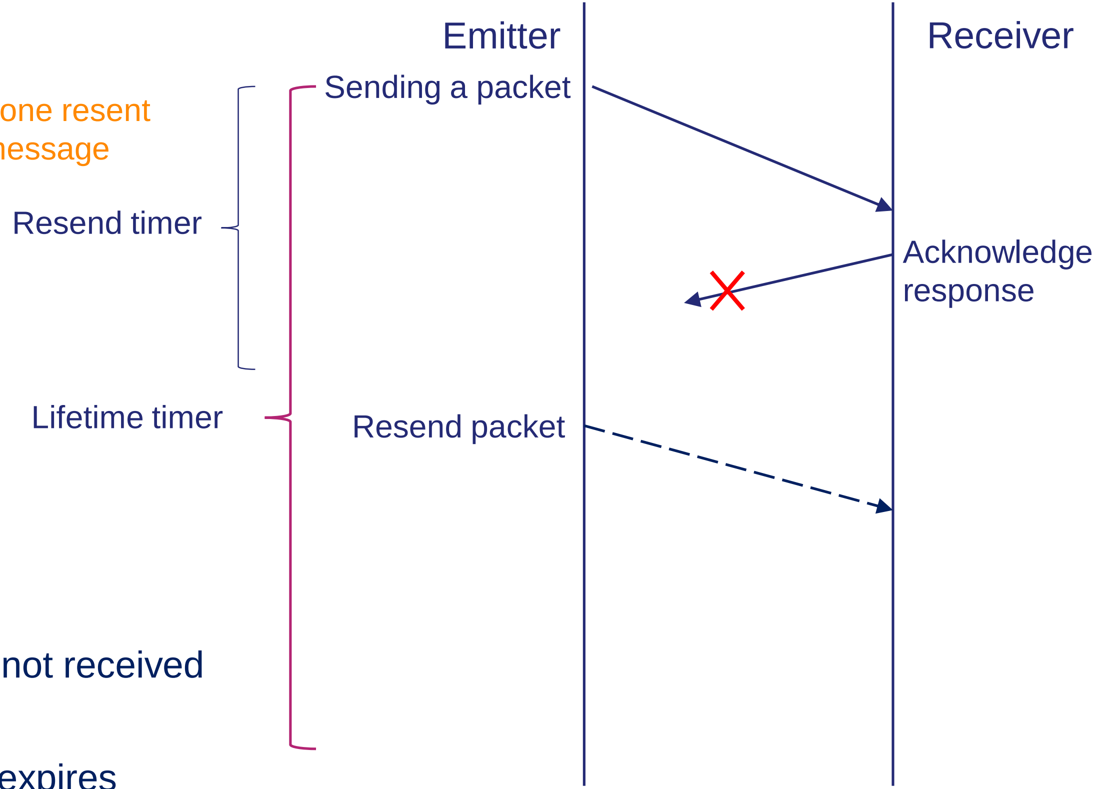
Acknowledge received
OK (delete from resend buffer)

Acknowledge not received

↓

Lifetime timer expires
NOK (delete from resend buffer)

Only one resent per message



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QOS PRESENTATION

- **Best Effort QoS**
  - data transmission without any service
  - the receiver shall check the correctness of the data and transmit the packet to the application layer

Advantages: fast transmission

Disadvantages: no deterministic services

- **Scheduling QoS**
  - data transmission in accordance with a schedule at the network level synchronized thanks to timecodes.
  - This adds a feature which is required for some cases where a time minimum bandwidth is reserved for one end-point

Advantages: all the priority packet can be sent

Disadvantages: some packets may be lost due to lifetime timer expiration while waiting for the next allocated time-slot

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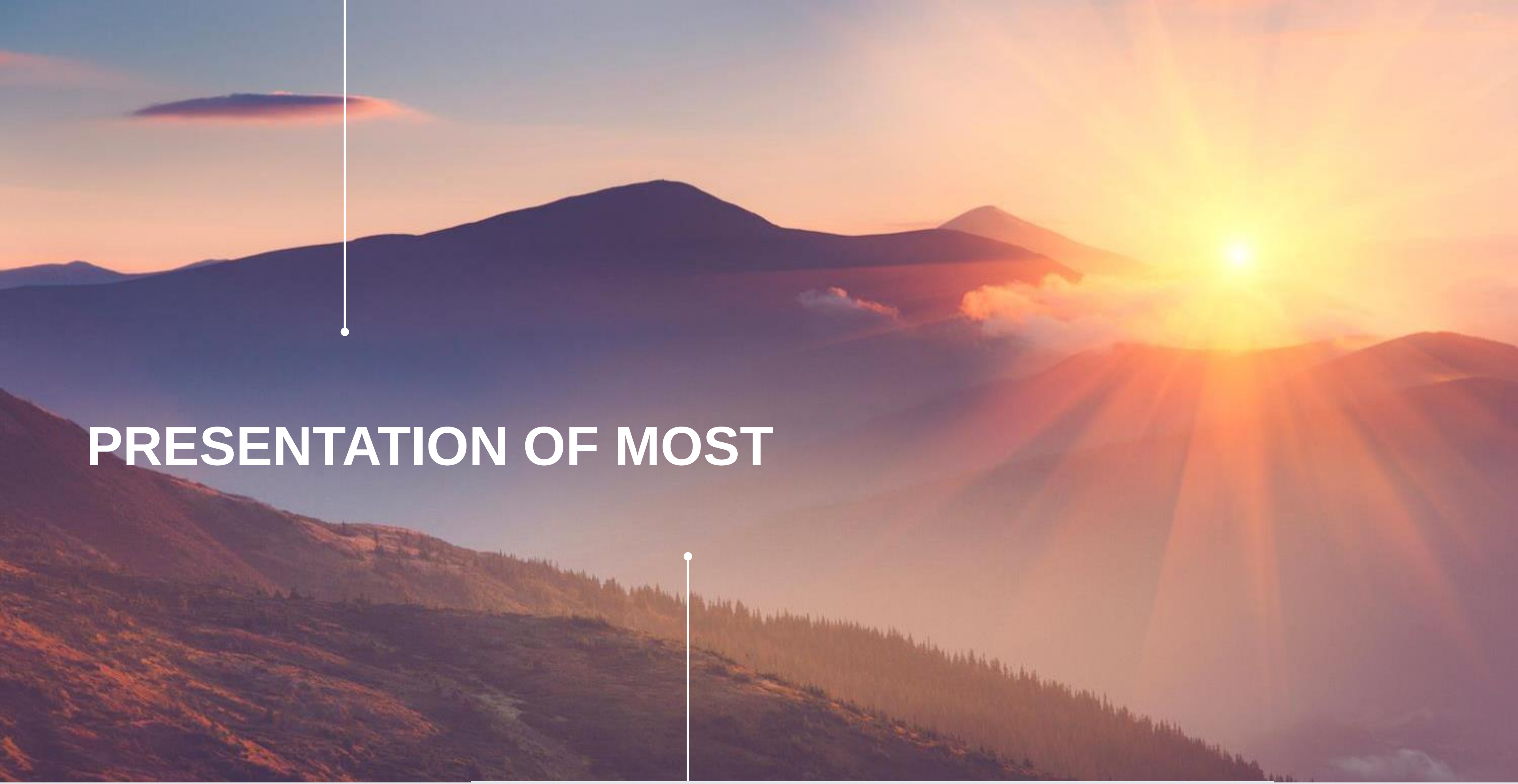


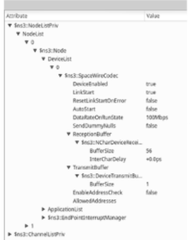
PRESENTATION OF MOST

MOST PRESENTATION

- Goal of MOST Simulator:
  - To support SpW network **design** and **optimization**
  - To allow SpW networks **performances analysis** from the beginning, without waiting for system testing phase
  - To offer a progressive tool for SpW experts who would like to integrate **specific SpW components**, or to update existing library with regard to **standard upgrades**

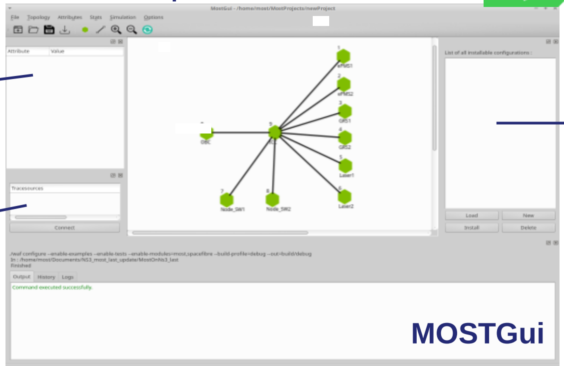
- MOST can be used during all phases of a project:
  - **Phase A and before**: performs evaluations, starting from a preliminary specification of network and nodes
  - **Phase B**: consolidate design by enhancing and completing nodes models behavior in terms of data provider and consumer
  - **Phase C and D**: design, validation and investigation.

- For an easier utilization a GUI has been developed:



Network attributes

Observables & tracesources (example: Buffers occupation, number of packet sent and received, latency …)



MOSTGui

Panel of configuration:
- CPTP node
- RMAP emitter / RMAP receiver
- STP-ISS node
- 10X Switch
- NMS Router
- HW-SW interface node

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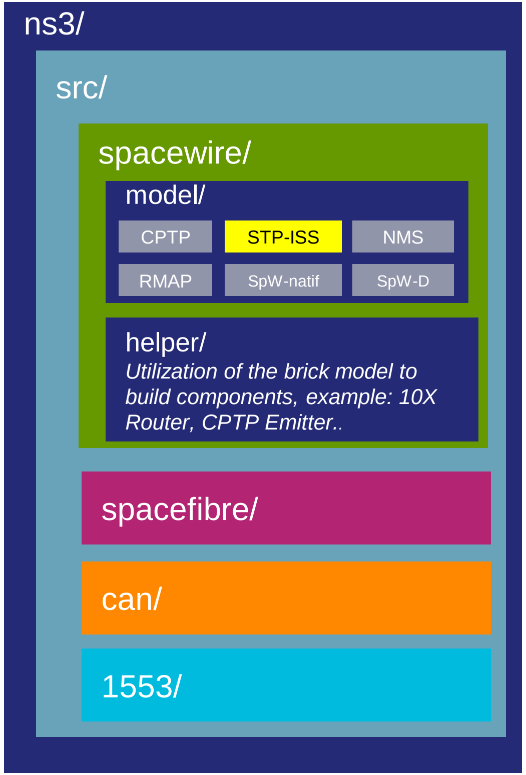
MOST USED FOR STANDARDIZATION AND TESTS

Help to implement new standards to perform early tests before implementation and adoption

- MOST is based on the following standards:
  - **ECSS-E-ST-50-11C** → SpaceFibre
  - **ECSS-E-ST-50-12C** → SpaceWire – Links, nodes, routers and network
  - **ECSS-E-ST-51C** → SpaceWire Protocol IDentification
  - **ECSS-E-ST-52C** → Remote memory access protocol
  - **ECSS-E-ST-53C** → CCSDS packet transfer protocol

- New standards implemented in MOST:
  - **D1-SpaceWire Net Management Service** → SpaceWire-NMS
  - **STP-ISS-14E-specification** → STP-ISS
  - **SpaceWire-D** → SpaceWire-D

MOSTNs3 *(simulation core)*



STP-ISS IMPLEMENTATION IN MOST SIMULATOR AND ITS VALIDATION

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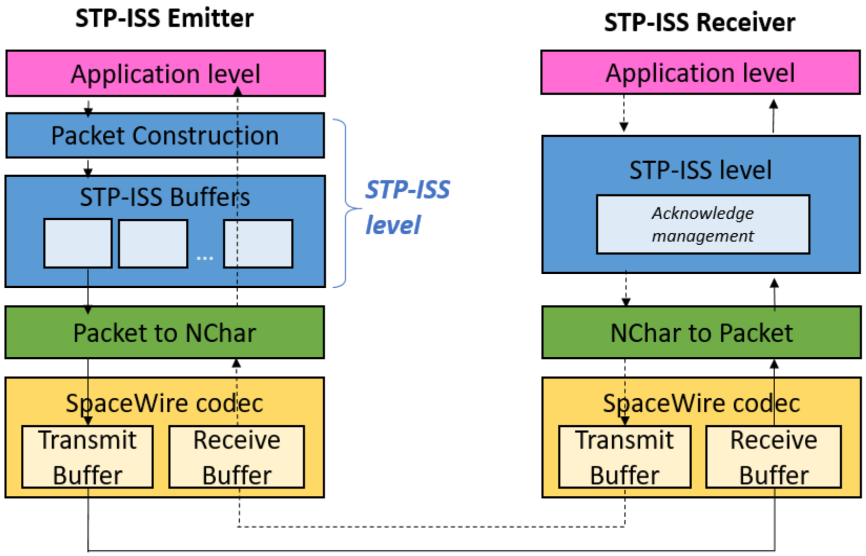
DEVELOPMENT OF A NEW STP-ISS NODE

- Impact at the **end-point level,** nothing at switch level
- STP-ISS level between Application level and Native SpaceWire level
- **Packet construction & QoS management:**

	Target SpW address	...	Target SpW address
Target logical address	PID	Flags (MSB)	Flags (LSB)
Application ID	Packet ID number	Data length (MSB)	Data length (LSB)
Source logical address	...	...	Source logical address
Source logical address	Reserved	Reserved	Reserved
Data	Data	Data	Data
Data	...	...	Data
Data	CRC (MSB)	CRC (LSB)	EOP



- Store in the associated buffer defined in STP-ISS

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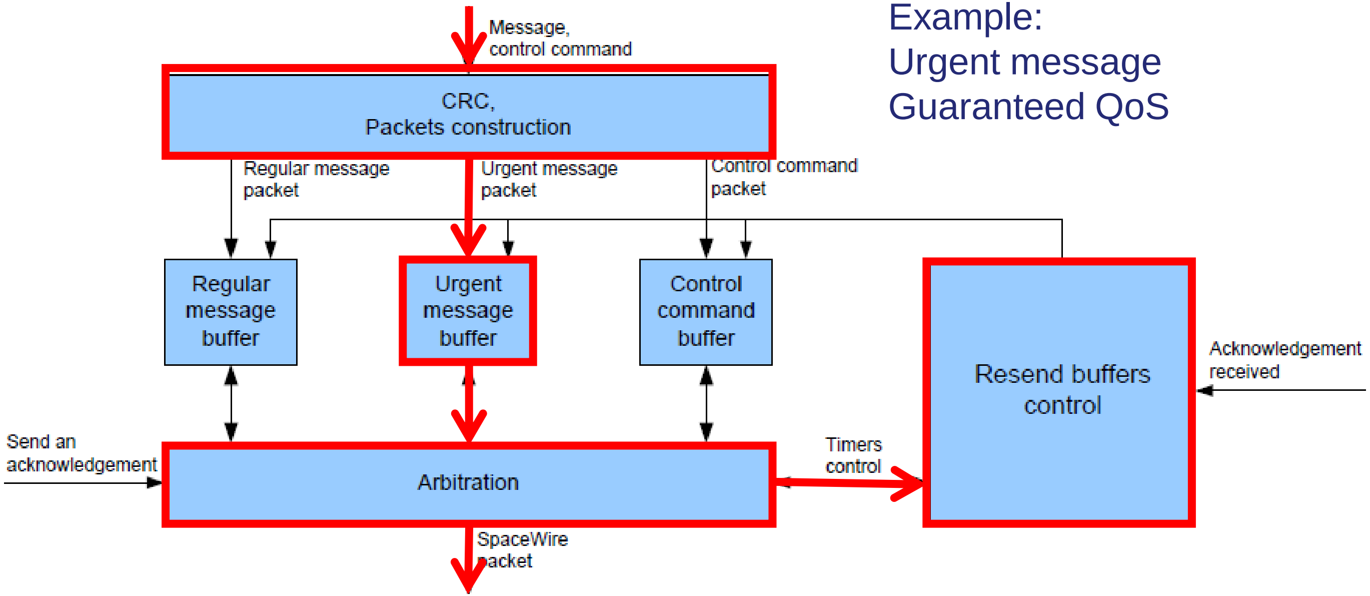
IMPLEMENTATIONS MECHANISMS



Example:
Urgent message
Guaranteed QoS

- Steps to emit a message:

1. Packet construction
2. Place in corresponding buffer
3. Choice of next message to send
4. If Guaranteed QoS activated, keep copy in resend buffer

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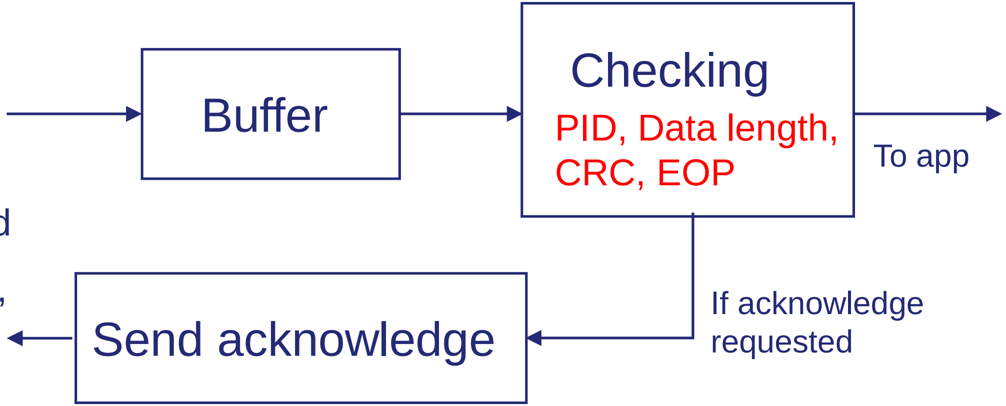
2. IMPLEMENTATIONS MECHANISMS

- **Steps when receiving a message:**

1. Check if packet is correct
   1. If not correct and best effort QoS: send to app with error flag
   2. If not correct and guaranteed QoS, discard
2. If acknowledge is needed and packet correct, send it back



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VALIDATION PHILOSOPHY

- **Basic Tests** have been carried out:
  - point-to-point network realization
  - small architecture with a single router for QoS scheduling
- One for each characteristic:
  - standard STP-ISS characteristics and parameters
  - One section for each QoS
- Principles: traces sources of NS3 to validate the implementation
- **Finally, Complex network simulation** using STP-ISS end-points: MTG

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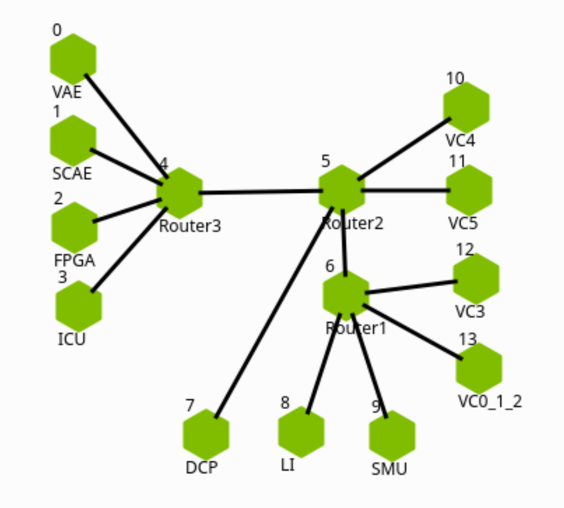
VALIDATION : MTG SIMULATION FINAL TEST

SpaceWire Network architecture of MTG designed with MOSTGUI:



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Traffic definition:

Source	Destination	Useful Data	Packet Type	Guaranteed	Packet Size	Period
LI	VC3	Mission Data	Regular		1024 bytes	274us
DCP	VC5	Mission Data	Regular		1016 bytes	221us
SMU	VC0	HK	Regular		103 bytes	206ms
SMU	VC1	Memory dump report	Control Command	Yes	103 bytes	275ms
SMU	VC2	Auxiliary reports	Urgent		103 bytes	4,12ms
SMU	SCAE	Work plan	Urgent	Yes	4104 bytes	4,10ms
SCAE	VC4	Mission Data	Urgent		943 bytes	50ms
SCAE	VC4	Mission Data	Urgent		727 bytes	50ms
VAE	FPGA	Mission Data	Urgent		1425 bytes	1,5112 ms
VAE	FPGA	Mission Data	Urgent		4449 bytes	1,5112 ms
VAE	FPGA	Mission Data	Urgent		1425 bytes	1,5112 ms
VAE	FPGA	Mission Data	Urgent		5457 bytes	1,5112 ms
FPGA	VC4	Mission Data	Urgent		1425 bytes	1,5112 ms
FPGA	VC4	Mission Data	Urgent		4449 bytes	1,5112 ms
FPGA	VC4	Mission Data	Urgent		1425 bytes	1,5112 ms
FPGA	VC4	Mission Data	Urgent		5457 bytes	1,5112 ms
ICU	VC4	Auxiliary Reports	Regular		1024 bytes	150000 ms

Only 3 priorities are used

→

Simulation results and conclusion:

- **loss of priorities on the switch** output ports
- some **packets dropped due to life timer expiration**
- **latency greater than 1ms** for some high priority packets

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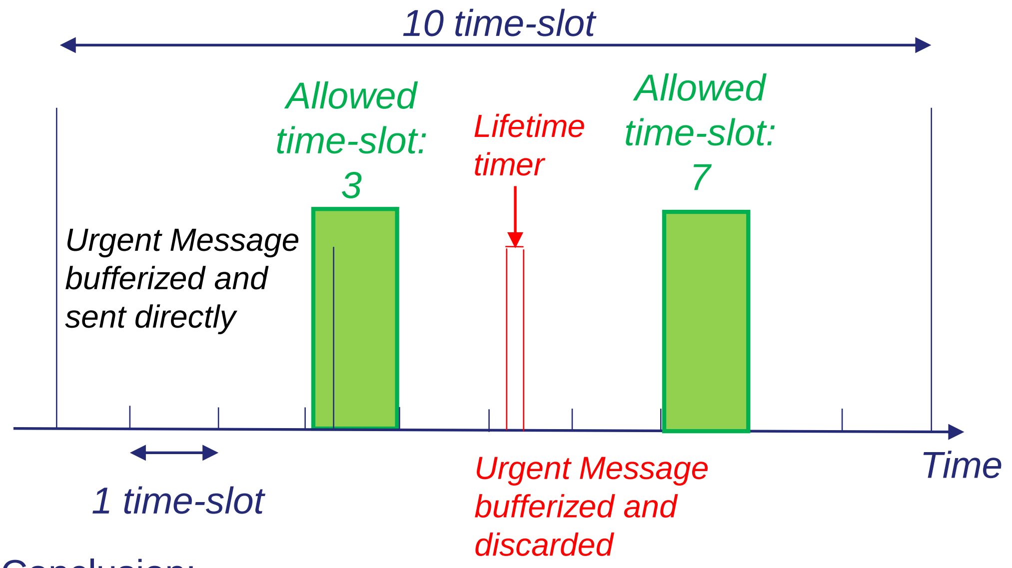
COMMENTS & REMARKS

IMPLEMENTATION QUESTION ON SCHEDULING QOS

Scheduling QoS: What happens when a message is buffered in a non-allowed time-slot?



Defined in the specification:
Lifetime timer < Time-slot duration

Configuration parameter	Default value
Control command packet lifetime	1,25 ms
Urgent message packet lifetime	2 ms
Regular message packet lifetime	4 ms
TC urgent message packet lifetime	64 ms
TC regular message packet lifetime	128 ms
Resend timer value	1 ms
TC packet resend timeout	64 ms
Guaranteed QoS	Off
Scheduling	Off
Time-slot number	32
Time-slot duration	31,25 ms
Schedule	Transmission allowed in all time-slots
Time-code relevancy window	2
TC stand-by timeout	525 ms

Conclusion:

1. Forcing the SW to buffer during allowed time-slots (constraints SW)
2. Letting the packet discard if not well configured

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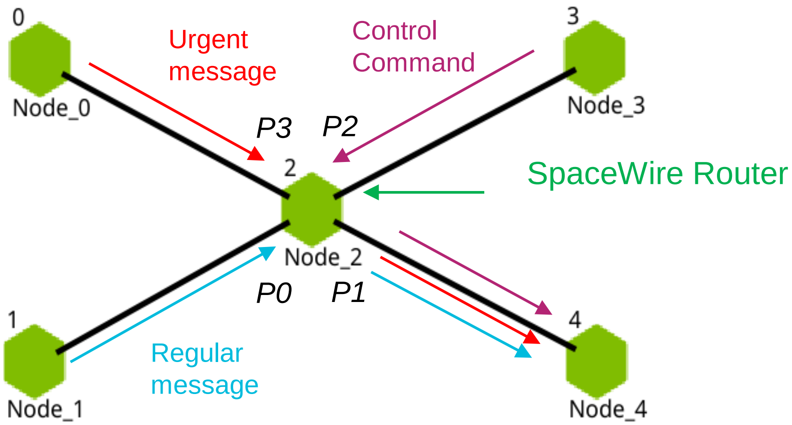
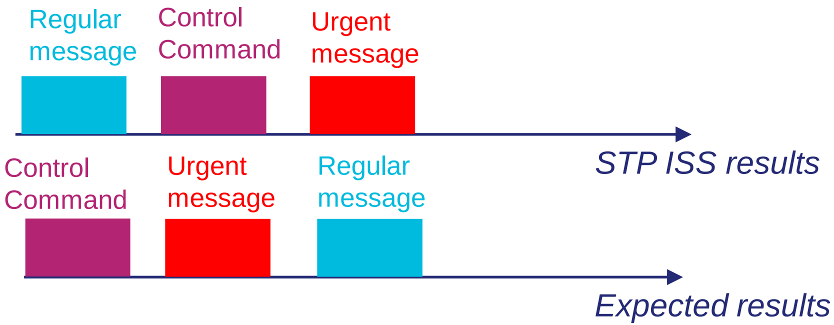
REMARKS ON THE STP-ISS SPECIFICATION

- Selection of priority only at the **end-point level → **loss of the notion of priority in SpaceWire Routers

- SpaceWire Routers use **Round-Robin Arbitration**

- Solution: add a specific router for STP-ISS, which would follow the **arbitration with priorities**





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CONCLUSION

- Attractive solution to **improve the quality of the SpaceWire** protocol
- Priority mechanism enables to configure and manage **mixed-criticality traffic**
- Scheduling and Guaranteed QoS bring a high level of determinism having **guaranteed delivery and guaranteed bandwidth.**
- **Lack of deterministic mechanism** implemented at the router level.
- **Only simulation part** of the mechanism of the STP-ISS data transport protocol
  → no HW implementation and no FPGA footprint size estimation: depend on the size of buffers at endpoint level.

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QUESTIONS?

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