MOST (Modelling of SpaceWire Traffic):
MOST v2.2 presentation

11/04/2013

Ref.: 83230918-DOC-TAS-EN-001

1

MOST short introduction

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MOST short introduction (1/3)

- Current steps of development:
  - Validated simulator delivery and installation in ESA facilities in Q4 2011
  - TAS: simulation activities & continuous development
  - ESA: simulation activities & development of specific needs
  - Now: merging of both developments, adding of new features & new simulation activities to come
- **This new development running on OPNET Modeler ® 16.0 targets a release to the SpaceWire community this year with MOST v2.2**

- People currently involved in MOST:
  - ESA:
    - David Jameux
  - 4Links:
    - Barry Cook
    - Paul Walker
  - Scisys:
    - Peter Mendham
    - Stuart Fowell
  - TAS-F Cannes :
    - Brice Dellandrea
    - Philippe Fourtier
    - Loic Parent
    - Baptiste Gouin

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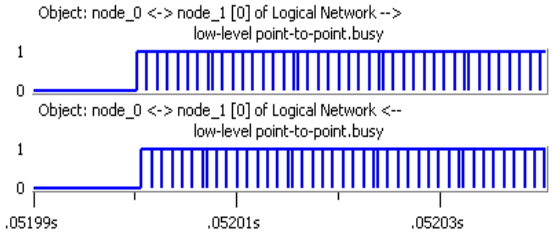
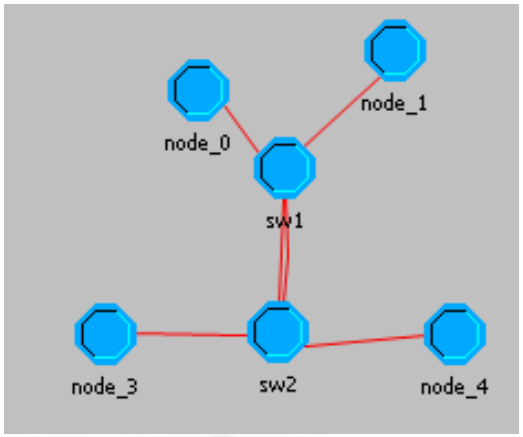
MOST short introduction (2/3)

- MOST simulator is dedicated to the following users:
  - System engineers who have to design network topology and to perform validation tests
  - Developers who would need to test new component features or protocol





- MOST can be used during all phases of a project:
  - During early steps of projects, MOST mainly plays a role in the following design activities :
    - 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
  - During development steps of a project, MOST participates to :
    - Phase C, D : design, validation and investigation
  - During maintenance step of a project, MOST takes part to :
    - Phase E : investigations, support to very specific operations

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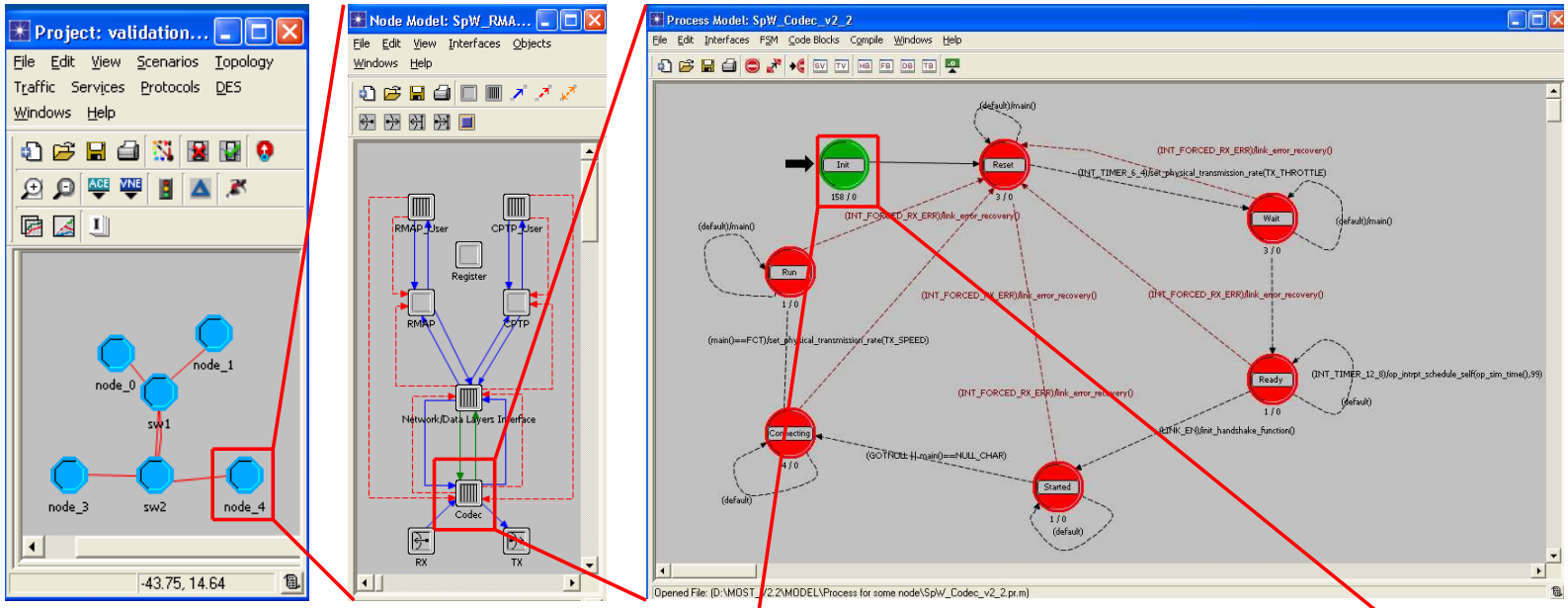
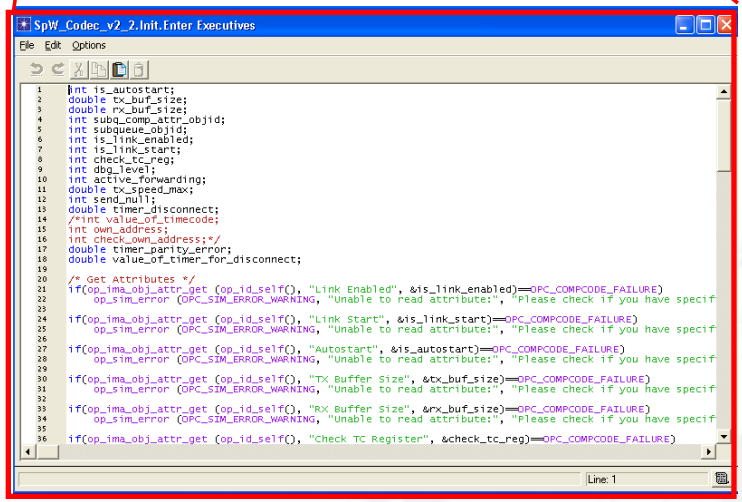
MOST short introduction (3/3)



Project or Network domain | Node domain | Process domain

- MOST is built on 4 different domains:
  - Network domain (connexion between components),
  - Node domain (building blocks/layer decomposition),
  - Process domain (machine states)
  - C code in each automate's states



OPNET Source domain

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MOST v2.2 development targets

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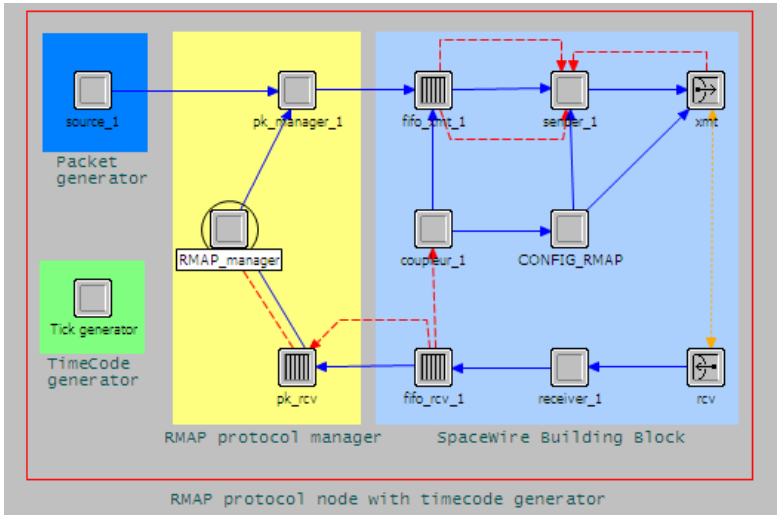
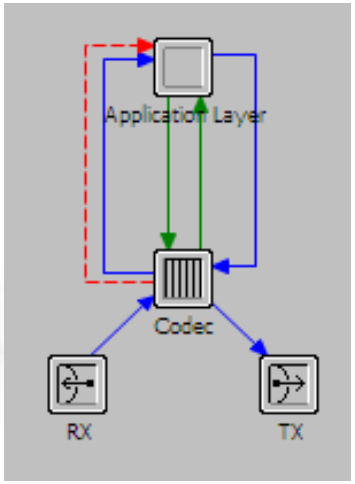
MOST v2.2 release 1: SpW layering simplification

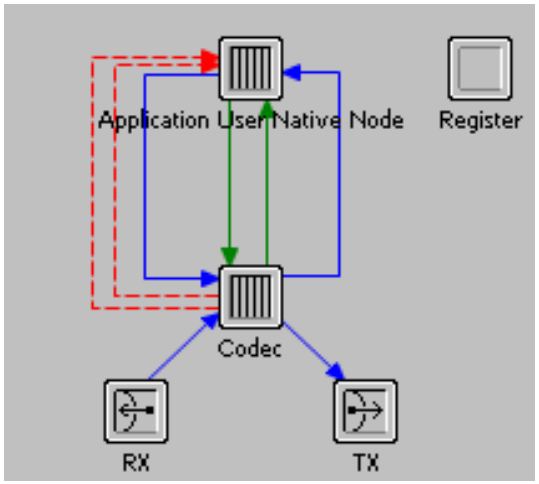
MOST v1.4 (Dec 2011):

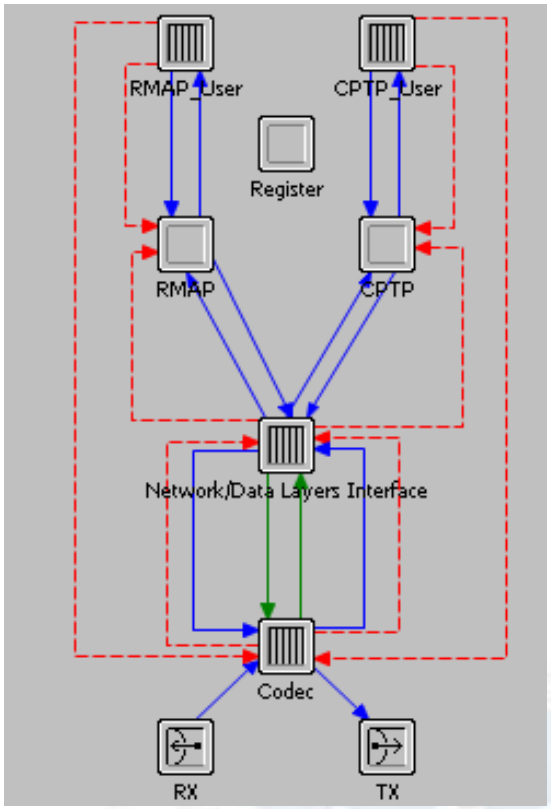


MOST v2.1 (Prototype/June 2012):



MOST v2.2 (Native Node and CPTP& RMAP Node):





Each layer provides an independent set of configurable parameters & statistics

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MOST v2.2 release 1: Performance & easiness of use

- MOST v1.4 was fairly complete:
  - Components:
    - Generic CPTP & RMAP Node
    - SPW 10X Router
    - SMCS116SPW & SMCS332SPW
    - Remote Terminal Controller
    - From MTG simulation: Generic Buffer coupling node
    - From MTG simulation: Generic Virtual Channel Multiplexer
  - Links: SpaceWire link

- MOST v2.2 release 1 currently implements:
  - Generic Native Node (CODEC + Application)
  - Generic CPTP & RMAP Node (CODEC + PID + CPTP + RMAP + Applications)
  - Generic Switch (CODECs + PID + RMAP + Application)
  - Other components to be added later on

  → ***Easier to use & adapt to user's needs and faster***

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MOST v2.2 components

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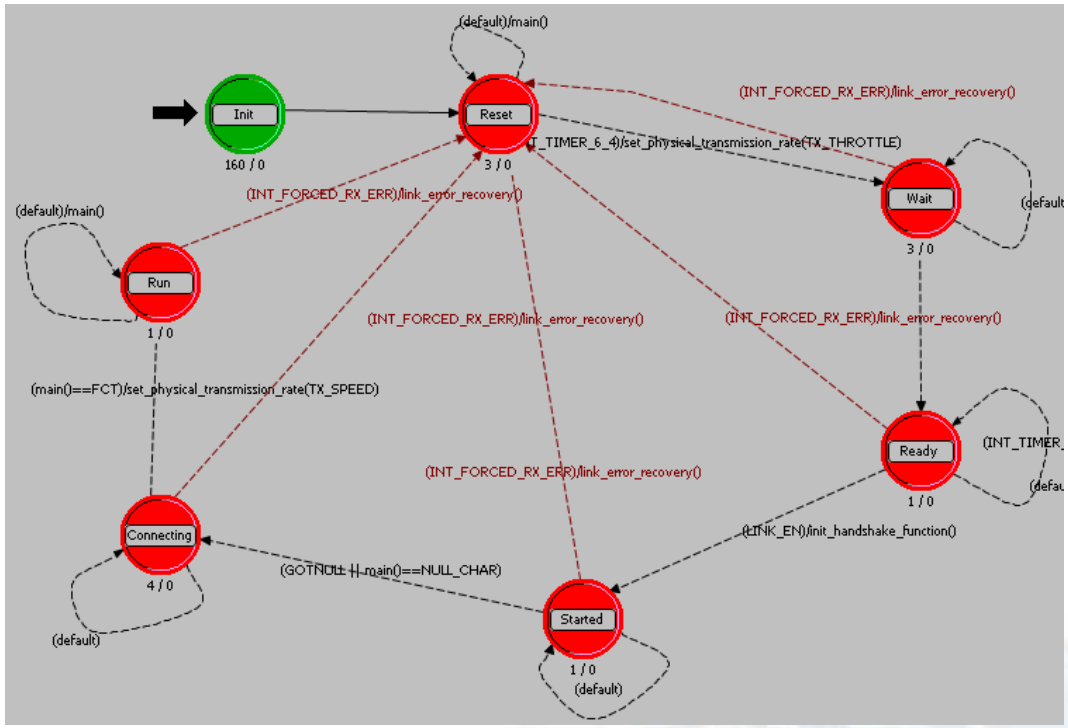
MOST v2.2 release 1: A single common building block: SpW CODEC

- The same Building Block is implemented in all components: **the SpW CODEC**
  - It is implementing ECSS-E-ST-50-12C: Network, Link, Signal & Physical layers

- Configurable through OPNET user interface:
  - Link Enabled status (= NOT [Link disabled])
  - Autostart status,
  - Link Start status
  - TX Data Rate,
  - RX Buffer Size,
  - Debug Level,
  - Show NULL Messages,
  - Timer Disconnect,
  - Timer Parity Error,
  - Delay For Disconnection After Parity Error,
  - Initial Timecode Register Value.



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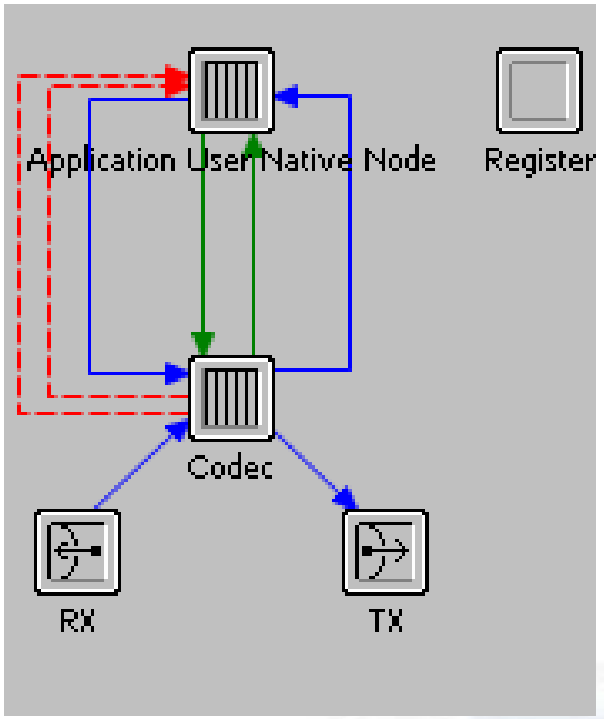
MOST v2.2 release 1: Native Node presentation

- Native Node is quite basic:
  - CODEC + Application
- Protocol handling: ECSS-E-ST-50-12C
  - Packets (without PID!!)
    - Packet Emission & Reception buffers in Application layer
  - Time-codes with a local register
- The application is fairly generic and configurable:
  - Timecode Master status,
  - Timecode Interarrival Time,
  - Time Code Start & Stop Time,
  - Debug Level,
  - Packet Type,
  - Cargo Size,
  - SpW Packet Interarrival Time,
  - SpW Destination Address,
  - Packet Generator Start & Stop Time,
  - SpW Packet Deadline.



- **! The application is developed in C-Code and can be easily modified !**

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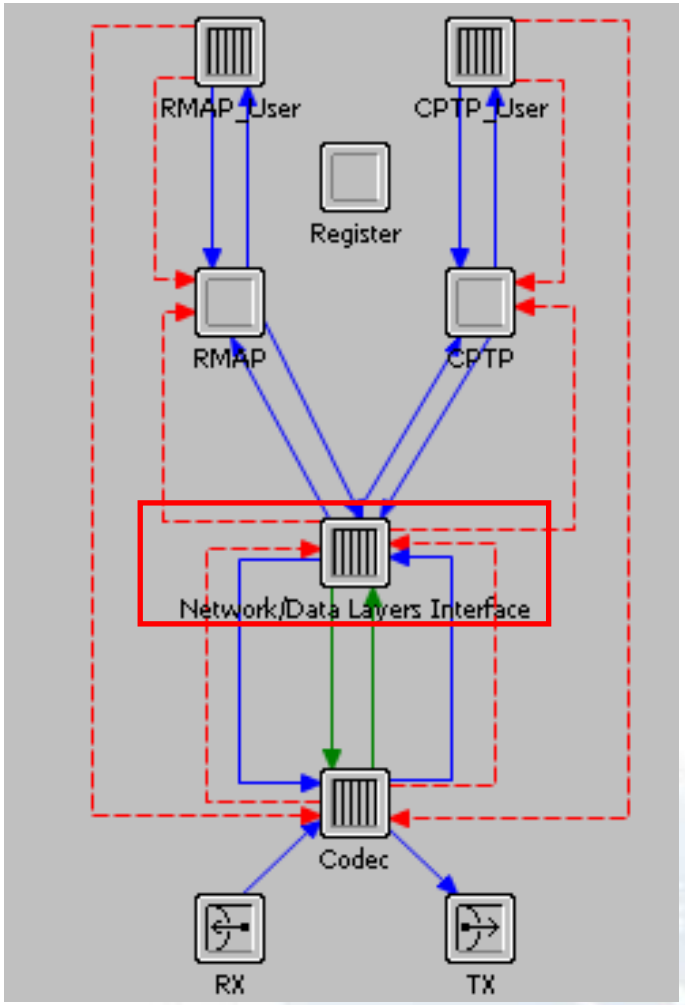
MOST v2.2 release 1: CPTP & RMAP Node presentation (1/2)

- CPTP & RMAP Node is more advanced:
  - CODEC + PID + RMAP + CPTP + Applications (1 per CPTP or RMAP protocol)

- Protocol handling:
  - ECSS-E-ST-50-12C (in CODEC)
  - ECSS-E-ST-50-51C (in NDLI)
  - ECSS-E-ST-50-52C (RMAP)
  - ECSS-E-ST-50-53C (CPTP)

- NDLI switches the packets between RMAP & CPTP and handles Time-codes:
  - NDLI Timecode Master status,
  - NDLI Timecode Interarrival Time,
  - NDLI Time Code Start / Stop Time,
  - NDLI Debug Level,
  - NDLI Emission Buffer Size,
  - NDLI Local address,
  - NDLI Local address Check.



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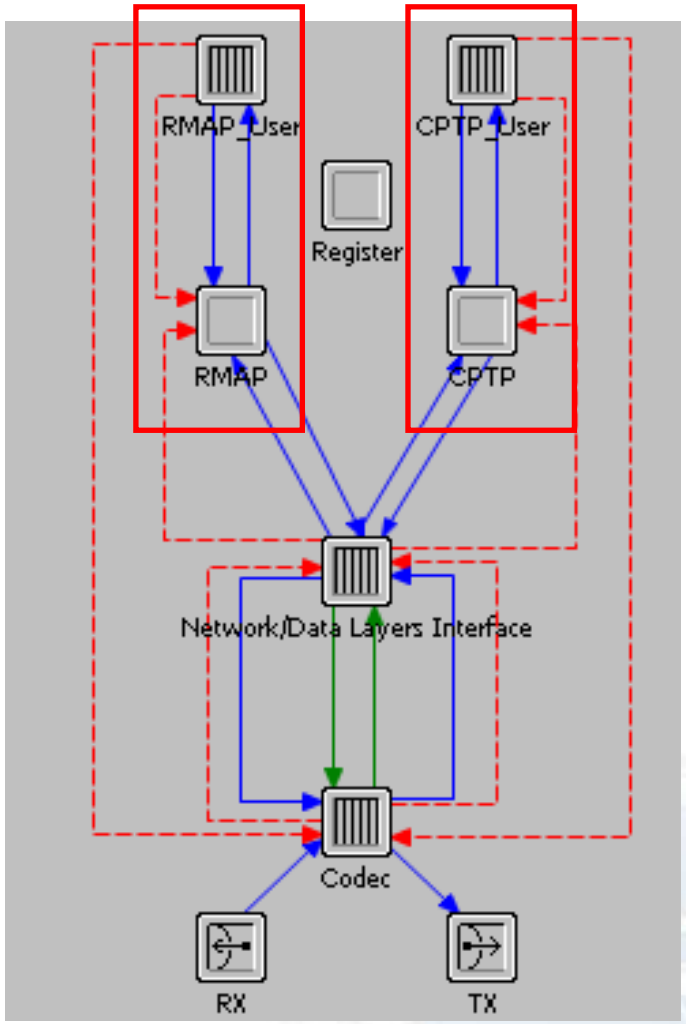
MOST v2.2 release 1: CPTP & RMAP Node presentation (2/2)

- As for the Native Node application, the CPTP application is fairly generic and configurable:
  - CPTP Packet Type,
  - CPTP Packet Deadline,
  - CPTP Destination Address,
  - CPTP Reception Buffer Size,
  - CPTP Debug level,
  - CPTP Packet EEP Status,
  - CPTP Elephant Message Size,
  - CPTP Elephant Message Destination Address,
  - CPTP Elephant Message Start Time.
- The RMAP application is similar:
  - RMAP Packet Interarrival Time,
  - RMAP Packet Type,
  - RMAP Command Value,
  - RMAP Start / Stop Time,
  - RMAP Packet Deadline,
  - RMAP Debug Level,
  - RMAP Key,
  - RMAP Reception Buffer Size,
  - RMAP Reply Delay,
  - RMAP Local Address,
  - RMAP Reply Packet Type.



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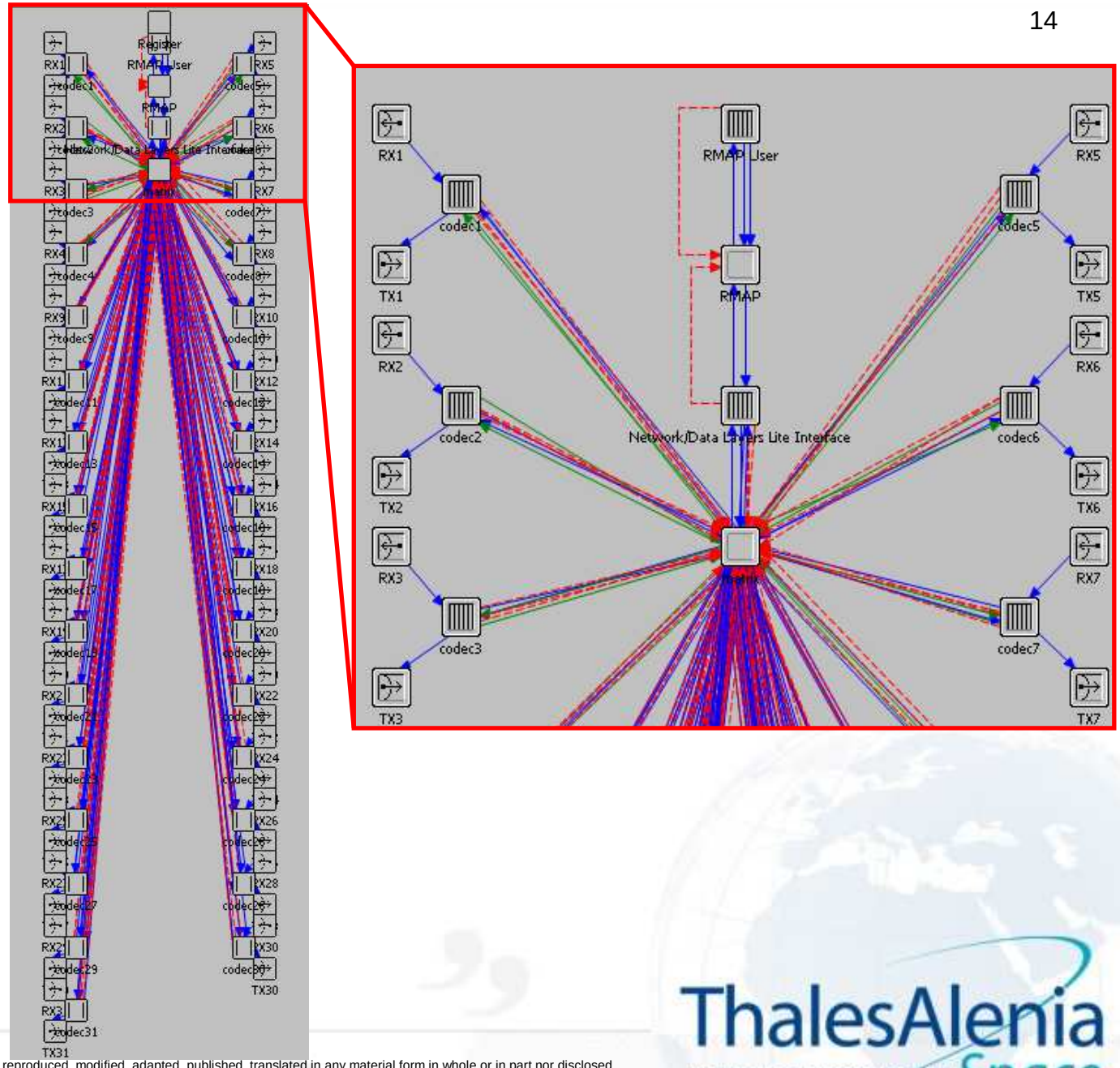
MOST v2.2 release 1: Generic Switch

- 32 port generic switch:
  - 31 CODECs
  - 1 configuration port

- Can be dynamically configured by RMAP commands

- Also configurable:
  - Watchdog Timer status,
  - Timeout value,
  - Switching Table,
  - Router Latency,
  - Debug Level.



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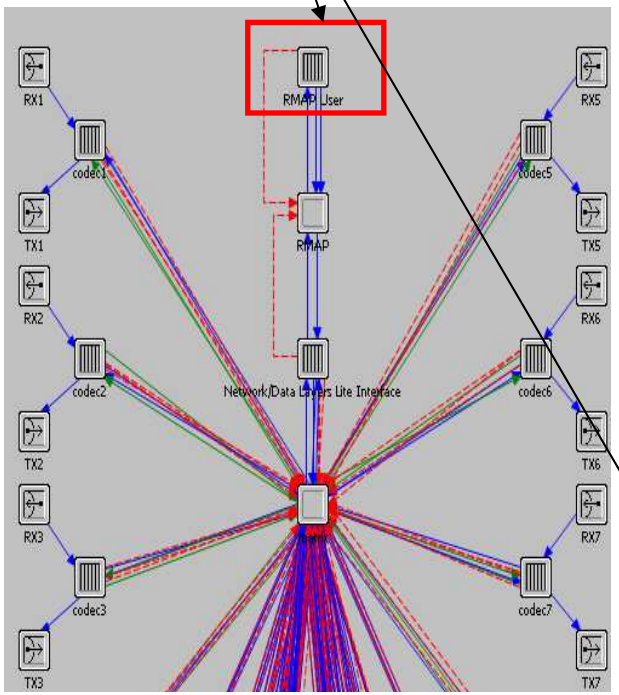
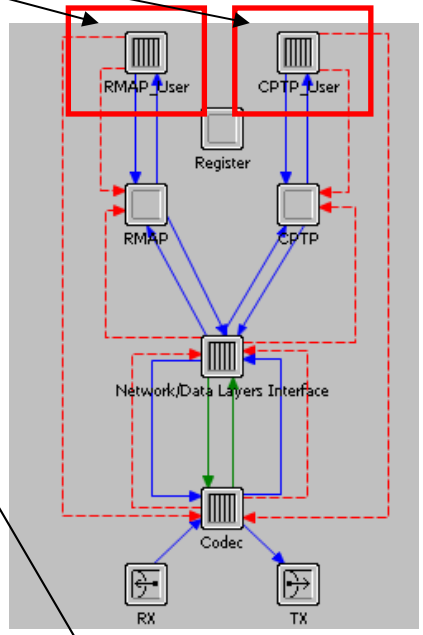
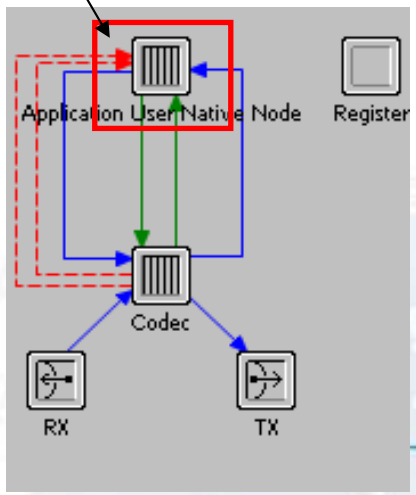
MOST v2.2 release 1: Application Layers

- All Nodes and Switch have at least one embedded application:
  - Native Node:
    - App User Native Node
  - CPTP & RMAP Node:
    - RMAP User
    - CPTP User
  - Generic Switch:
    - RMAP User
- These applications are developed in C-Code to handle basic SpW features:
  - Packet sending/receiving (Nodes)
  - RMAP packet interpretation (Switch)
- Other C-Code can be added in apps:
  - PUS management
  - CUC time transfer
  - TC handling triggering TM generation
  - Etc… *(Virtual Channel Multiplexing Machine, Mass memory, couplers,)*







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Some of the MOST v2.2 capabilities

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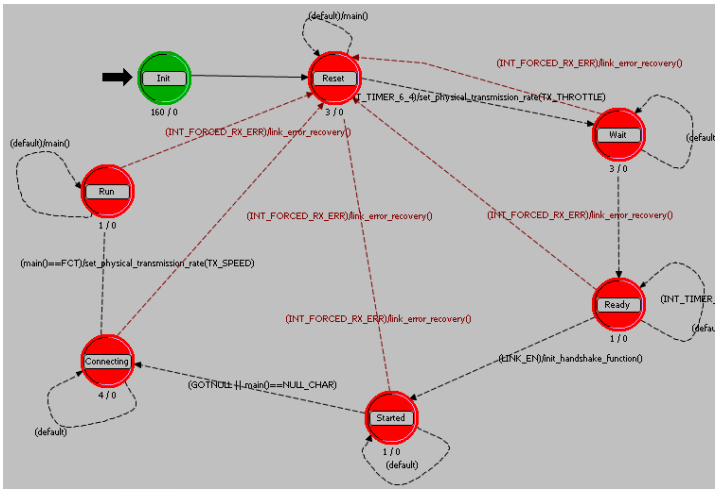
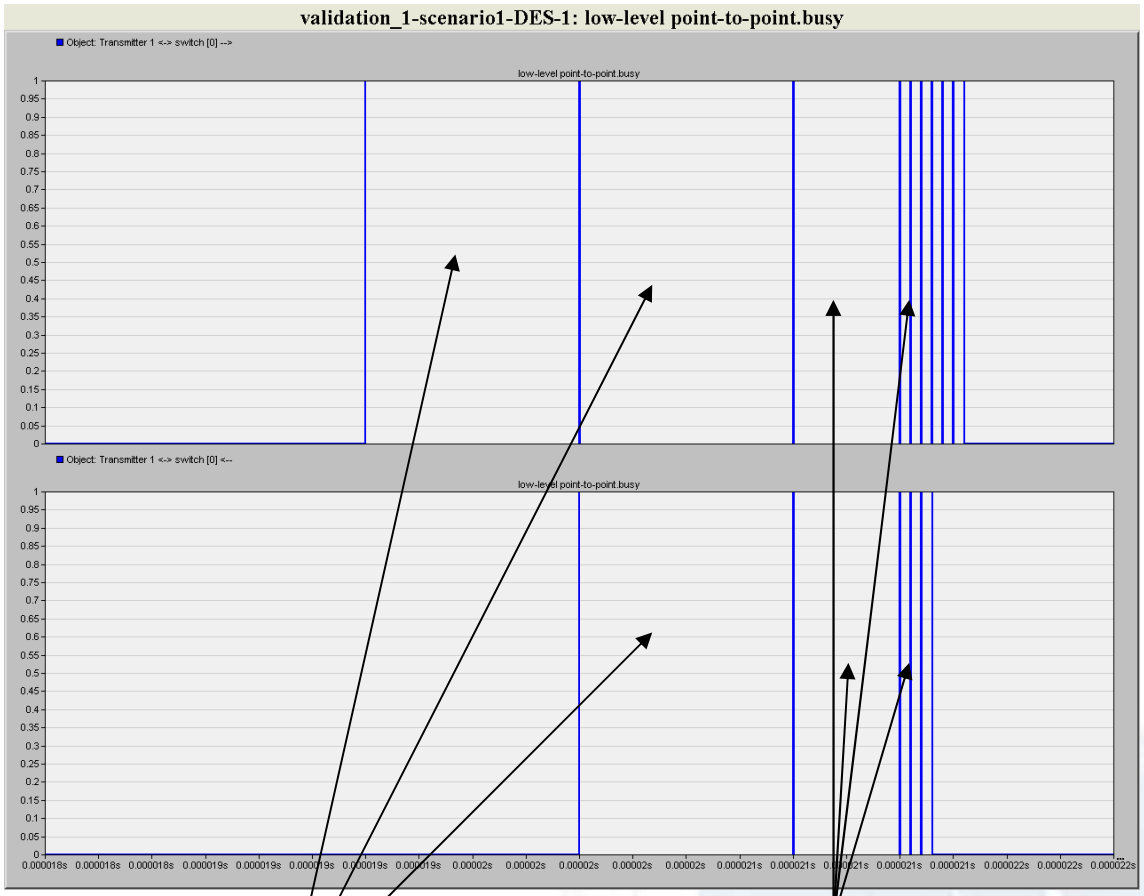
MOST v2.2 release 1: Links initialisation (1/7)

- You can provoke link disconnection during the simulation to analyze the impacts on the network (loss of packets, reconfiguration procedures, etc…)
- You can test any combination of init status with:
  - LinkStart
  - AutoStart
  - Link Disabled



- *LinkDisabled OFF*
- *LinkStart ON*
- *AutoStart OFF*

- *LinkDisabled OFF*
- *LinkStart OFF*
- *AutoStart ON*



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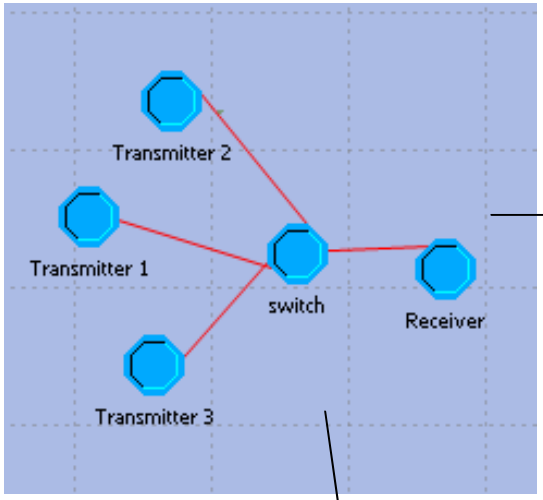
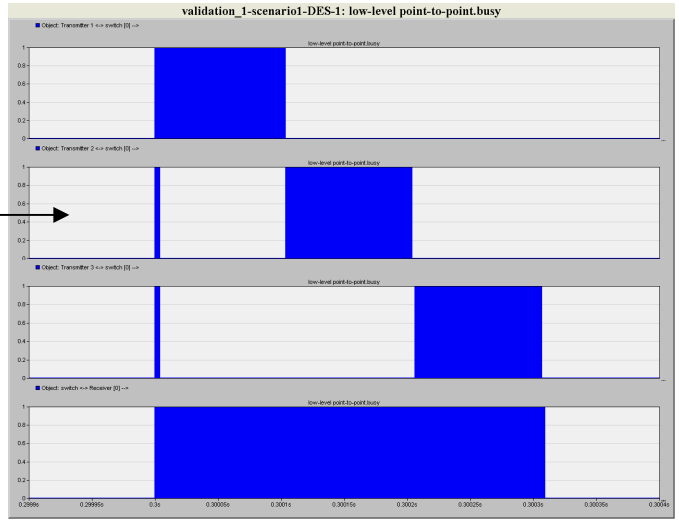
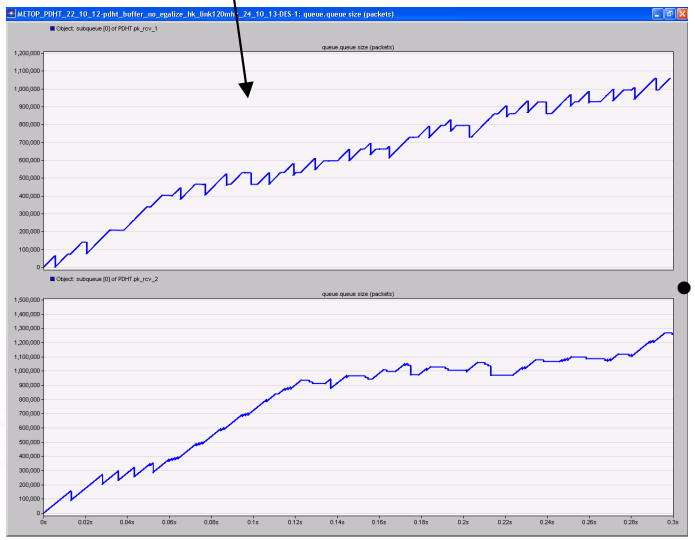
MOST v2.2 release 1: Traffic analysis (2/7)

- You can finely tune packet generation sequence, length, type and destination, allowing to see the effects of congestions on your network and on the nodes emission buffers:





- Sender 1
- Sender 2
- Sender 3
- Receiver input



- Evolution of Node packet output buffer content

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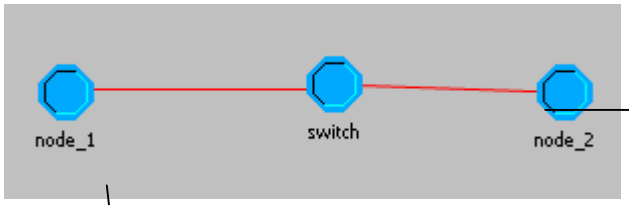
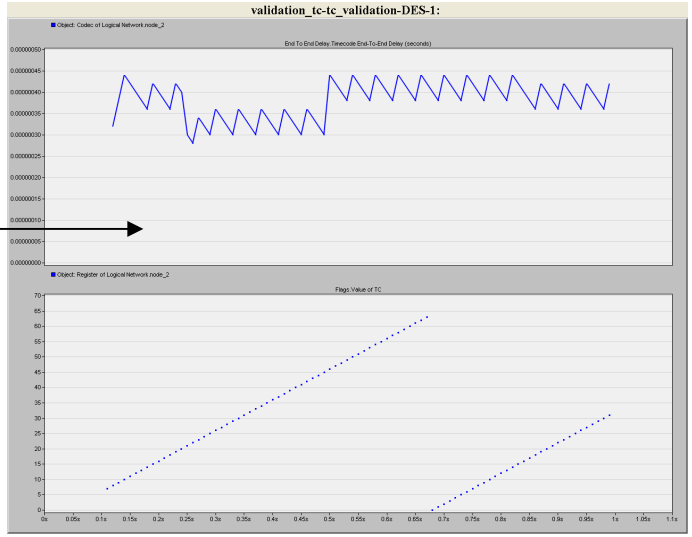
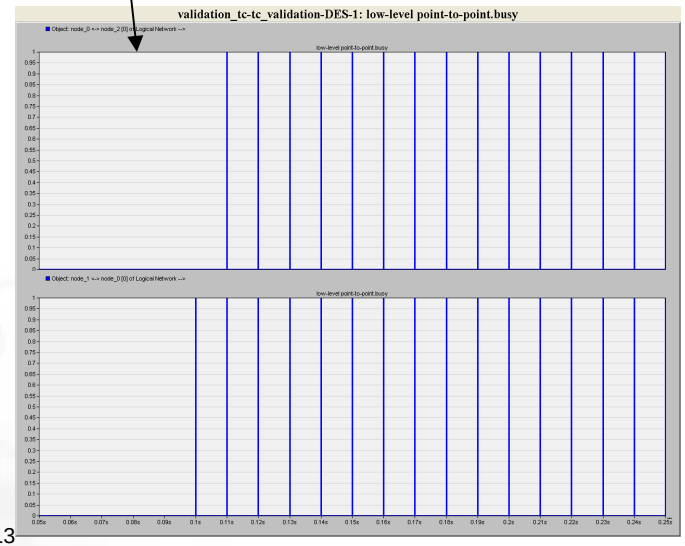
MOST v2.2 release 1: Time Code propagation (3/7)

- You can finely tune time code generation sequence and if a node is Time-Master or not
- Multiple “time masters” are allowed:





- Time-code propagation jitter
- Time-code value



- Time code propagation busy states

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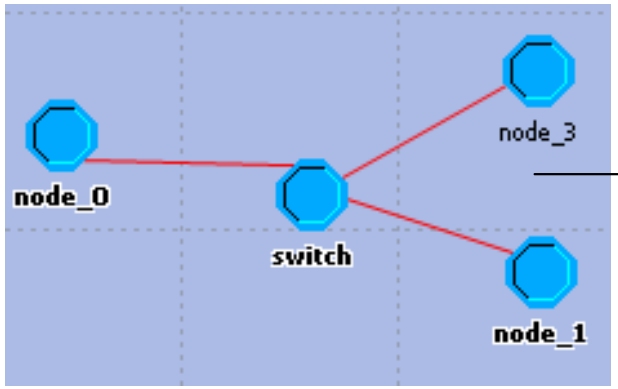
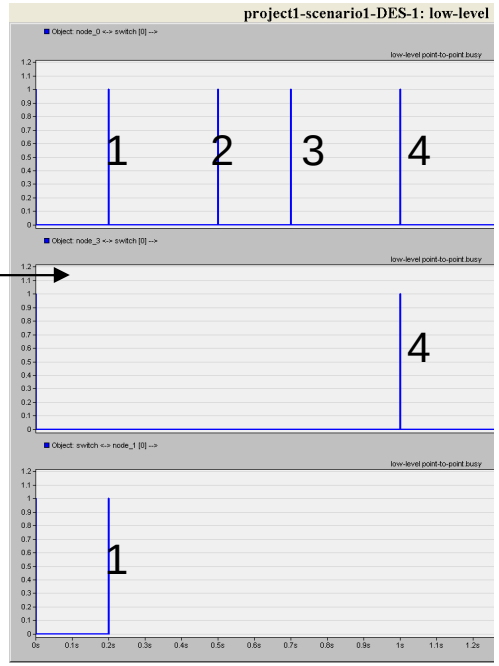
MOST v2.2 release 1: Dynamic Switch reconfiguration (4/7)

- Any Node can send a RMAP message to a Switch with enabled RMAP configuration port to reconfigure its switching table during the simulation:





- Node 0 →
- Node 3 ←
- Node 1 ←

- Seq1 is a CPTP packet sent from Node_0 to a logical address associated with Node_1
- Seq2 is a RMAP switching reconfiguration packet changing the allocation of the logical address
- Seq3 is a FCT sequence sent in response of the reception of the RMAP reply packet from the Switch acknowledging the reconfiguration request
- Seq4 is a CPTP packet sent to the same logical address as Seq1. The CPTP packet goes to node_3.

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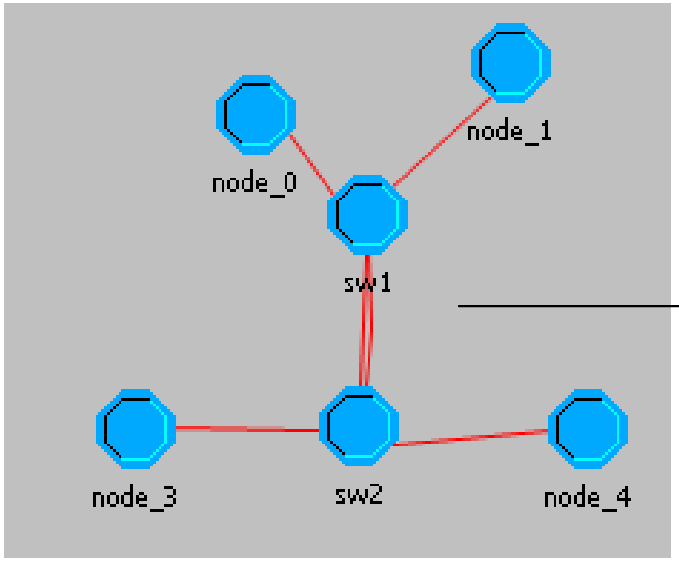
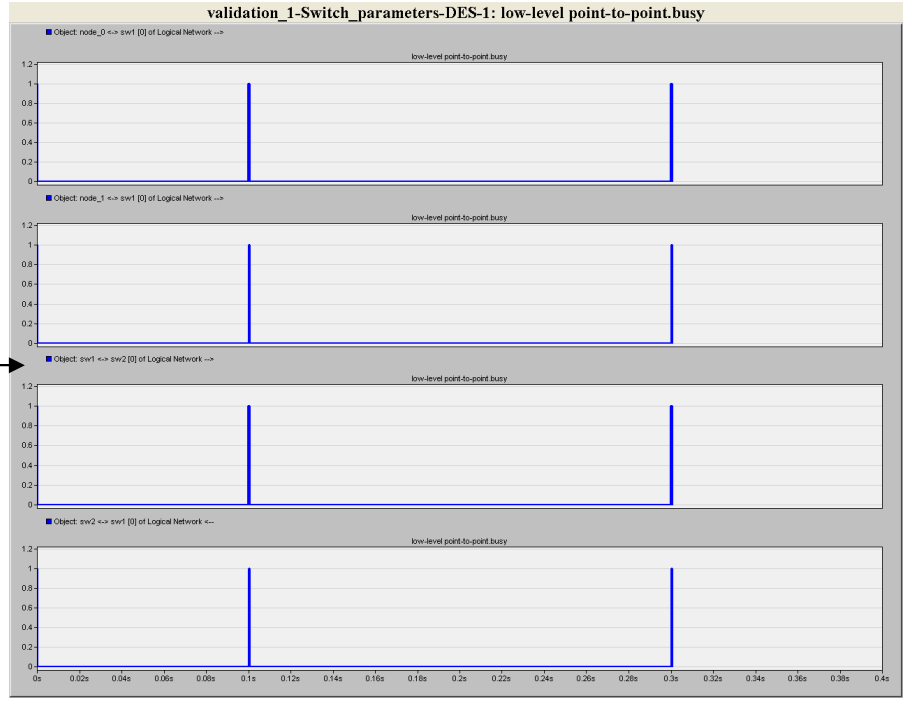
MOST v2.2 release 1: Group adaptative Routing (5/7)

- Illustration of Group Adaptative Routing:





- This shows that both links between the Switches are used simultaneously to switch packets:
  - From Node_0 to Node_3
  - From Node_1 to Node_4

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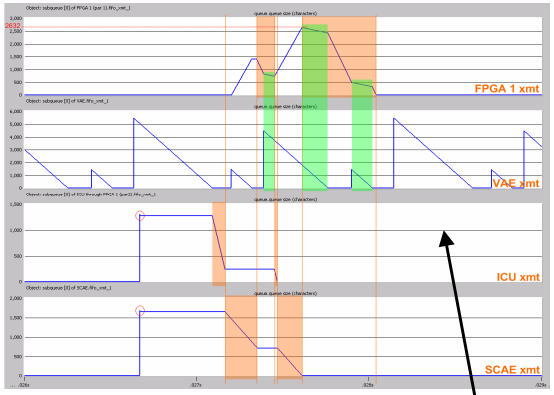
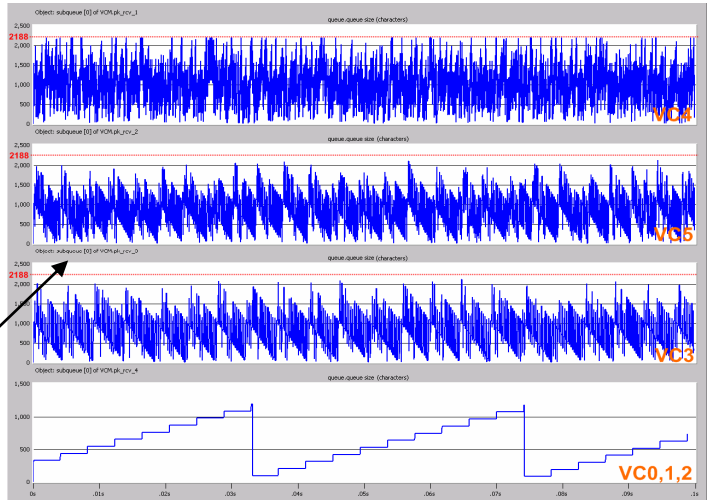
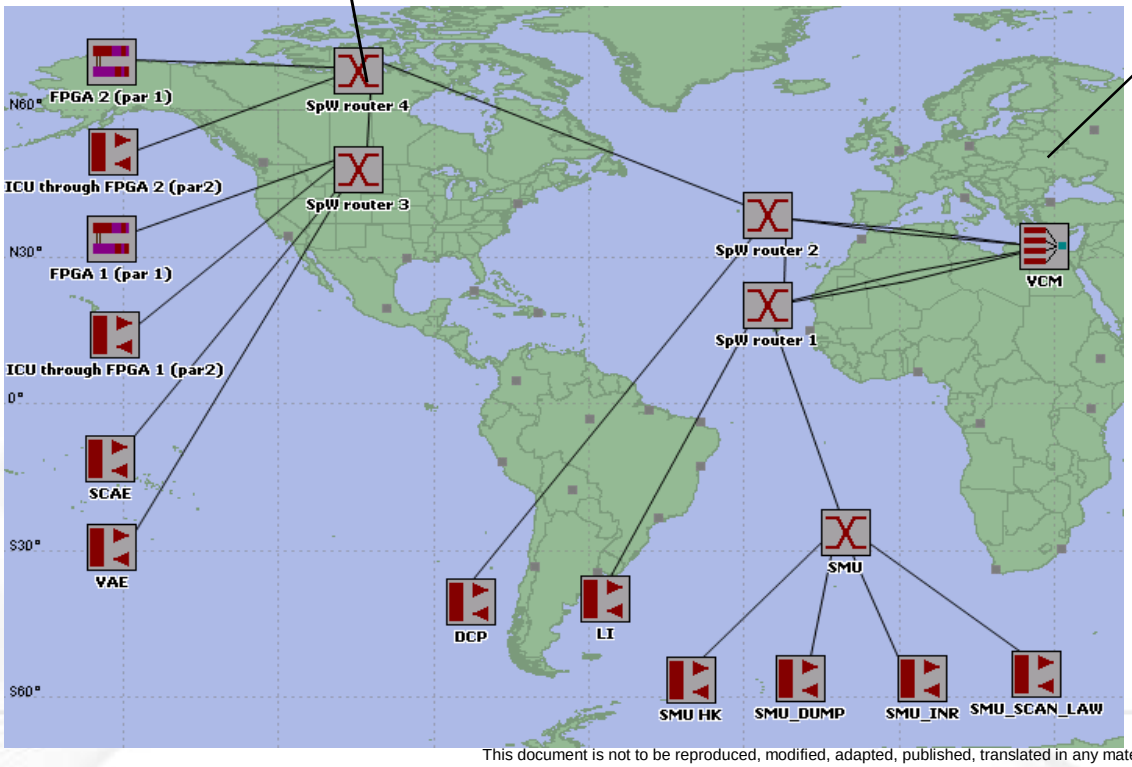
MOST v2.2 release 1: Complex Network Analysis (6/7)

- Of course, the main target is to test complete networks embedding Nodes with specific behaviors, here as an example: MTG “equivalent topology”







	Link usage	Link occupation *(incl. congestion delays)*		
	T_{cbar} / $T_{simulation}$	Average usage (Mean + T_{FCTi2})	Accuracy (+/- T_{FCTi2})	**Upper bound (Mean + T_{FCT})**
R3 -> R4 *(1)*	61.16 %	71.34 %	0.18 %	71.53 %
R4 -> R3 *(2)*	10.37 %	22.04 %	1.52 %	23.56 %
R4 -> R2 *(3)*	61.14 %	75.09 %	0.18 %	75.28 %
R2 -> R4 *(4)*	10.37 %	22.04 %	1.52 %	23.56 %
R1 -> R2	7.33 %	20.52 %	0 %	20.52 %
R2 -> R1	0.37 %	0.37 %	-	0.37 %
FPGA2 -> R4 *(5)*	63.81 %	76.42 %	1.52 %	77.94 %
R4 -> FPGA 2 *(6)*	63.81 %	72.66 %	1.52 %	74.18 %
VAE -> R3 *(7)*	70.58 %	70.6 %	0 %	70.6 %
R3 -> VAE	3.53 %	3.53 %	-	3.53 %
ICU -> R3	0.096 %	0.8 %	0 %	0.8 %
R3 -> ICU	0.005 %	0.005%	-	0.005 %
SCAE -> R3	1.7 %	2.17 %	0.51 %	2.69 %
R3 -> SCAE	20.55 %	20.53 %	0.02 %	20.55 %
FPGA1 -> R3 *(8)*	63.5 %	72.44 %	1.51 %	73.95 %
R3 -> FPGA1 *(9)*	63.5 %	72.07 %	1.51 %	73.58 %
DCP -> R2	45.93 %	50.72 %	0 %	50.72 %
R2 -> DCP	2.3 %	2.3 %	-	2.3 %
LI -> R1	37.51 %	42.33 %	0 %	42.33 %
R1 -> LI	1.88 %	1.88 %	-	1.88 %
SMU -> R1	21.09 %	21.1 %	0 %	21.1 %
R1 -> SMU	1.06%	1.06 %	-	1.06 %

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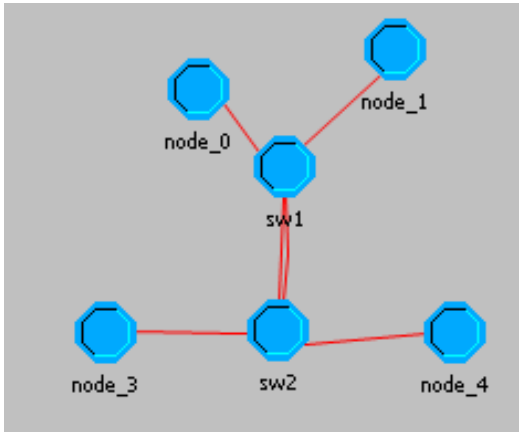
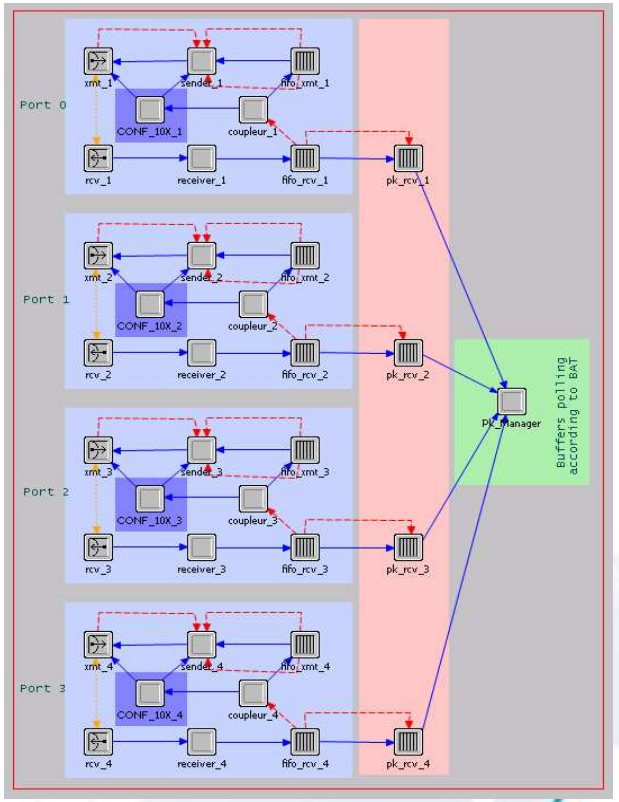
MOST v2.2 release 1: New components design (7/7)

- To do such analysis & design new components or change their behavior:
  - ***(Level 1):*** Either use standard components (now available: Native Node, CPTP & RMAP Node, 32-port dynamically configurable Switch)



  - ***(Level 2):*** Optionally: modify C-Code in User Applications to add services
    - As illustration, taking into account the reception of a TC to generate 3 TM packets takes several minutes to implement
  - ***(Level 3):*** Optionally: modify the Nodes shaping to add new layers / additional CODECs, etc…
    - That requires to change Nodes configuration in OPNET: it takes several hours (illustration: VCM machine in MOST v1.4)



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Conclusion

- MOST has already proved itself very useful providing the capability to test SpaceWire networks and help sizing the main parameters (link speed, buffers, …), identify bottlenecks, critical components of the network, etc…
- MOST concept provides a progressive tool, built with independent SpW building blocks which can be exchanged to test new SpaceWire technology or even SpW standard evolutions, without waiting for HW development,
- This new version is much more easy to use and runs faster than MOST v1.4. New components will be added to the MOST v2.2 library in the next development phases.
- MOST v2.2 targets a release in 2013 to the SpaceWire community, it will have to be carefully tested and validated in the incoming months,

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Ref.:

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Thanks for your attention !

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