GMPLS/Lightwave Agile Switching Simulator

Oliver Borchert

GLASS January Workshop

January 6th to January 10th 2003

Software – www.antd.nist.gov/glass
Questions – glass@antd.nist.gov

NIST Participants

- NIST ANTD – David Su / Division Chief
  - High Speed Network Technologies Group
    Optical Framework and Graphical Tools
    - Nada Golmie – Group Manager
      - Oliver Borchert – Project lead, Stephan Klink
      - Richard Rouil
  - Internetworking Group
    MPLS / Diff Serv / TE
    - Doug Montgomery – Group Manager
      - Chul Kim
      - Young-tak Kim, Kwang-il Lee, Eun-hyuk Lim

Agenda (1)

- Monday
  - Introduction
  - SSFNet Overview
  - Optical Components
  - The TSC in general
- Lunch
  - Events in GLASS
  - TSC Event Panel
  - ONIC and failure detection / propagation
  - The Optical Frame Header
- Tuesday
  - Optical Protocols
    - The OXCSwitch
    - Signaling Protocol Example
- Lunch
  - Algorithms
  - The Optical Path Structure
  - Utilities
  - The TSC Configuration

Agenda (2)

- Wednesday
  - GMPLS
- Lunch
  - Splitting into 2 groups for the advanced sessions.
- Thursday
  - Advanced session
- Lunch
  - Advanced session
- Friday
  - Advanced session
- Lunch
  - Ending discussion
- Advanced Session:
  - Group1:
    - Integration of Algorithms
    - interfacing with TSC
  - Group2L
    - Data Structure of new GMPLS and DML schema.
    - Scripting scenarios

Introduction

- This workshop is scheduled on request of the IOWA state University.
- The workshop contains two "advanced sessions" in parallel and one joint
  - Joint:
    - Overview over the GLASS framework.
  - Parallel:
    - Integration of Algorithms into GLASS and the TSC.
    - Modeling and design of GMPLS scenarios.

First Intension

- Allow the development and evaluation of R&WA algorithms.
- Create a tool to facilitate:
  - the easy planning of a WDM network.
  - the analysis for WDM protocol performance.
- Test a network constellation before building it in reality.

Our step to SSF (1)

- NIST already had a "simulator" called MERLiN
- Simulation had to be implemented in the protocol itself.
- No discrete simulation framework users could use.

Our step to SSF (2)

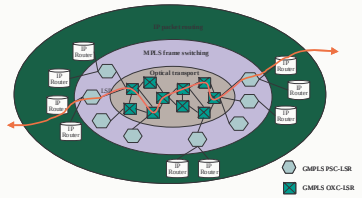
- We checked simulator such as:
  - NS2
  - JavaSim (OHIO State University)
  - SSF/SSFNet
- We had 3 teams to test the simulation frameworks.
- We tested the tools for an approximately time of 2-3 Months.
- Final decision was SSFNet – It was already used at NIST

What is GLASS?

- GLASS is an extension of the Scalable Simulation Framework Network (SSFNet).
- It contains:
  - An optical framework
  - MPLS framework
- Allows the modeling and performance evaluation , restoration, and developing of signaling protocols for optical / GMPLS networks.

GOALS

- Enhance the NIST optical network modeling tool, MERLiN, to include discrete event simulation.
- Provide models to evaluate architectures and protocols for protection and restoration, routing, signaling and management of GMPLS / Optical networks.
- Support multi-level / multi-protocol schemes for traffic engineering, QoS, protection and restoration.



GLASS Project Statistics

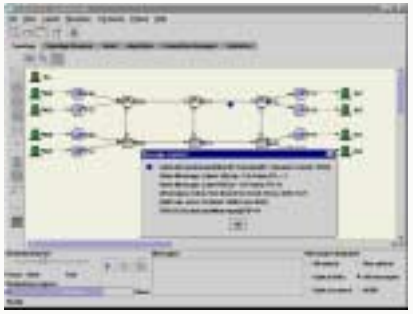
- 7 java libraries.
- 86 packages.
- 717 classes.
- 508 java source files.
- 129,673 lines of code.
- 18,236 lines of documentation.
- 1 Command line Simulator.
- 2 Graphical Simulator tools.
  - TSC and Browser

GLASS Components (1)

- **Optical Components**:
  - Optical Network Interface
    - WDM interfaces
    - λ / fiber level attributes, behavior models
    - Failure notification
  - Optical Cross Connects
    - Add-drop ports
    - Switching - λ, port
    - λ conversion
    - OXC edge router
  - Algorithms (RWA, protection)
    - Best-Fit, SPF, SPF-SRLG
    - Link protection, restoration
    - More are produced by GWU
- **MPLS Components**:
  - MPLS Core Switching
    - LSRs, LERs
    - E-LSPs, L-LSPs
    - Multi Field Classifier
    - Hierarchical LSPs
    - LSP metering
  - Signaling / Routing
    - CRLDP (TE,GMPLS), OAM
    - s-OSPF-(TE,GMPLS)
  - Traffic Engineering
    - TE Agent: OSPF-TE, CRLDP, event notifications

GLASS Components (2)

- **Diff Serv Components**:
  - Metering: TBM, TSW, SRTCM, TRTCM
  - Queue Management: Drop tail, RED, RIO
  - Scheduling: Priority, WRR, WFQ, Hierarchical combos
- **SSF Environment:**
  - Topology explorer
  - Failure scripting
  - Interactive simulation
  - Protocol Animator
  - Network designer



More than just new Components

- Support of shared risk strategies for failure recovery. (SRG & SRLG)
- Facilitate customized granularity of failure detection. (Failure Recovery Module - FRM)
- Support monitoring of incoming traffic.
- Scripting of events such as failures or recoveries.
- Providing an internal data structure for algorithm and protocol writers.
- Providing a generic algorithm interface.

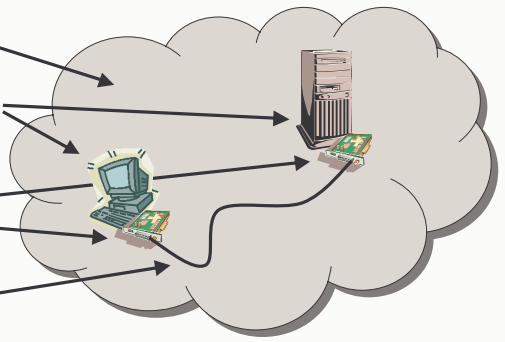
SSFNet Overview

SSFNet:

- A collection of Java SSF-based components.
- Modeling and simulation of Internet protocols and networks at and above the IP packet level of detail.
- Each component configures itself through a configuration database.
- Use Data Modeling Language (DML) to script an network topology and simulation scenarios.
- The Package SSF.OS contains components for modeling the basis framework.
- Package SSF.Net contains components for modeling network connectivity as well as components for creating node and link configurations.

The Package SSF.Net

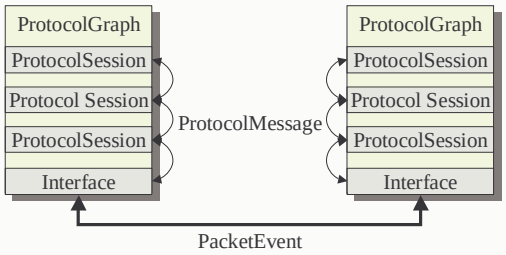
- Net
- Host and Router
- NIC
- Link



The Package SSF.OS

Package SSF.OS:

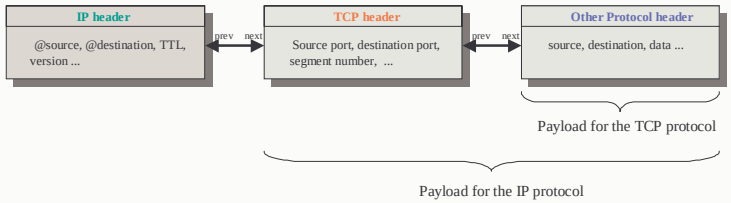
- ProtocolGraph
- ProtocolSession
- ProtocolMessage
- PacketEvent



The ProtocolMessage

- The object ProtocolMessage represents the message exchanged between the different ProtocolSessions (protocol layers) in a node (ProtocolGraph).
- The basic idea of a ProtocolMessage is the same as the real world : a Protocol Message has a header and a payload. The payload itself is also a ProtocolMessage.

The ProtocolMessage (2)



- The class ProtocolMessage provides the necessary methods for manipulation (add/remove payload).

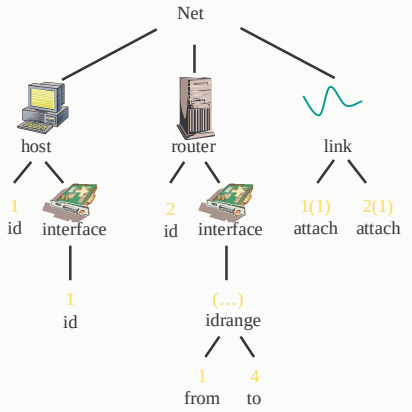
DML - The Domain/Data Modeling Language

- The DML syntax specifies a hierarchy of lists of attributes (key-value pairs).
- It is used for:
  - The model description
  - Model instantiation (first phase of simulation)
  - Runtime inspection

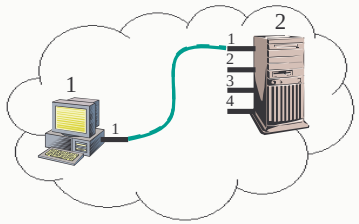
2 important interfaces:

- Configuration:
  used by the classes that store and provide access to DML configurations in memory (the database objects).
- Configurable:
  used by any class that can self-configure itself using the attributes obtained from the matching Configuration objects (protocols, interface…).

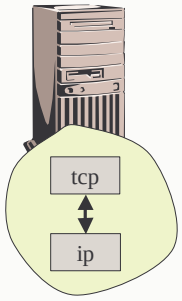
Scripting a Network in DML




```
Net [
  host [
    id 1
    interface [ id 1 ]
  ]
  router [
    id 2
    interface [ idrange [from 1 to 4] ]
  ]
  link [
    attach 1(1)
    attach 2(1)
  ]
]
```



Scripting Protocols in DML



Protocol graph

```
router[
  graph[
    ProtocolSession [
      name tcp
      use SSF.OS.TCP.tcpSessionMaster
    ]
    ProtocolSession [
      name ip
      use SSF.OS.IP
    ]
  ]
]
```

Creation and Configuration

Initialization

Simulation monitoring (1)

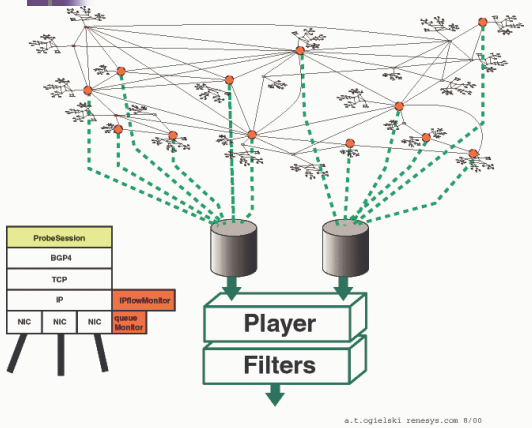
Measurement of…

- end-2-end application data.
- internal state of protocol sessions.
- the queue monitor.
- routing and wavelength assignment update.
- …

Characteristics:

- Flexibility: Automatic configuration of the monitors in multiple nodes: use of dml file to place the monitors and to configure them.
- Fast output: use byte streams of *records* and source multiplexing.
- Fast record retrieval: demultiplex records.

Simulation monitoring (2)



- The user configures via the DML file where the monitors are installed (protocols and queues).
- During the simulation, monitors write a byte stream into one or more files.
- After the simulation, the user uses a player to retrieve the collected information and formats them.

Monitoring Input Traffic

new

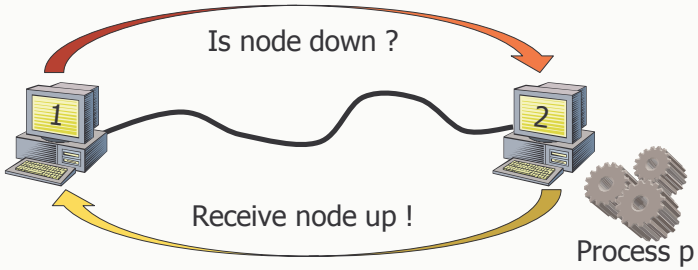
- Provides the capability to use the SSF monitor framework for incoming traffic.
- Allows to monitor loss of packages in the link layer.
- Facilitates the collection of raw data of message delays in the link layer.

Multi timeline in SSFNet

- Each node can be in its own timeline.
- Direct access can cause a timeline conflict.
- Data exchange only by sending messages.

Timeline problematic (1)

Direct access by method call !



Timeline 1

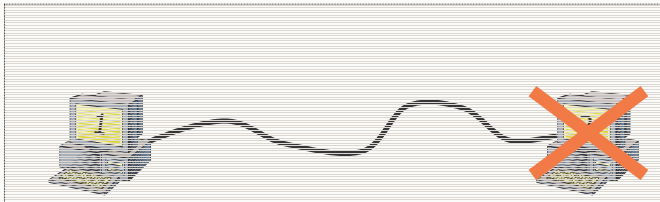
t0 t1 t2

Timeline 2

t0 t1 t2

Timeline problematic (1)

Timeline Conflict !



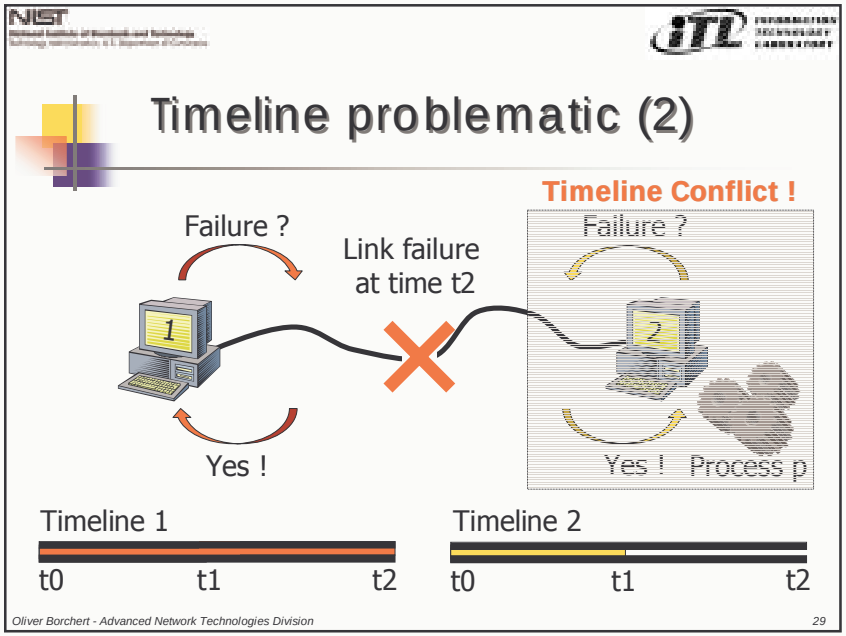
Received node 2 is up
because of different timelines!

Timeline 1

t0 t1 t2

Timeline 2

t0 t1 t2


Timeline problematic (2)
Timeline Conflict !
Failure ?
Link failure
at time t2
Failure ?
1
2
Yes !
Yes ! Process p
Timeline 1
Timeline 2
t0
t1
t2
t0
t1
t2
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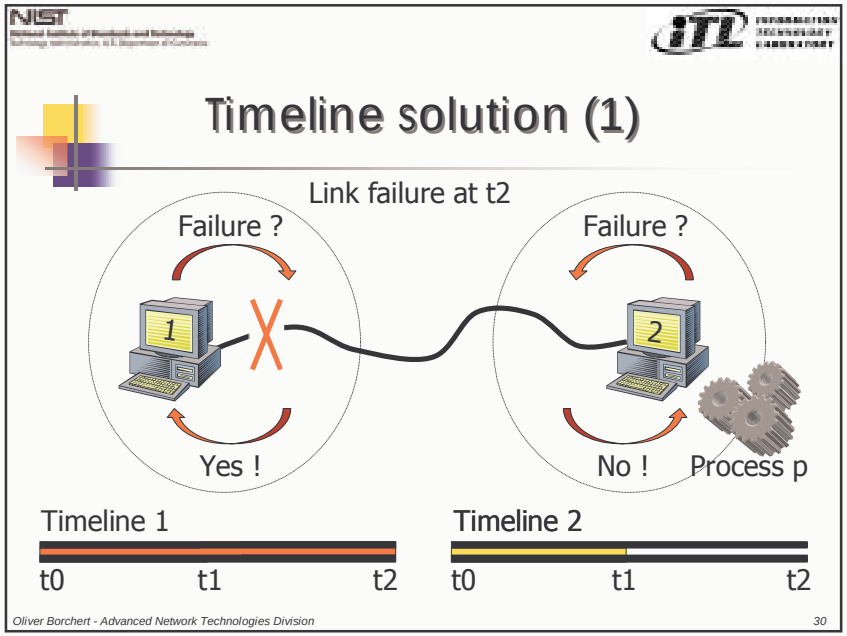
Timeline solution (1)
Link failure at t2
Failure ?
Failure ?
1
2
Yes !
No ! Process p
Timeline 1
Timeline 2
t0
t1
t2
t0
t1
t2
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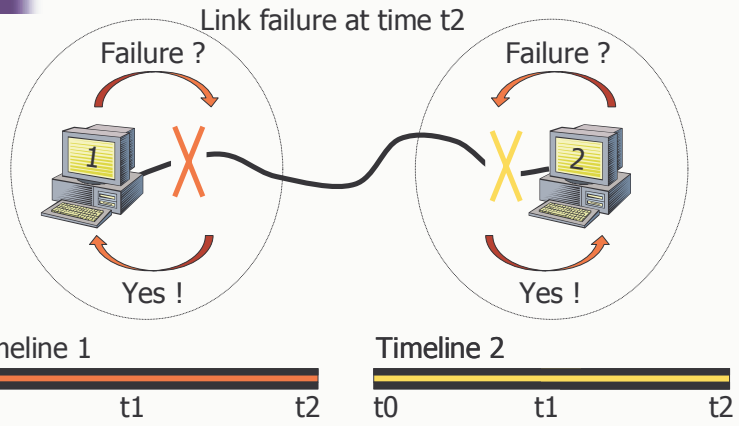
Timeline solution (1)

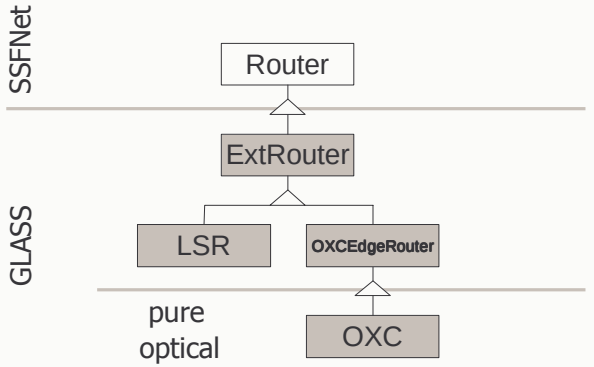


Optical Components

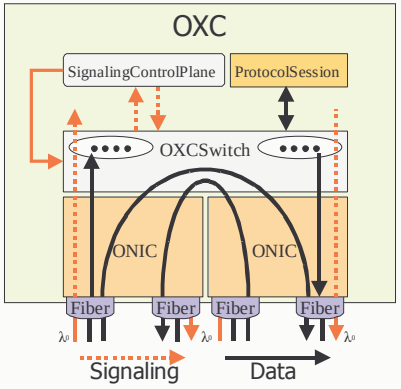
The Optical Components

- Routers and components:
  - Optical Cross Connect (OXC)
  - Edge Router (OXCEdgeRouter / LSR)
  - Optical Network Interface (ONIC)
  - Optical Switch (OXCSwitch)
- Link:
  - Optical Link – Optical Link Layer
  - Fiber
  - Lambda
- Optical Connection:
  - Optical Channel
  - Optical Channel Segment

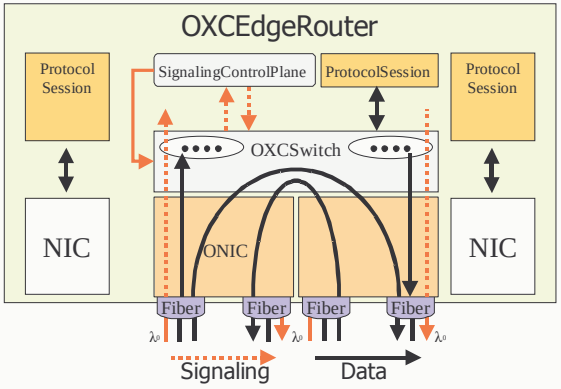
The Optical Components class hierarchy



Optical Cross Connect
- OXC -

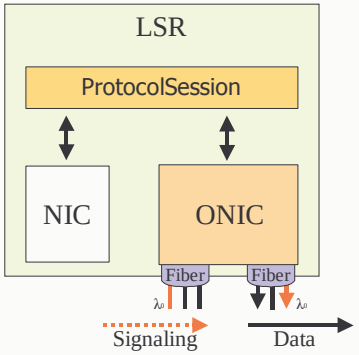


OXC Edge Router



Label Switched Router (LSR)

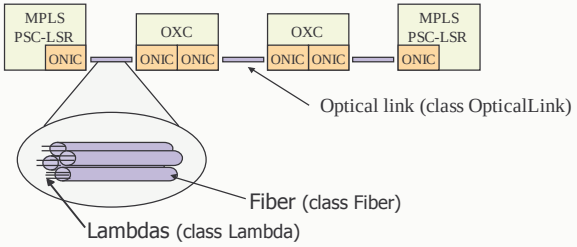
- The Protocol must be able to communicate with the NIC and ONIC.
- The switching must be done in the protocol layer.



Optical Links

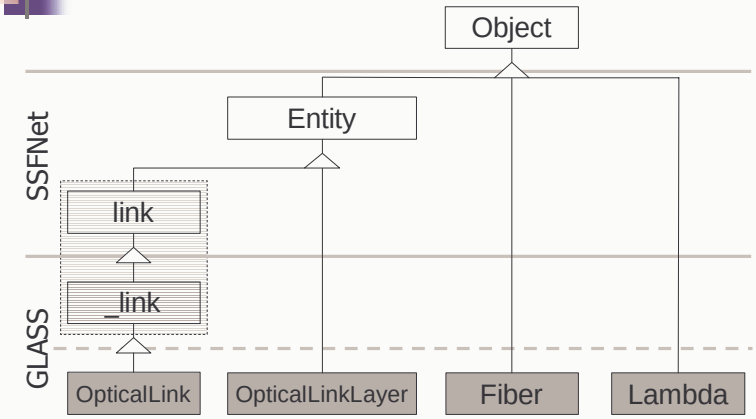
- The basic medium to transport a message through an optical network is a fiber.
- Can we use the link of SSF as representation of a fiber?

The Optical Link



- Consists of:
  - A bundle of fibers
  - Each fiber contains a list of lambdas

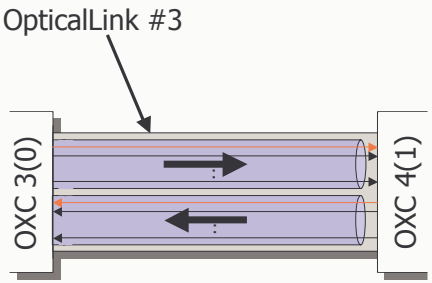
The Optical Link class hierarchy



Scripting an Optical Link

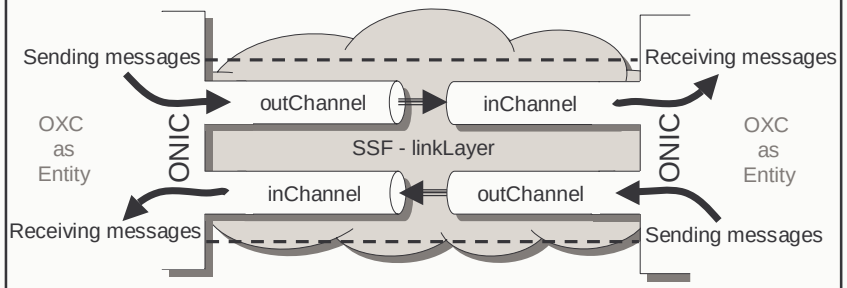
```
OpticalLink [
   id 3
   attach 3(0) attach 4(1)
   distance 1
   delay 0.00005
]

No Fibers specified:
    => automat-generation of two
       unidirectional Fibers
    => Each fiber has ten
       Lambdas with 2.5 Gig.
       - one control (red)
       - 9 data (black)
```



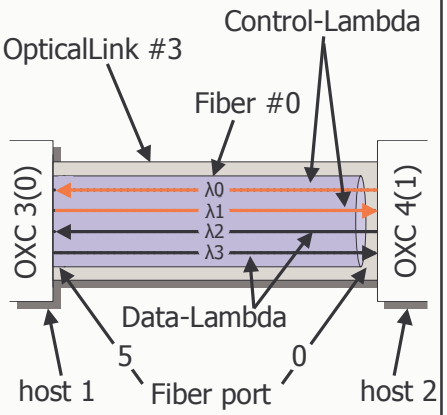
The Optical Link Layer

- Is an abstract helper to create channels for the "entity" communication.



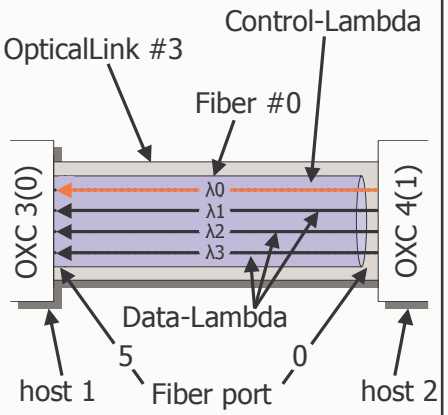
Scripting a Fiber (1)

```
OpticalLink [
  id 3
  attach 3(0) attach 4(1)
  distance 1
  delay 0.00005
  Fiber [
    id 0
    host2Nhi 4
    host2PortID 0
    host1PortID 5
    noLambdas 4
    bidirectional true
  ]
]
```



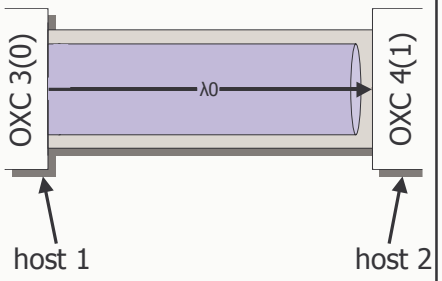
Scripting a Fiber (2)

```
OpticalLink [
  id 3
  attach 3(0) attach 4(1)
  distance 1
  delay 0.00005
  Fiber [
    id 0
    host2Nhi 4
    host2PortID 0
    host1PortID 5
    noLambdas 4
    bidirectional false
  ]
]
```

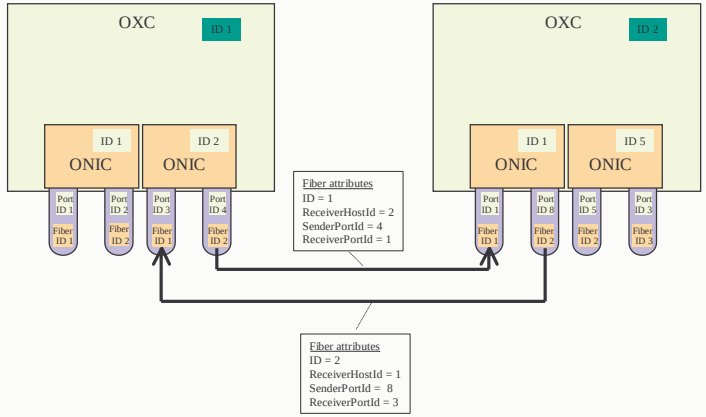


Scripting a Lambda

```
Fiber [
   id  0
   host2Nhi
   host1PortId
   host2PortId
   Lambda [
      id 0
      wavelength 1500
      bandwidth 2.5
      control false
      receiver host2
   ]
   …
]
```



The Optical Id Structure

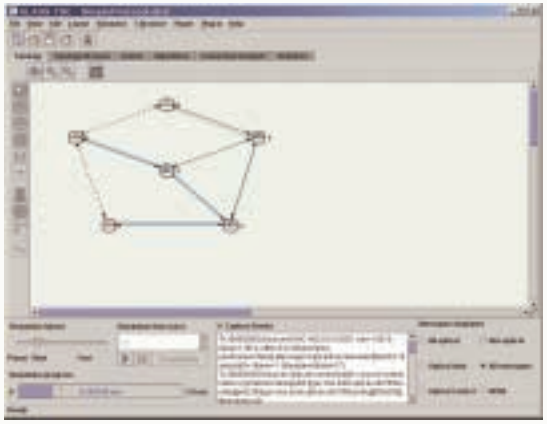


DML EXAMPLES

GLASS-TSC

- The Topology and Simulation Creator (TSC) is a graphical interface that provides:
  - Creation and configuration of topology
    - Network
    - Hosts (protocols, interfaces)
    - Links
    - Algorithms
    - Connections …
  - Runtime simulation
    - Control of simulation (speed, breakpoints)
    - Protocols and messages debugging
    - Visualization of connections and packets.

Demo of the GLASS - TSC



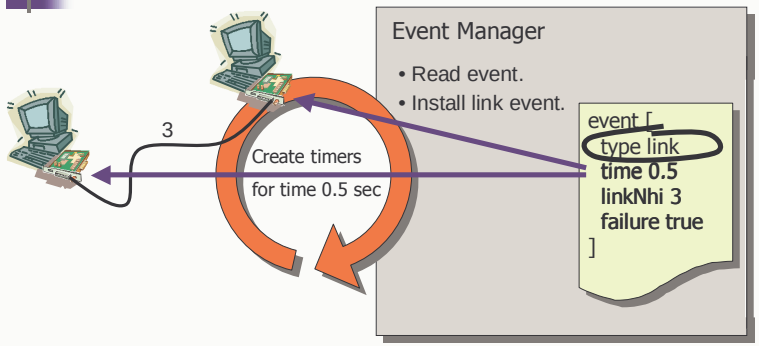
Framework Events

- The Framework provides a capability to manage topology events.
- These events are part of the simulation.
- They are configured in the DML.
- Events are located in the timeline of the affected component.

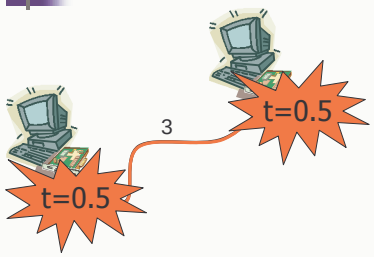
Types of events

- At this time we only have failure and recovery events.
- Script Event.
  - Node Event — class DefaultNodeEvent
  - Link Event — class DefaultLinkEvent
  - ONIC Event — class DefaultONICEvent
  - Fiber Event — class DefaultFiberEvent
  - Lambda Event — class DefaultLambdaEvent
- These events manipulate the attribute "failure" in the components.

Example of Event injection



Example of Event injection

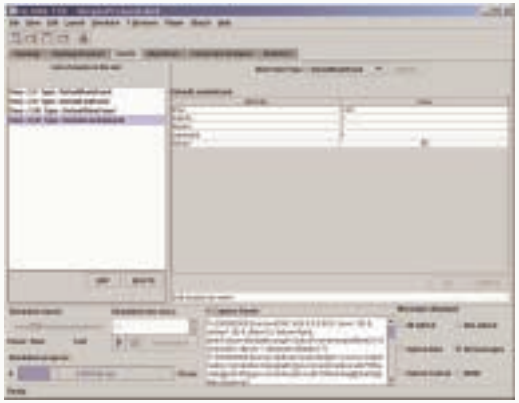


Event Manager

- Read event.
- Install link event.

```
event [
  type link
  time 0.5
  linkNbi 3
  failure true
]
```

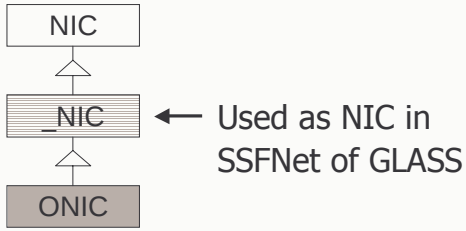

Demo TSC – Event Panel



The Network Interface Card

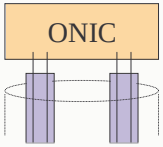
- Problem:
  - The Network Interface Card (NIC) is connected to
    - IP on the upper side
    - SSF link infrastructure on the lower side.
- Solution:
  - ~~Rewrite the NIC~~
  - Subclass the NIC and create an Optical Network Interface Card (ONIC)

The ONIC class hierarchy

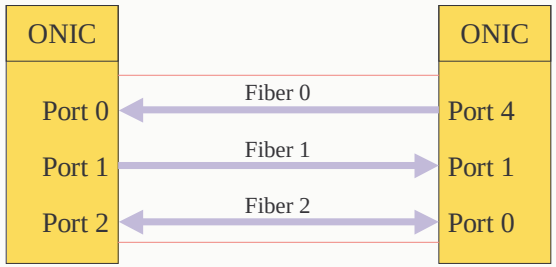


The ONIC

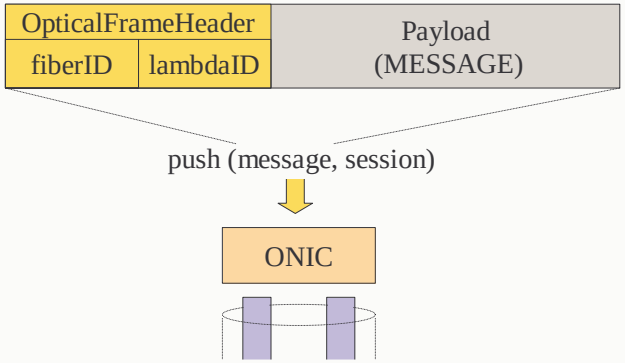
- The ONIC connects node to an optical link.
- The optical link is similar to multiple links.=> Each lambda in a fiber similar to an independent link.
- Parallel message processing.



ONIC - Ports



The ONIC Interface



More (2)
Hardware Failure Detection

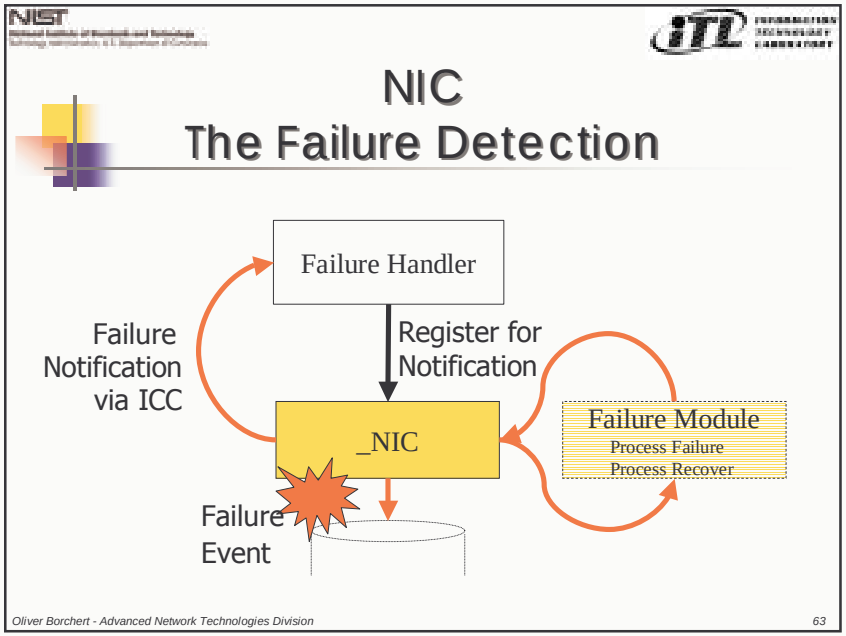
- Failure detection not only in the optical domain .
- We want to be able to detect failures in the link as well as in the optical link.
- Using the event scripting capability.

The Failure Module

- An interface to allow customized modules in the _NIC
- Detects the failure and produces the Event - Message
- Passes the message back to the _NIC

Event Message

- Used for Inter-Component-Communication (ICC) → Failure notification
- 3 Basic Message types:
  - Alarm Message
  - Error Message
  - Information Message
- 2 Specialized Messages:
  - Failure Message (Error Message Type)
  - Recover Message (Information Message Type)


NIC
The Failure Detection
Failure Handler
Failure
Notification
via ICC
Register for
Notification
_NIC
Failure Module
Process Failure
Process Recover
Failure
Event
Oliver Borchert - Advanced Network Technologies Division
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