

SpaceWire-RT Standard Simulation Models

PhD student, Researcher, EmCoMobile R&D Lab, SUAI
ilya.korobkov@guap.ru

Ilya Korobkov

Researcher, EmCoMobile R&D Lab, SUAI
irina.lavrovskaya@guap.ru

Irina Lavrovskaya

Ph.D., Senior Researcher, EmCoMobile R&D Lab, SUAI
valentin.olenev@guap.ru

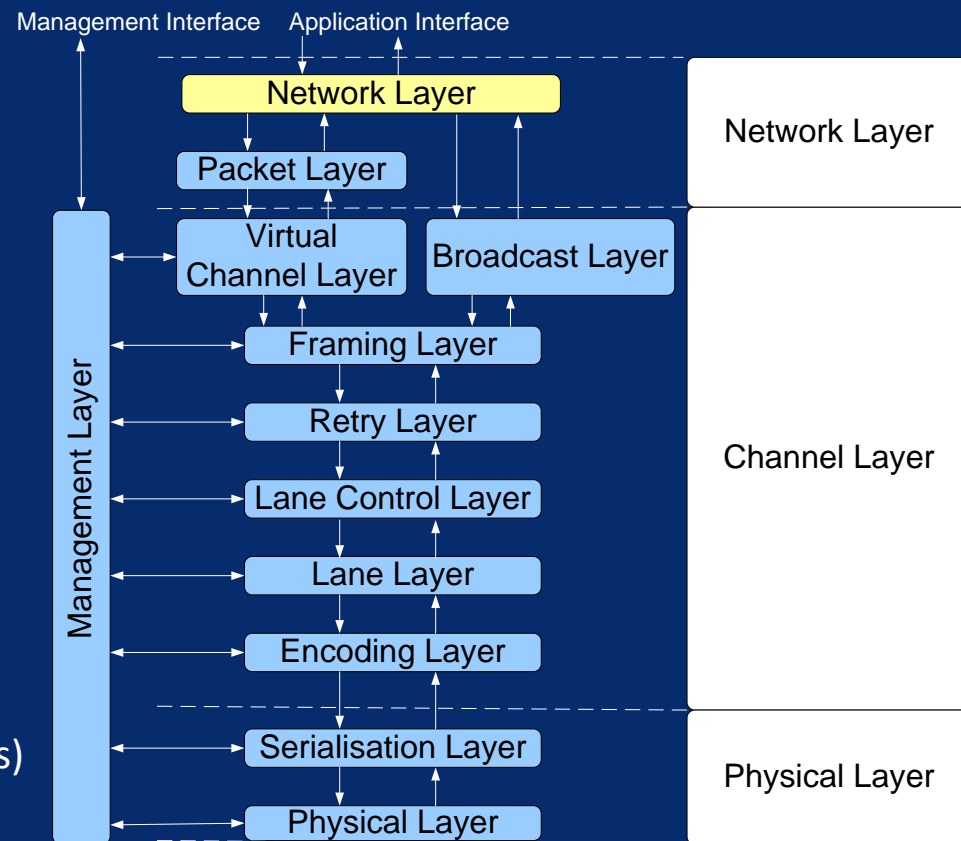
Valentin Olenev

SpaceWire-RT – new communication onboard standard designed in terms of FP7 SPWRT project, under grant agreement n° 263148

Features:

- ▶ It is based on SpaceFibre technology;
- ▶ data rates 2 Gbits/s (potentially up to 20 Gbits/s);
- ▶ multiple data transfer via virtual channels;
- ▶ broadcast message transfer;
- ▶ various kinds of Quality of Service and data flow control;
- ▶ fault detection, isolation and recovery methods;
- ▶ reliable data delivery (checking CRC and others)

SpaceWire-RT stack OSI reference model

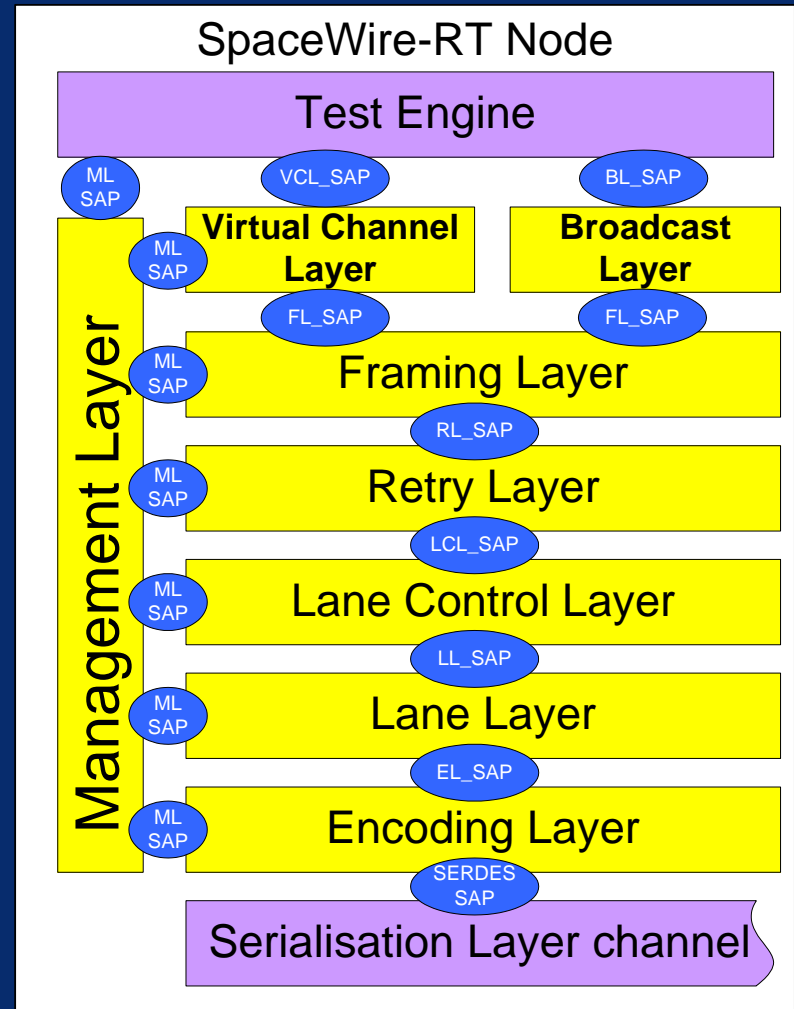


The SPACEWIRE-RT project has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no. 263148



SpaceWire-RT SDL Point-to-Point model (1/2)

- SDL model **implements all layers** of the SpaceWire-RT protocol stack (except the Serialisation and Network Layers);
- It describes the **internal mechanisms** and functionality of the layers
- Each pair of adjacent layers communicates via a special interface between them, which is called a Service Access Point (SAP);
- The test system comprises:
 - two SpaceWire-RT nodes
 - Serialisation Layer channel.
 - Test Engine, which performs configuration and generation of test sequences.
- This simulation gave an ability to check all internal mechanisms of investigated layers and verify them.

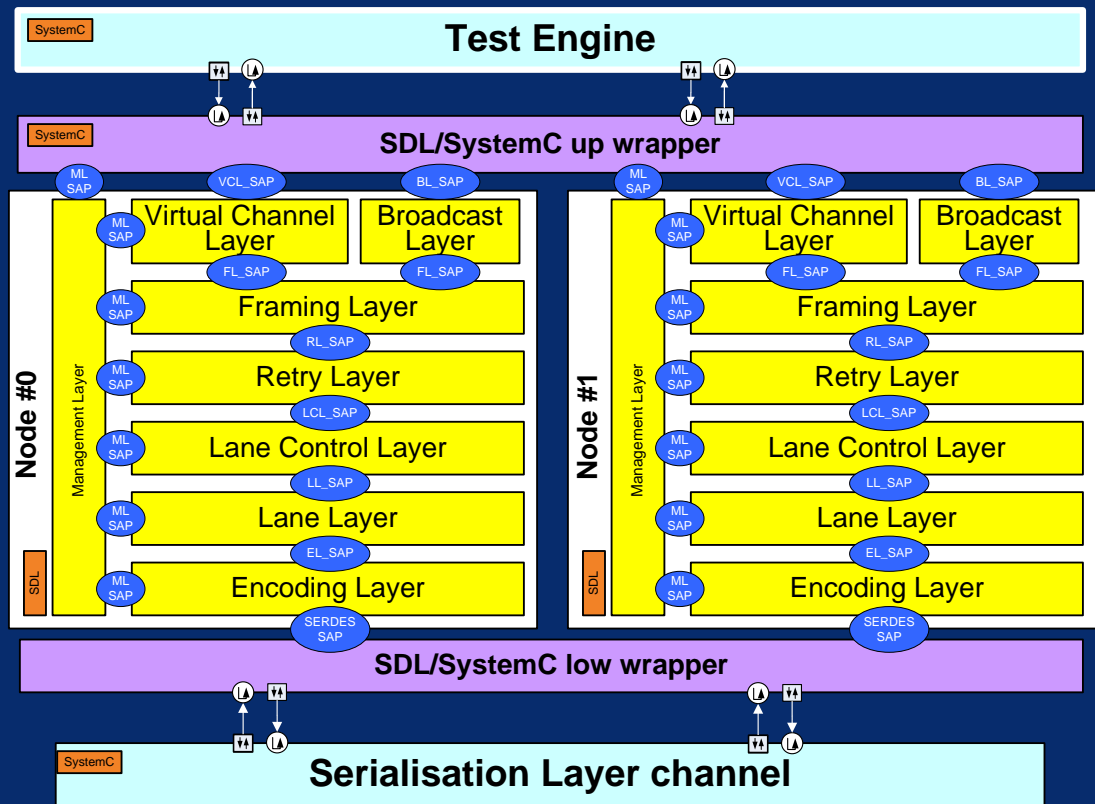


The SPACEWIRE-RT project has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no. 263148

SDL/SystemC tester provides a possibility for simulation of a *point-to-point interconnection* between two nodes implemented in SDL and communicating via a channel implemented in SystemC.

The tester is a flexible tool:

- ✓ setting different configurations;
- ✓ generating various test sequences;
- ✓ gathering statistics.



The aim of the Network model development is to **simulate communication of devices via the SpaceWire-RT network**.

The SpaceWire-RT network model consists of:

- SpaceWire-RT stack model, which provides main functions of SpaceWire-RT;
- Node model;
- Switch model.

It supports different topologies:

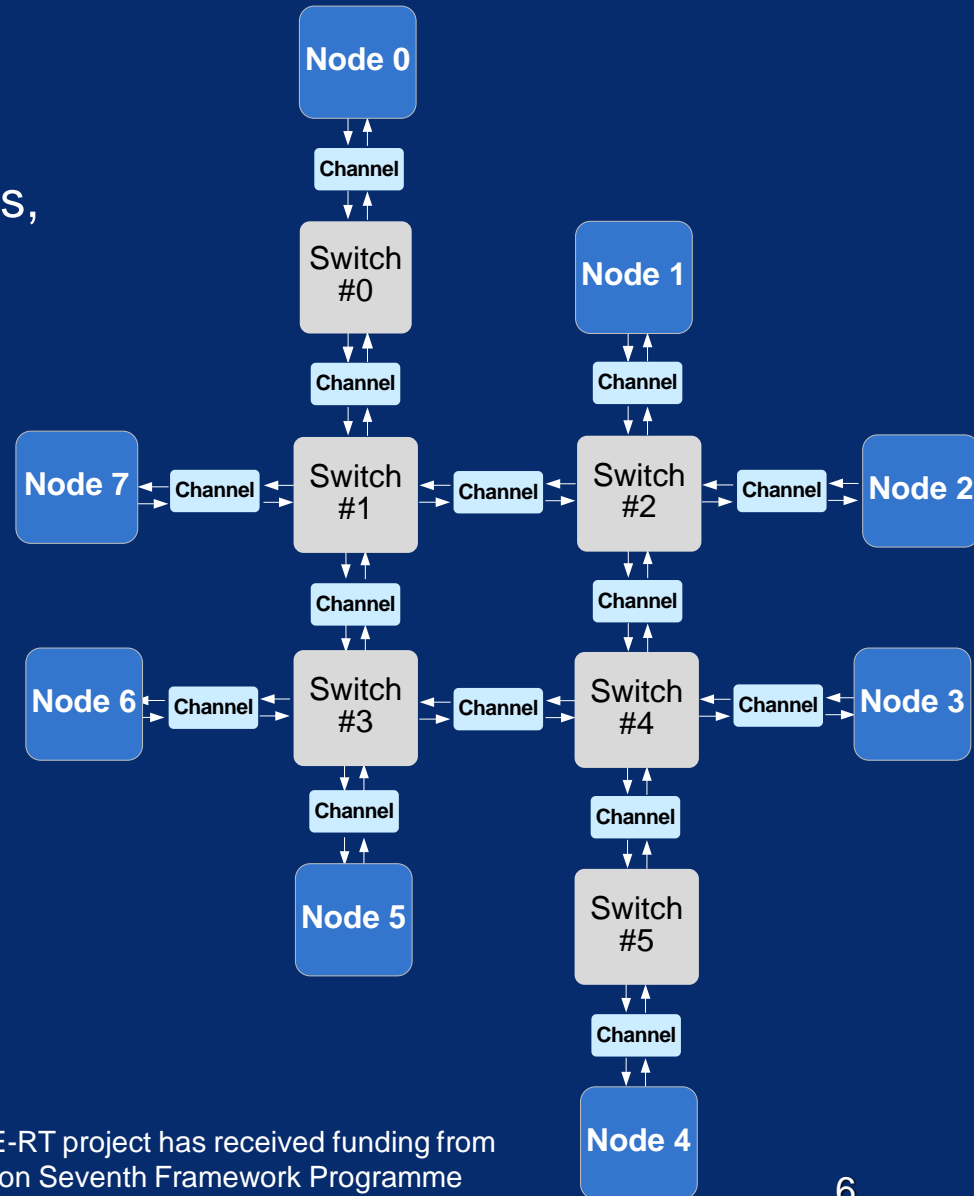
- tree;
- circular;
- mixed.

For testing of network mechanisms we used **the mixed configuration**, which is a combination of tree and circular topologies.



The SPACEWIRE-RT project has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no. 263148

- **Mixed configuration** gave an opportunity to check the network parameters:
 - latencies for different packet sizes,
 - reliability of data transfer with specific BER (Bit Error Rate),
 - various QoS (Quality of Service),
 - fault packet detection and identification,
 - failure and fault tolerance of a network (deadlock),
 - broadcast
 - multi-cast,
 - path and logical addressing.

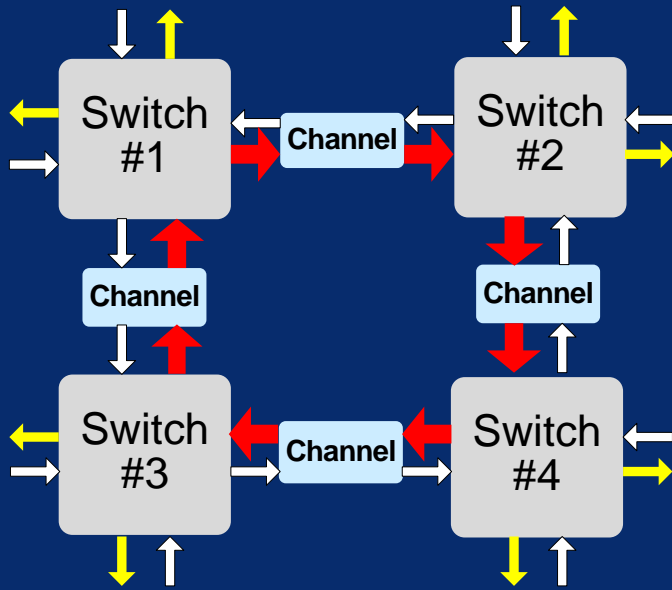


SpaceWire-RT Simulation Results (1/3)

SpaceWire-RT standard was checked on conformance to the Russian and European industry requirements

NOT provide:

- $Latency_{BROADCAST} < 100 \text{ ns}$ over $S_{ONE-SWITCH}$
- mechanism of discard broadcast messages in switches during the repeated transmission over $S_{CIRCULAR}$



Used notations:

- $Latency_{BROADCAST}$ – deliver time of broadcast messages;
- $S_{ONE-SWITCH}$ – SpaceWire-RT network with one switch between nodes;
- $S_{CIRCULAR}$ – SpaceWire-RT network with circular topology.

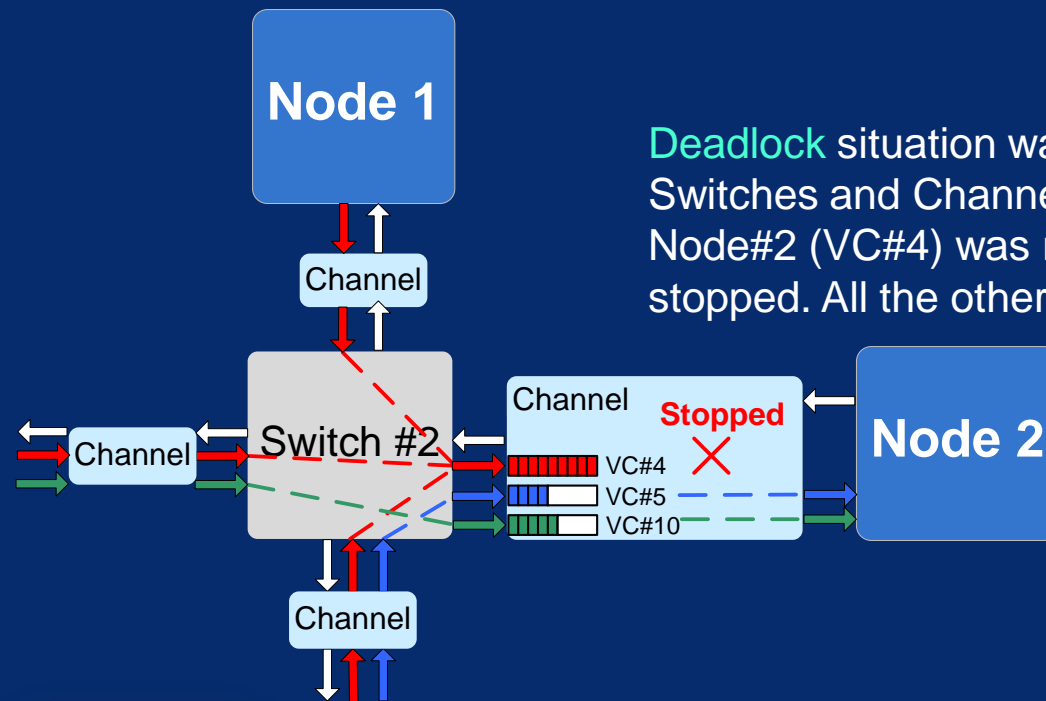


The SPACEWIRE-RT project has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no. 263148

SpaceWire-RT Simulation Results (2/3)

Successfully **provide**:

- ✓ reliable data delivery via checking CRC, mechanism of automatic acknowledgments ACK/NACK and others;
- ✓ Automatic fault detection at different layers of the stack by means of checking specific packet fields at every layer;
- ✓ data transfer via virtual channels, when there is *Deadlock* for one virtual channel



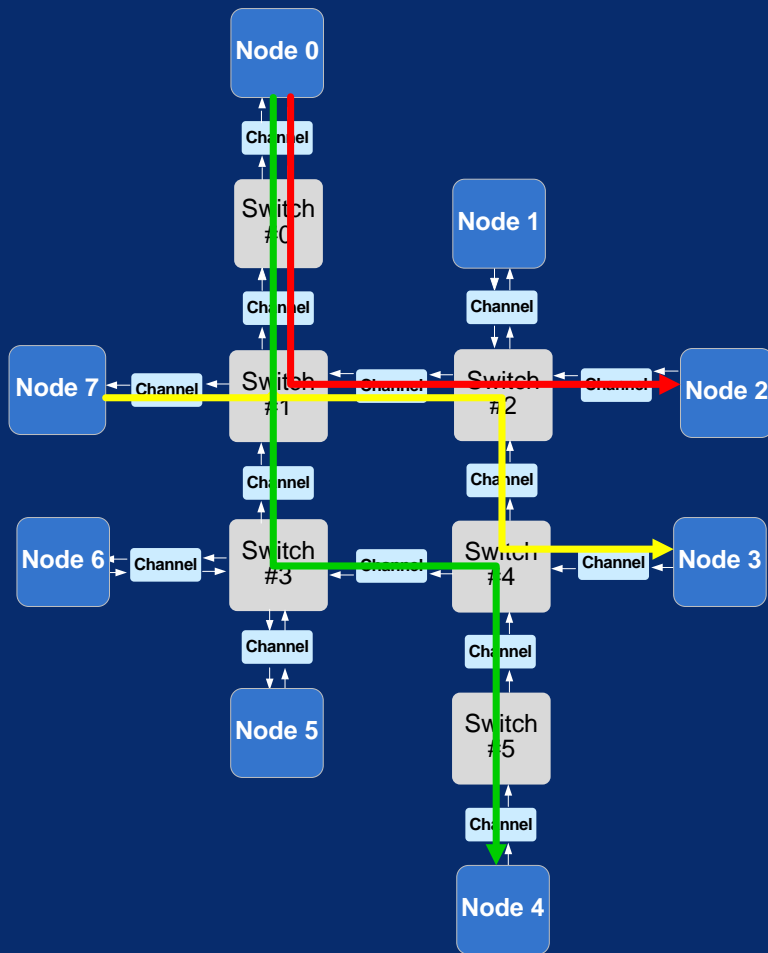
Deadlock situation was modelled by a special configuration of Switches and Channels: channel between the Switch#2 and the Node#2 (VC#4) was made full so the data transmission for this VC stopped. All the other data transmissions for the VC#4 to the Node#2 also stopped. The model started to work slower, but the transmission of the data to the Node#2 via the other virtual channels (VC#5, VC#10) did not stop



The SPACEWIRE-RT project has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no. 263148

Successfully **provide**:

- ✓ multicast and multipath transmission;
- ✓ mechanism of automatic acknowledgments at the Retry Layer;
- ✓ deterministic data delivery via $QoS_{SCHEDULED}$.



Time Slot	Test Schedule #1			Test Schedule #2		
	VC #2	VC #5	VC #13	VC #2	VC #5	VC #13
0	Red					Yellow
1		Green				Yellow
2			Yellow		Green	
3		Green			Green	
4	Red				Green	
5		Green		Red		
6			Yellow			Yellow
7		Green				Yellow
8	Red				Green	
9		Green			Green	
10			Yellow		Green	
11		Green		Red		
12	Red					Yellow
...						
60	Red				Green	
61		Green		Red		
62			Yellow			Yellow
63		Green				Yellow

- Found ambiguities in specification.
- Prepared a set of additions and clarifications to the specification.
- New version of the SpaceWire-RT standard is produced and it is based on the simulation impact.

Lates news and results of the project are available on web-site:

www.spacewire-rt.org



The SPACEWIRE-RT project has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no. 263148

THANK YOU



The SPACEWIRE-RT project has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no. 263148

SDL P2P model

- Simulation of the point-to-point communication (i.e. the model comprises nodes and channels).
- Formal specification which can be used for:
 - checking the SpaceWire-RT for ambiguities and inconsistencies in the internal mechanisms on a per-layer basis.
 - checking of *functional requirements*, defined for the standard.
- Validation and verification of SpaceWire-RT standard.
- Formal reference for the SpaceWire-RT.
- SDL/SystemC tester providing abilities for:
 - different configurations,
 - generating various test sequences,
 - gathering statistics.

SystemC Network model

- Simulation of the SpaceWire-RT network operation (comprises nodes, routing switches and channels).
- Possibility for simulation of networks of various topologies (tree, circular, mixed)
- Investigation and proving the network level features and characteristics of the SpaceWire-RT standard.
 - Performance characteristics
 - Network FDIR
 - Quality of service provision
- Checking of *non-functional requirements*, defined for the standard.

