SimWORKS, A Hybrid Java/C++ Simulation Platform

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Acknowledgements

- The Photonics CAD Project (PCAD)
  - PCAD is part of the NIST Advanced Technology Program
  - Goal: Research on an integrated, multi-level design and simulation environment for the US photonics industry
  - Members: RSoft, Telcordia, SAIC, IBM, and Columbia
- The LinkSIM Development Team
  - The LinkSIM features and simulation actors illustrated in this talk were developed by the LinkSIM team at RSoft Design Group independently from the SimWORKS team.

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Motivation

- RSoft has a large base of intellectual property:
  - Synchronous Data Flow models of optical components
  - Data tokens are large structures representing optical signals
  - Not easily portable to Java for performance reasons
- SimWORKS allows us to:
  - Create and edit simulation schematics within Vergil
  - Use the Ptolemy II scheduler (with modifications)
  - Write and compile electro-optical simulation models in C++
  - Perform all computation, data transport, and display in C++
- SimWORKS supports:
  - Flexible Higher-Order Composite objects
  - Repetition Loops and disconnected topologies
  - Single-process or Client/Server operation (w/ pure C++ server)
  - Hybrid topologies with Java and C++ actors

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LinkSIM and SimWORKS

- LinkSIM is an existing commercial product
  - System-level simulator for datacom applications
  - Platform consists of a C++ simulation kernel and GUI
  - Uses a Synchronous Data Flow model of computation
  - Simulation actors are independent C++ modules
- SimWORKS is a general-purpose platform
  - Schedules and executes Java or C++ actors
  - Implements all the major LinkSIM functions
  - Supports some special SDF semantics and scheduling
  - Provides binary compatibility with LinkSIM modules
  - Stubs for LinkSIM actors are auto-generated

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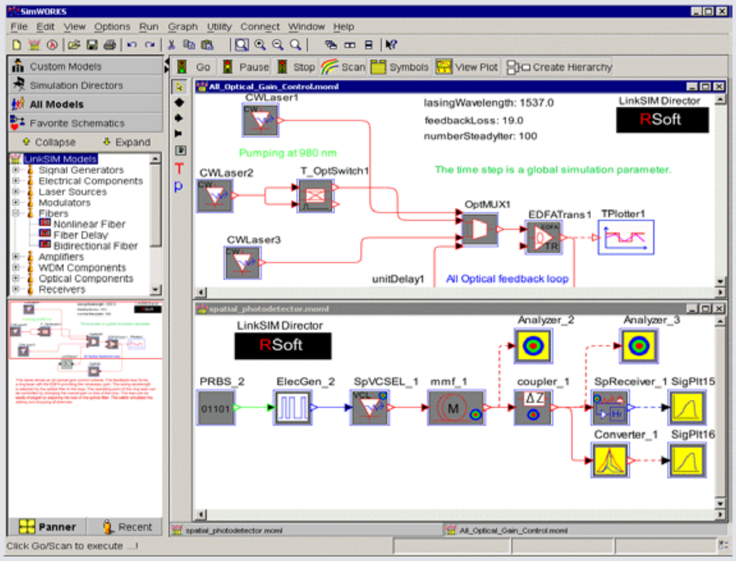
The SimWORKS MDI



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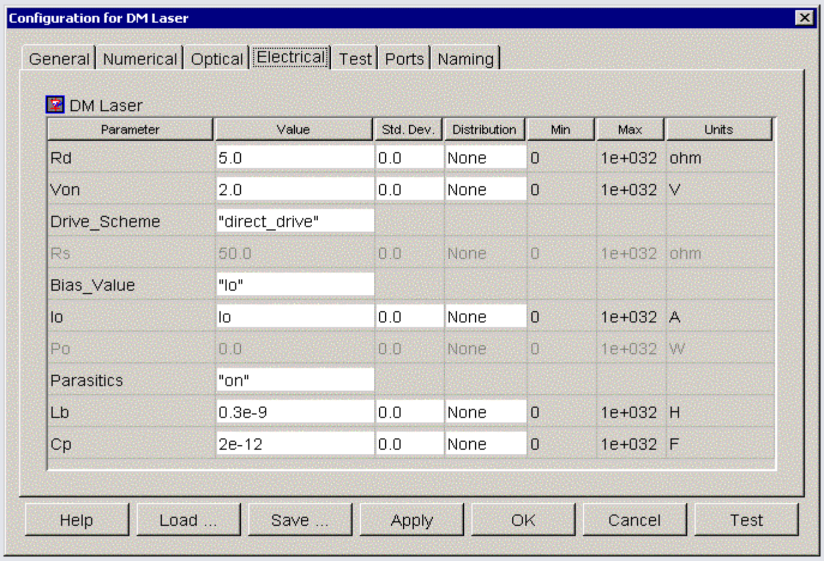
SimWORKS GUI Features

- Variable snap-to-grid resolution
- Auto-generated range-checking for parameters
- Context-sensitive parameters (based on values)
- Parameter groupings onto Properties sheets
- Selection-drag interactor ignores icon labels
- ‘Custom Models’ and ‘Favorite Schematics’ palettes
- FIFO display of unique recently accessed actors
- Cascading and tiling feature within the MDI
- Diva changed to route links underneath actor icons
- Colored links and ports to indicate the signal type
- Synchronized the scroll view with the panner view

Actor Properties Dialog



Configuration for DM Laser

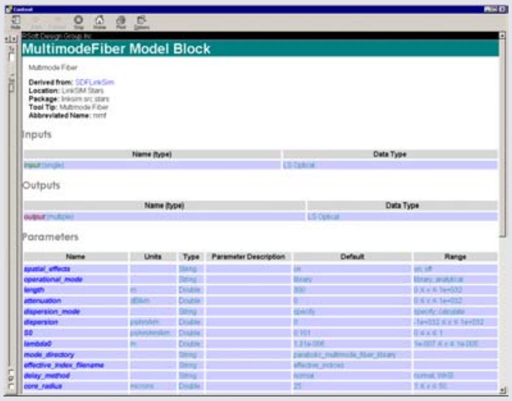
General | Numerical | Optical | Electrical | Test | Ports | Naming

DM Laser

Parameter	Value	Std. Dev.	Distribution	Min	Max	Units
Rd	5.0	0.0	None	0	1e+032	ohm
Von	2.0	0.0	None	0	1e+032	V
Drive_Scheme	"direct_drive"					
Rs	50.0	0.0	None	0	1e+032	ohm
Bias_Value	"Io"					
Io	Io	0.0	None	0	1e+032	A
Po	0.0	0.0	None	0	1e+032	W
Parasitics	"on"					
Lb	0.3e-9	0.0	None	0	1e+032	H
Cp	2e-12	0.0	None	0	1e+032	F

Auto-generated HTML

HTML documentation is auto-generated for each actor and is available through its 'Get Documentation' menu item



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MultimodeFiber Model Block

Multimode Fiber

Derived from: SDFLinkSim
Location: LinkSIM Stars
Package: linksim.src.stars
Tool Tip: Multimode Fiber
Abbreviated Name: mmf

Inputs

Name (type)	Data Type
input (single)	LS Optical

Outputs

Name (type)	Data Type
output (multiple)	LS Optical

Parameters

Name	Units	Type	Parameter Description	Default	Range
spatial_effects		String		on	on, off
operational_mode		String		library	library, analytical
length	m	Double		300	0 ≤ x ≤ 1e+032
attenuation	dB/km	Double		0	0 ≤ x ≤ 1e+032
dispersion_mode		String		specify	specify, calculate
dispersion	ps/nm/km	Double		0	-1e+032 ≤ x ≤ 1e+032
S0	ps/nm/nm/km	Double		0.101	0 ≤ x ≤ 1
lambda0	m	Double		1.31e-006	1e-007 ≤ x ≤ 1e-005
mode_directory		String		parabolic_multimode_fiber_library	
effective_index_filename		String		effective_indices	
delay_method		String		normal	normal, WKB
core_radius	microns	Double		25	1 ≤ x ≤ 50

Topology Editing Features

- Repetition Loop Actor
  - Quick and compact layout for repeated topology blocks
- Configurable Higher-Order Composite actor
  - Supports parallel or serial repeated topology blocks
- Variable numbers of input and output ports
  - Some actors support many parallel I/O channels
  - Used to configure ports on the HOC actor
- Flexible auto-connect feature for parallel links
- Parameter Save/Load and Signal Save/Load
  - Save a single actor's parameters to a MoML file
  - Save an output signal to a file for use in another topology
- Faster cutting, pasting, and dragging
- Converts native LinkSIM topology files to MoML

SimWORKS Execution Features

- Scheduler supports repetition loops
  - Useful for modeling repeated regenerator spans, etc.
  - Creates a nested schedule for each nested loop
- Optimized scheduling for parameter scans
  - Upstream actors are not fired after the first iteration
  - Selected data tokens are cached for later iterations
  - Avoids unnecessary recalculation of upstream tokens
  - Cached statistical values for nested scans
- Efficient handling of disconnected ports
- Optional caching of signal summaries for ports
- Four separate logging facilities
- Socket interface permits client/server execution

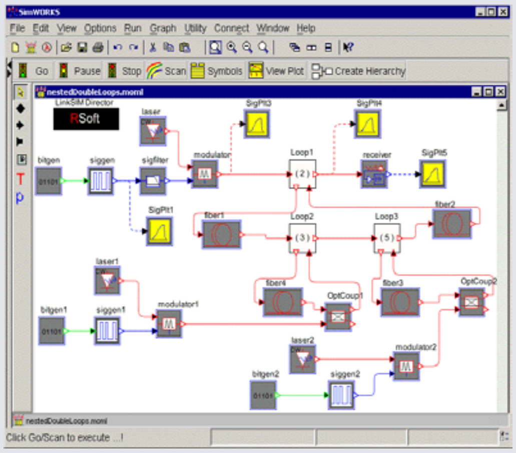
Repetition Loop Actor

Repetition Loops may be nested to arbitrary levels.

The Loop Icon displays the value of the NumReps expression, which controls the number of repetitions.

Loops implement an implicit delay to break apparent circular dependencies.

The scheduler throws an exception if it detects branching into or out of the loop body.



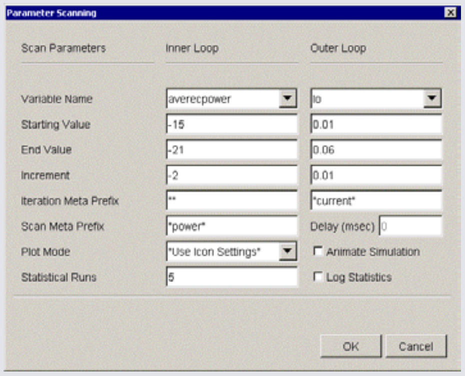
Parameter Scan Dialog

Statistical, inner, and outer parameter scans may be executed independently or may be nested.

All top-level symbols are automatically loaded into the choice boxes.

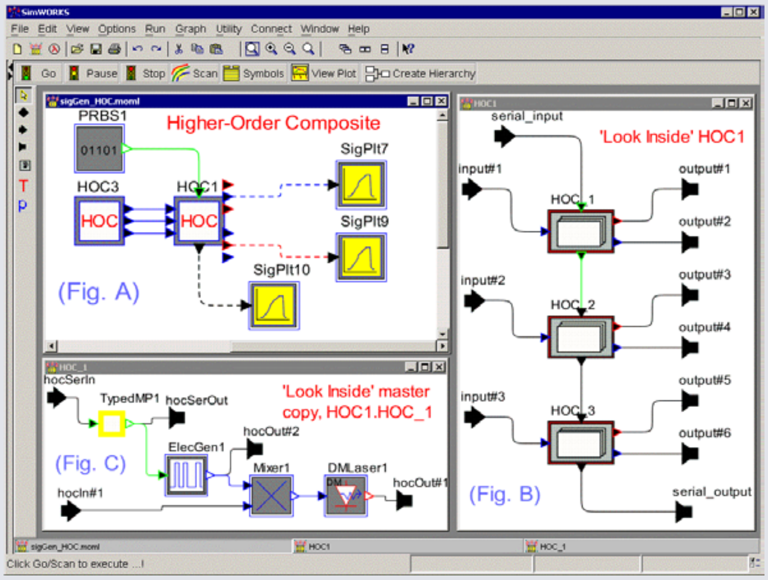
The Director will change inner and outer values before each scan iteration.

Statistical scanning is implemented in C++, with no parameter dependencies.


Parameter Scanning

Scan Parameters	Inner Loop	Outer Loop
Variable Name	averecpower	lo
Starting Value	-15	0.01
End Value	-21	0.06
Increment	-2	0.01
Iteration Meta Prefix	""	"current"
Scan Meta Prefix	"power"	Delay (msec) 0
Plot Mode	"Use Icon Settings"	☐ Animate Simulation
Statistical Runs	5	☐ Log Statistics

HOC GUI Interface

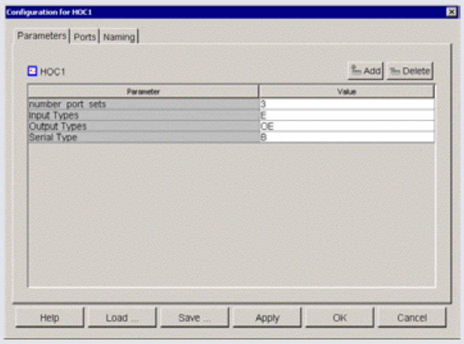


HOC Example Captions

- (Figure A) An example topology with two HOC instances, each configured to have three port sets.
- (Figure B) A 'Look Inside' of the HOC_1 block, which shows how the master HOC instance and its two copies are wired to the external port sets that the user configured.
- (Figure C) A 'Look Inside' of the master copy of the HOC1 schematic. Each port of a single port set appears just once as an external port of the master copy. The user can create an arbitrarily complex topology schematic inside the master copy and connect it to those external ports. The 'instance' parameter of the HOC has the value, 1, in the master copy and an incremented value in each clone. This value can be used to parameterize the actors in the HOC.

HOC Properties Dialog

- Four parameters provide HOC Port Configuration
  - One or more type-code letters are used to specify the number, type, and order of the ports in a single port set.
  - A blank field would indicate that no ports of that type are required. The template HOC actor has no ports.


Configuration for HOC1

Parameter	Value
number port sets	3
Input Types	E
Output Types	OE
Serial Type	B

SimWORKS HOC Features

- Flexible Higher-Order Composite actor
  - Control is based on the concept of a port set
  - Multiplicity is controlled by ‘number_port_sets’
  - ‘Look Inside’ reveals one master HOC template object
  - The master automatically displays one complete port set
  - The type and number of I/O ports are configurable
  - One pair of Serial ports is permitted
- Expansion and collapse of the HOC actors
  - Cloned in preinitialize() and destroyed in wrapup()
  - Clones are no stored in MoML (or memory, in idle state)
  - Clones are identical, except for an ‘instance’ parameter
  - The master and clones are each wired to one port set
  - The serial ports are wired in series, the rest in parallel

Summary

- Ptolemy provides a powerful platform for modeling
- Diva is easily modified for new menus and actions
- Ptolemy II is well organized, flexible, and easy to modify when additional functionality is required

- SimWORKS leverages Ptolemy II and Ptolemy Classic to provide a solid platform for electro-optical simulations at the link and system levels.
- The SimWORKS scheduler extends SDF semantics
- The SimWORKS Director implements parameter scanning and statistical variation features
- A Java/C++ interface supports hybrid execution.