

A Ptolemy Based Optical Network Simulator

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Overview

- Why simulate optical networks ?
- Desired features of an optical network simulator
- Why use Ptolemy ?
- The network simulator
- Examples of network simulation
- Some comments about Ptolemy Classic
- Conclusion

Why Simulate Optical Networks ?

- Network Analysis
 - Power budget
 - Impairment analysis
 - Crosstalk
 - Noise
 - Filter effect
 - Performance evaluation
 - BER
 - Q
 - Architecture evaluation
- Device Simulation
 - Spectral analysis
 - Sensitivity analysis

3

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Desired Features of an Optical Network Simulator

- GUI
- Flexible Data Structure
- Hierarchical Modeling
- Automated Scheduling

4

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Why Use Ptolemy ? (Why need a software framework ?)

- Open source code
 - No need to start from scratch
 - Easy to customize
- Lots of built-in modules
 - provides numerous functionality (signal source, visualization..)
- Flexible data structure
 - allows customized messaging between network elements
- Hierarchical modeling capability
 - extremely useful for complex network module development
- Built-in GUI
- Automated scheduling
- Open discussion forum
- Widely accepted across industry

5

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The Network Simulator

- Collection of modules
 - Device
 - Simple (Demux/Mux, Switch, Amplifier, VOA)
 - Complex (WADM, WSXC)
 - Auxiliary
 - Visualization
 - QoS
 - Histogram
- Ptolemy integration
 - develop back-end codes (device models)
 - develop front-end codes (.pl files/GUI code) for network elements
 - compile and link with Ptolemy

6

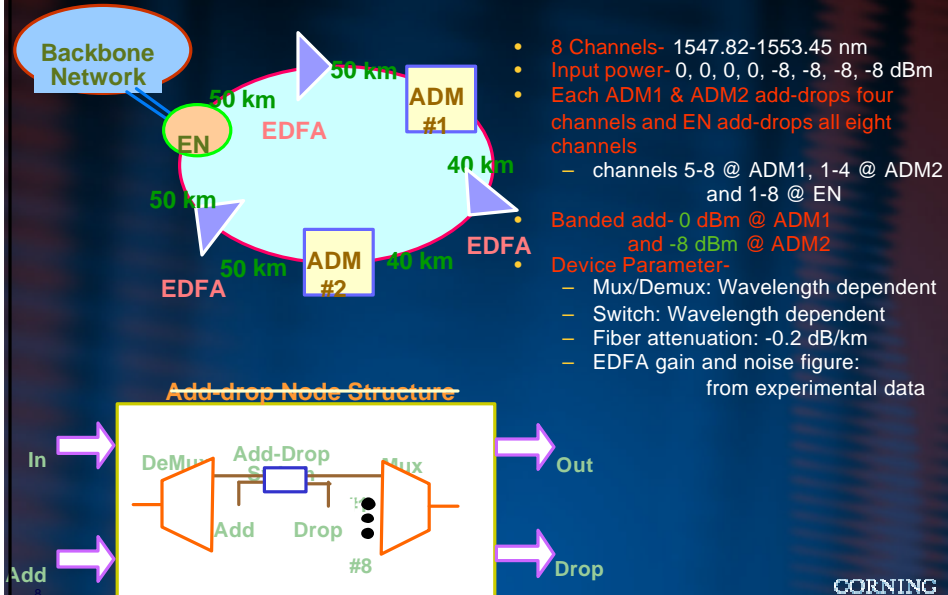
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The Network Simulator

- **Functionality**
 - **Impairment analysis**
 - Crosstalk
 - Amplifier noise
 - **Performance analysis**
 - Q
 - BER
 - OSNR
 - **Performance indicator**
 - Worst crosstalk level
 - Histogram of crosstalk

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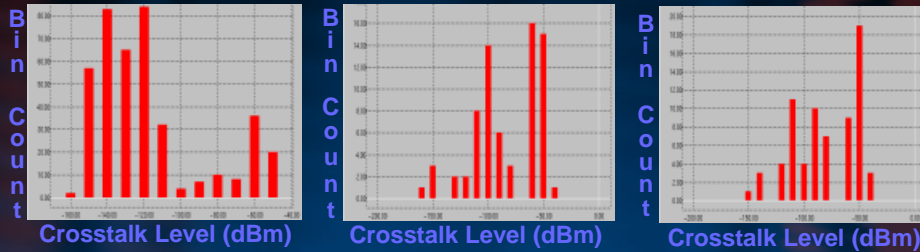
Network Simulation: Ring Network



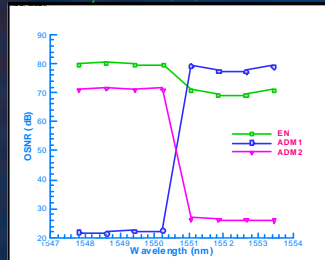
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Ring Network Simulation: Results

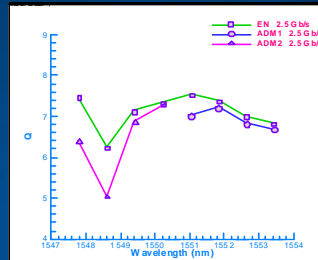
Histogram of crosstalk levels at the drop port of EN, ADM1 and ADM2



OSNR at output ports of EN, ADM1 and ADM2



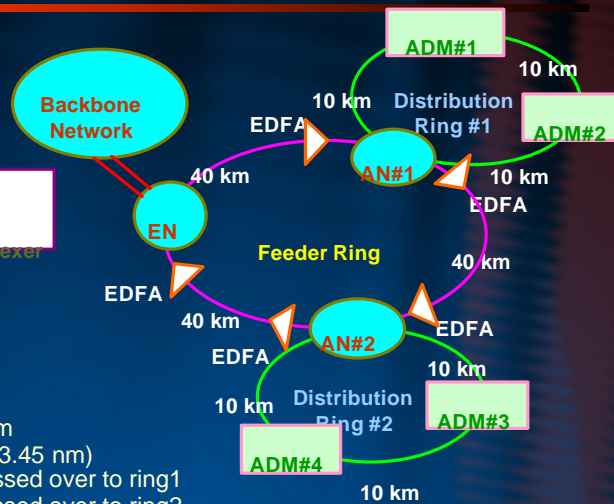
Q values at drop ports of EN, ADM1 and ADM2



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Network Simulation: Interconnected Ring Network

EN = Egress Node
AN = Access Node
ADM = Add Drop Multiplexer

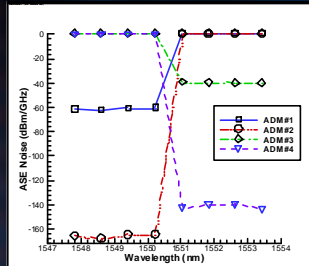


- Input/Added power -2 dBm
- 8 Channels (1547.82-1553.45 nm)
- AN#1 - Channels 1-4 crossed over to ring1
- AN#2 - Channels 5-8 crossed over to ring2
- ADM#1/ADM#3 - All channels add-drop
- ADM#2 - Channels 1-4 pass, channels 5-8 add-drop
- ADM#4 - Channels 5-8 add-drop, channels 1-4 pass

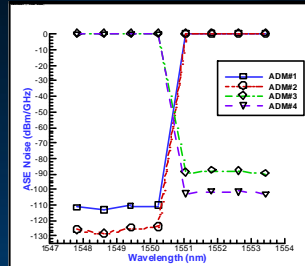
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Interconnected Ring Network Simulation: Results

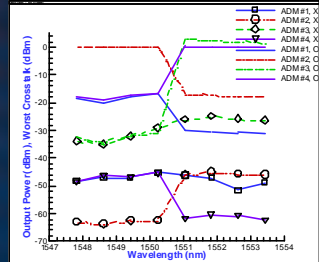
ASE Noise at ADM Drop Ports



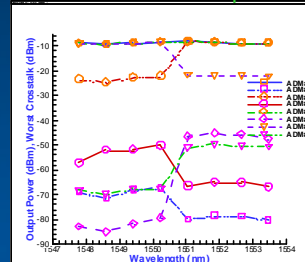
ASE Noise at ADM Output Ports



Output Power and Worst Crosstalk at ADM Drop Ports



Output Power and Worst Crosstalk at ADM Output Ports



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Some Comments About Ptolemy

- Very useful for optical network simulation development
 - provides all necessary features
 - framework architecture matches with application s/w structure
- Highly active and very helpful user community
 - useful for newcomers
 - fruitful exchange of information
- Long learning curve
- Customized application development not easy
 - no suitable debugger
- Ptolemy classic GUI not very user-friendly
 - users do not like memorizing function keys
 - window object manipulation is not intuitive (not drag-n-drop!)
- Non-graceful degradation

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Conclusions

- Ptolemy provided the near ideal platform for optical network simulation development
- The Ptolemy open source codes substantially simplified customized network element development
- Numerous built-in Ptolemy modules provided the functionality of most commonly performed functions. This significantly reduced the development time
- The Ptolemy-based optical network simulator calculates major impairments in optical networks

Conclusions

- The network simulator enables performance evaluation of different network architectures
- As an additional feature, the network simulator can also calculate impairments of standalone optical network components
- Developing customized application on Ptolemy is non-trivial
- For the network simulator, a more user-friendly GUI could make the tool easier to operate



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Discovering Beyond Imagination