SpaceWire-RT/SpaceFibre simulation models: implementation and application
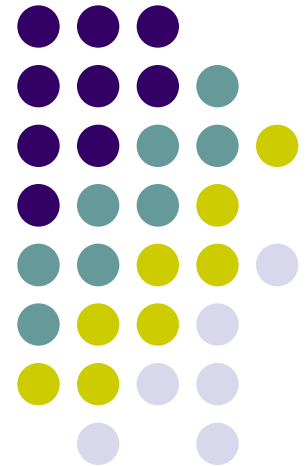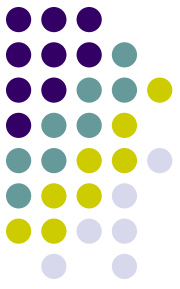
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SystemC

SystemC is a set of C++ classes and macros that provide an event-driven simulation engine. It is specifically designed for modeling parallel systems. This library allows describing multi-component systems and program components, and modeling their operation. By using the internal mechanism of events it allows to model operations distributed in time of the modeled system.

In contrast to pure C++, SystemC has following additions:

1) Processes
2) Events
3) Ports and channels
4) Timers and delays
5) Signals
6) FIFO
7) Special data types

and so on…

SDL
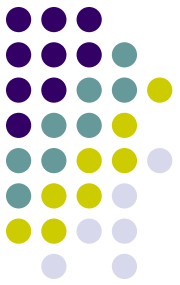
SDL (Specification and Description Language) is a language for unambiguous specification and description of the telecommunication systems behavior.

The SDL model covers the following five main aspects: structure, communication, behavior, data and inheritance.

SDL language is intended for description of structure and operation of the distributed real-time systems.

Writing an SDL model on the basis of the specification is itself a test of the specification for completeness and unambiguousness. As a result the consistent readable textual description and formalised specification in SDL are produced.

SpaceWire-RT standard
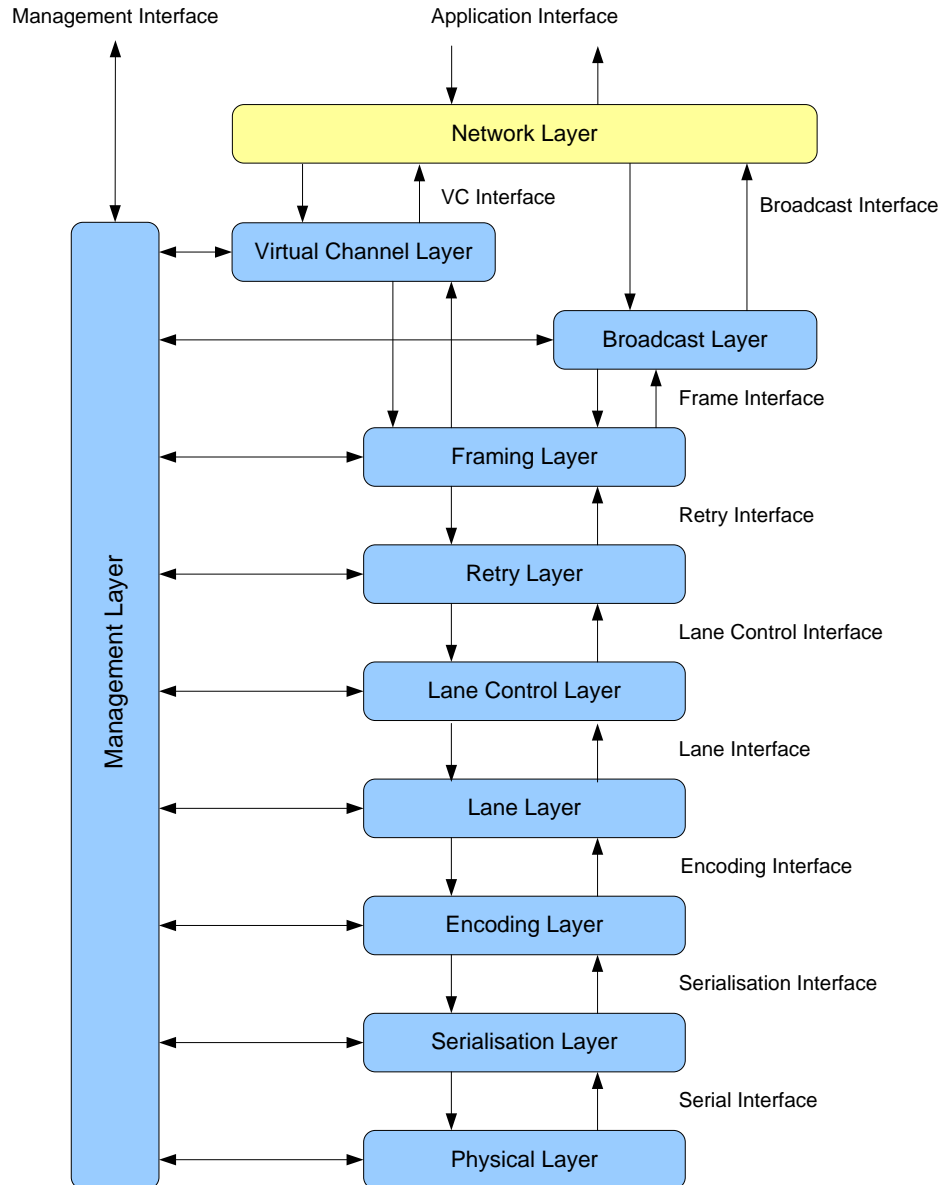
- The standard is developed in terms of FP7 SPWRT project, under grant agreement n° 263148.
- SpaceWire-RT standard is based on the SpaceFibre technology.
- An addition to SpaceFibre – Network layer.

SpaceWire-RT SDL Modeling

Simulation and investigation was done in two steps:

- verification of the SpaceWire-RT protocol stack by simulation in IBM Rational SDL Suite. This simulation gave an ability to check all internal mechanisms of investigated layers and verify them.

- validation of the SpaceWire-RT protocol stack by means of simulation within an SDL/SystemC tester.
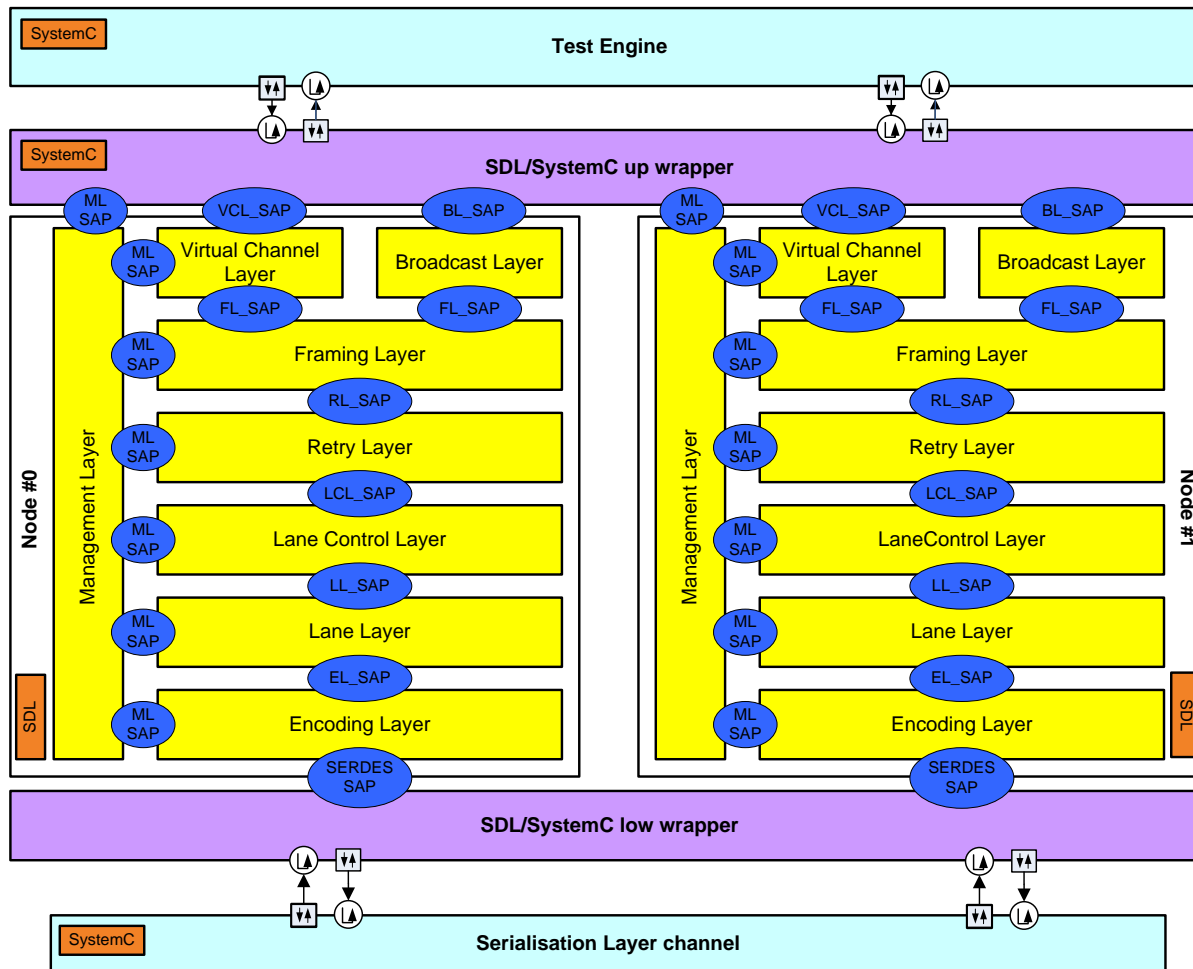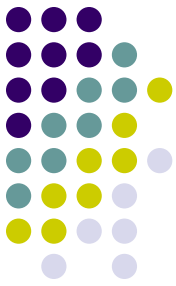
SpaceWire-RT P2P Model in SDL
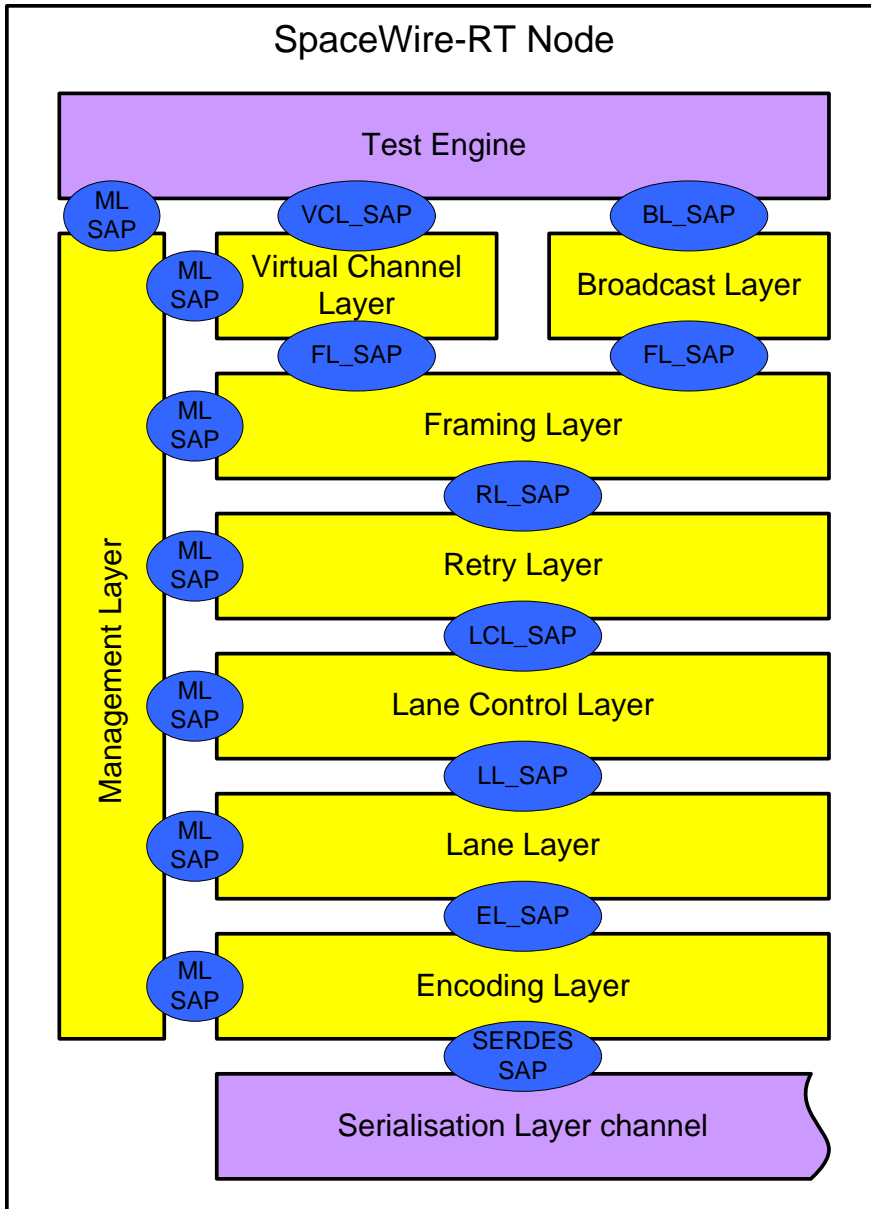
- The SDL model implements all layers of the SpaceWire-RT protocol stack, except the Serialisation and Network Layers;
- It describes the internal mechanisms and functionality of the layers
- Each pair of adjacent layers communicates via a special interface between them, which is called a Service Access 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.

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SpaceWire-RT SDL/SystemC tester

The 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 for setting different configurations, generating various test sequences and gathering statistics.

SpaceWire-RT Network Model in SystemC

- The aim of the SpaceWire-RT SystemC model development is to simulate communication of devices via the SpaceWire-RT network.
- The SpaceWire-RT network model consists of the following SystemC modules:
  - SpaceWire-RT stack model, which provides main functions of SpaceWire-RT;
  - SpaceWire-RT node model;
  - SpaceWire-RT switch model.
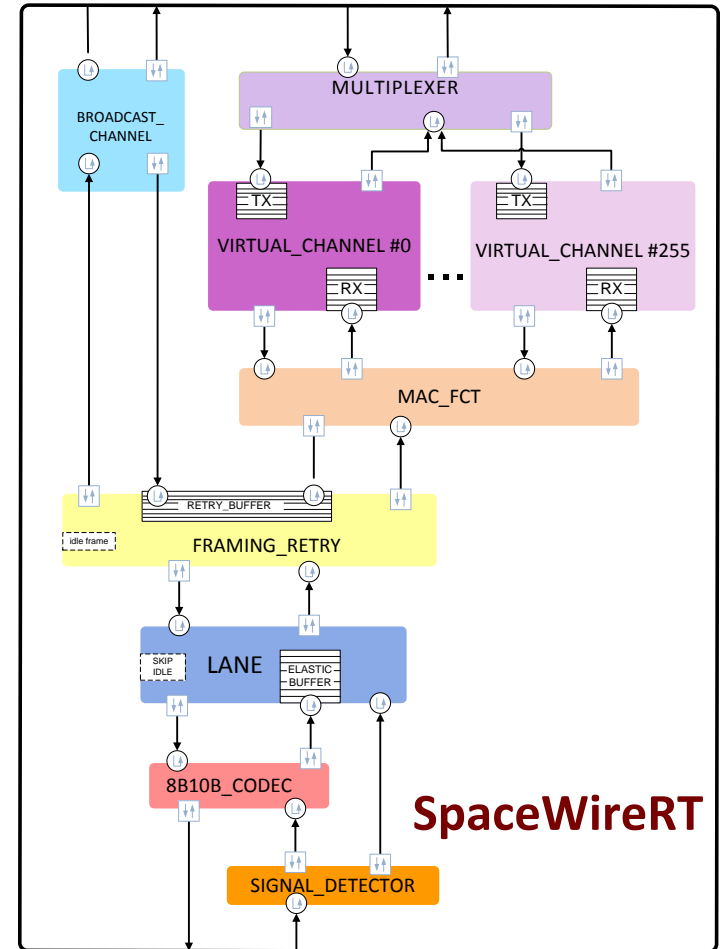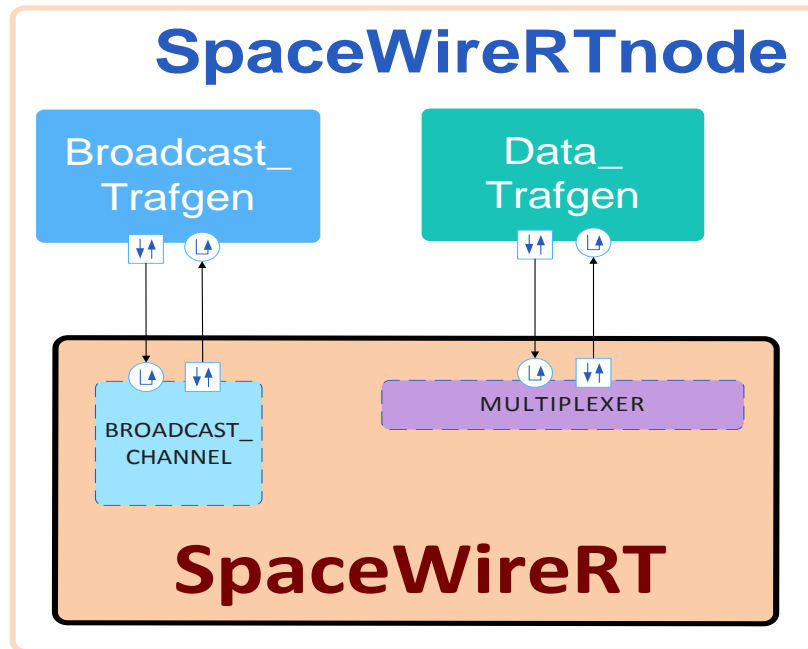
# **SpaceWire-RT Network Model in <u>SystemC</u>**

- The SpaceWire-RT network model contains a number of nodes and switches.

- Different topologies:
    - tree;
    - circular;
    - mixed.

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

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SpaceWire-RT Network Model in SystemC

- Mixed configuration gave an opportunity to check the following 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 and babbling idiot),
  - broadcast
  - multi-cast,
  - path and logical addressing.

  Any kind of a network structure could be assembled and tested.
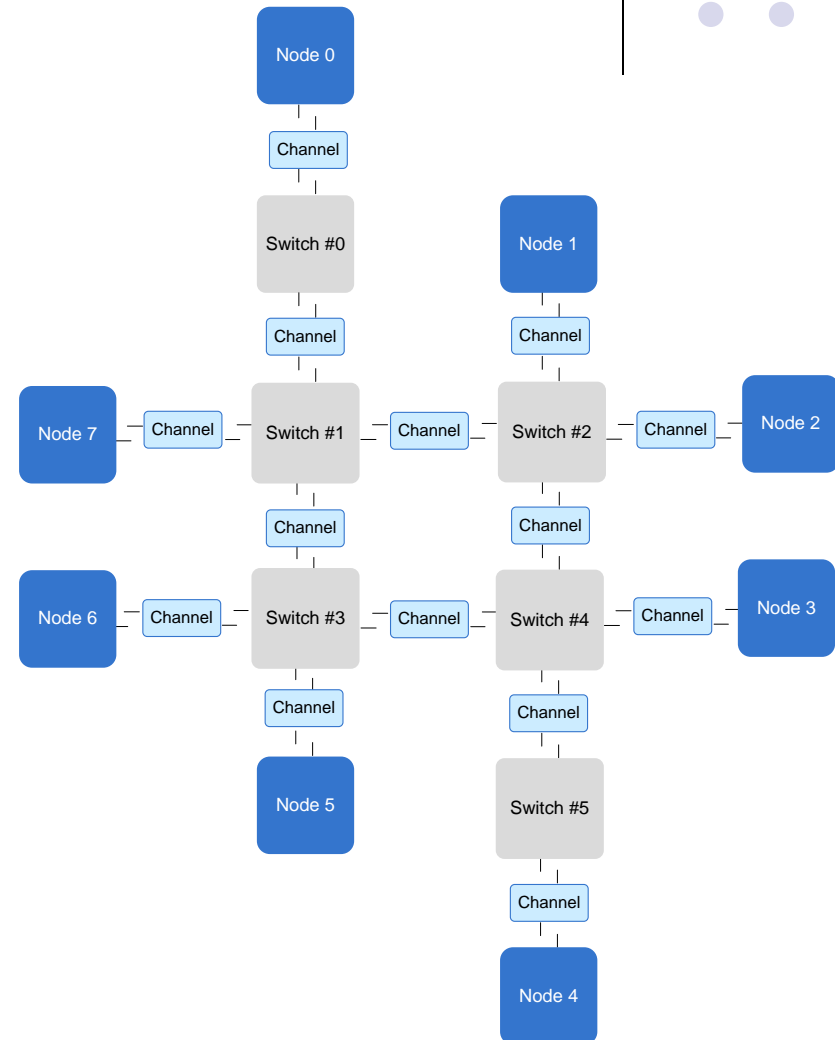
SDL and SystemC models features
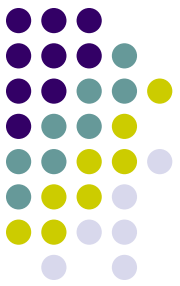
SDL model

- 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 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.

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SpaceWire-RT Models Future Use
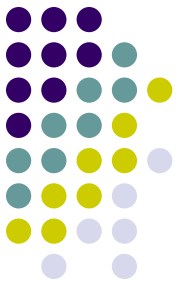
- SpaceFibre standard, which is the basis for the SpaceWire-RT standard, is in process of development.

- Any changes in SpaceFibre will result in changes of the SpaceWire-RT specification.

- New mechanisms and updated old ones can be successfully simulated on the SpaceWire-RT SDL and SystemC models by changing necessary parts of the models. So both models will follow the specification development process.
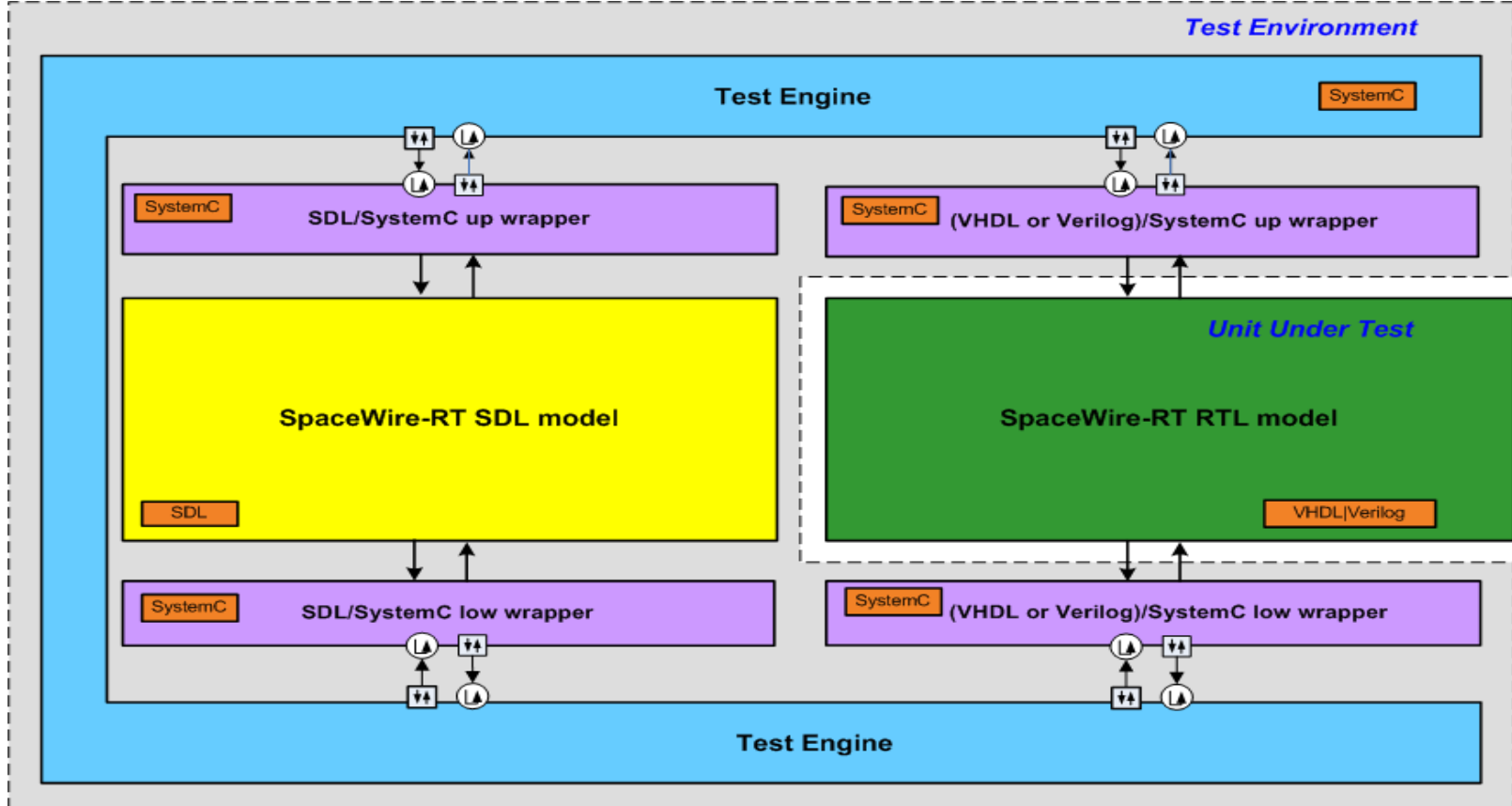
SpaceWire-RT Models Future Use: SDL Model
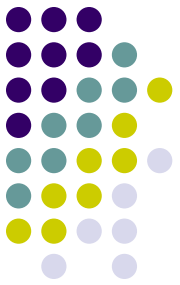
- Any changes in the new releases of the specification can be applied to the SpaceWire-RT SDL model. This would not cause any difficulties, as local changes in one layer will not affect the other layers.

- The SDL model can be used for verification of the new mechanisms in a stack during the development. It can help to make a decision on what mechanism to choose to be included to the new version of the specification.

- The SDL/SystemC tester gives opportunities for creation of complicated test sequences and for non-nominal testing.

- SDL model, as a reference, can be used for SpaceWire-RT hardware implementation testing (SDL model on one side and VHDL implementation – on the other).
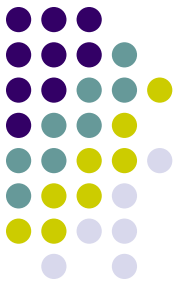
SpaceWire-RT hardware implementation testing
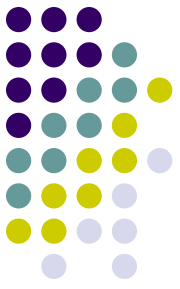
- SDL model will be a part of the test environment for the RTL model
- SDL model will be used for verification of the RTL model as a reference model
- SystemC Test Engine sends the same tests to both SDL model and RTL model and analyses results
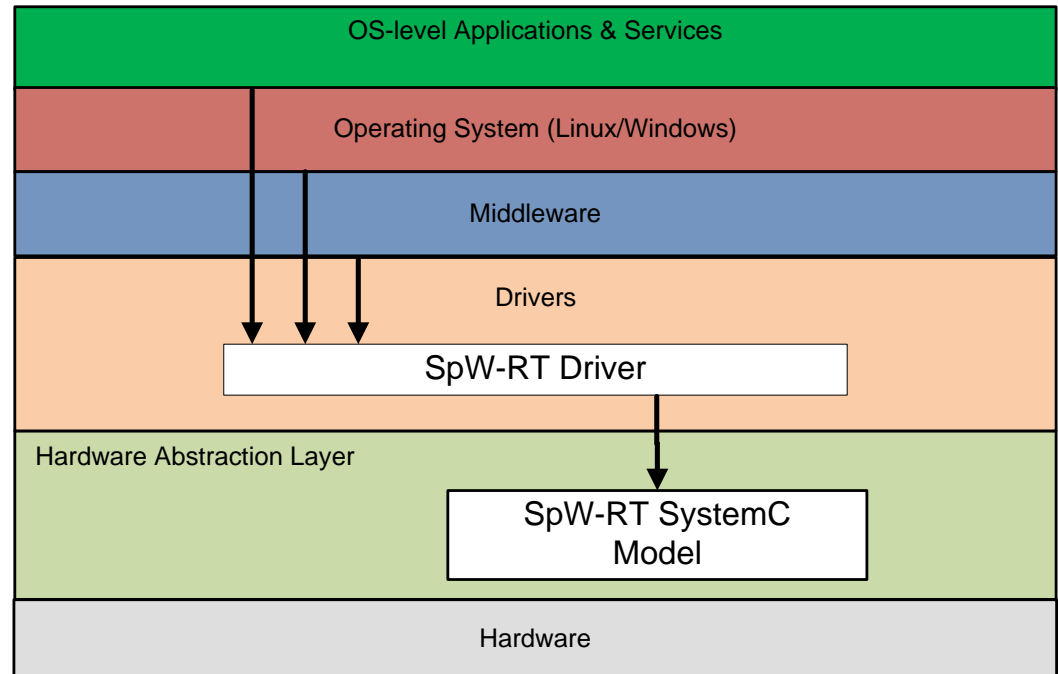
SpaceWire-RT Models Future Use: SystemC Model

- The SystemC model can be efficiently used for obtaining network performance characteristics such as latencies, QoS mechanisms operation, etc.

- SpaceWire-RT Network Layer is currently under development the SystemC model also will be applied for its further validation.

- SpaceWire-RT SystemC network model can give an opportunity for investigation of Transport Layer protocols operation over the SpaceWire-RT network (e.g. RMAP, STP, etc.).

SpaceWire-RT Models Future Use: SystemC Model

- SDL and SystemC models can be used for development of applications and drivers for future SpaceWire-RT devices.

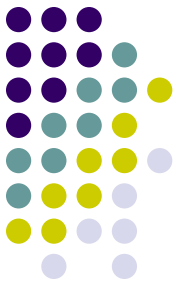| OS-level Applications & Services |
|---|
| Operating System (Linux/Windows) |
| Middleware |
| Drivers |
| SpW-RT Driver |
| Hardware Abstraction Layer |
| SpW-RT SystemC Model |
| Hardware |

SDL and SystemC modeling results:

- The SpaceWire-RT/SpaceFibre mechanisms work correctly.

- A number of inconsistencies in the specification were found → SpaceWire-RT Outline Specification 2.0.

- SpaceWire-RT standard satisfies the requirements of European and Russian industry.

- We got the latency results for the different packet lengths and network structures.

The latest news and results of the project are available on our website.

Thank you

Web-site: http://SpaceWire-RT.org

Contact us: http://SpaceWire-RT.org/Feedback

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