OPT-Transport Apps of O3 Orchestrator & Controller suite Starting guide

CONTENTS

1 ABBREVIATION

CTP	Connection Termination Point
DON	Dummy Optical Node
DPID	Data Path ID
EMS	Element Management System
HO ODU	Higher Order Optical channel Data Unit
LO ODU	Lower Order Optical channel Data Unit
MPLS	Multi-Protocol Label Switching
OCh	Optical Channel
OCNRM	Optical Core Network Resource Manager
ODU	Optical Data Unit
OMS	Optical Multiplex Section
ONF	Open Networking Foundation
OPT	Optical
Opt.	Optical
OSS	Open Source Software
OTN	Optical Transport Network
PCE	Path Computation Element
Pkt.	Packet
PT	Packet
QoS	Quality of Service
REST	Representational State Transfer
RM	Resource Manager
SDN	Software Defined Networking
SW	Switch
TL1	Transaction Language 1
TPN	Tributary Port Number
TS	Tributary Slot
TTP	Trail Termination Point
WDM	Wavelength Division Multiplexing
XC	Cross Connect

2 INTRODUCTION

If SDN in the optical core network area is realized, it becomes possible to request and utilize low latency and broadband resources on-demand. “OPT-Transport Apps of O3 Controller suite” is one of the applications of “O3 Orchestrator suite”, and can make your optical core network with OTN/WDM functions SDN-enabled.

3 TARGET NETWORK

The target of this software is an optical core network with OTN/WDM functions. Only 10GEther client ports are assumed for the optical network node.

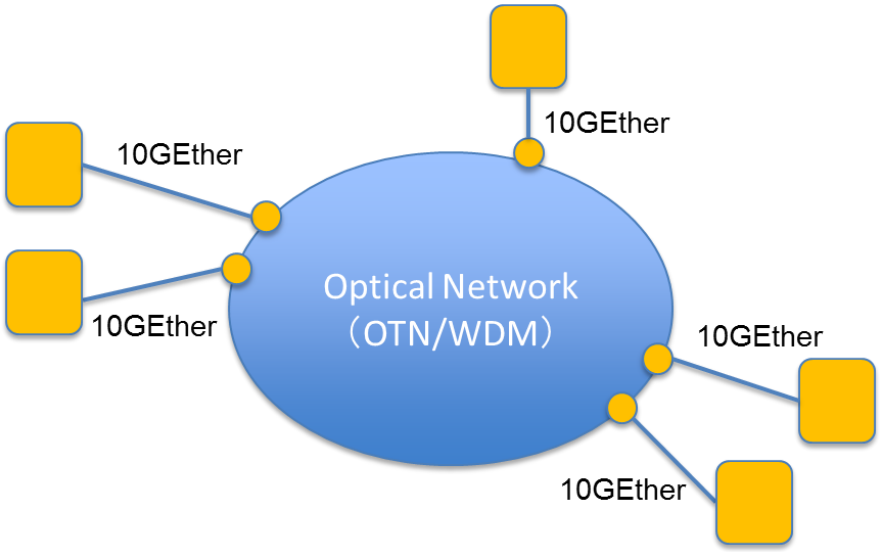


Figure 1 Target Network

4 OUTLINE OF OFFERED FUNCTIONS

- Virtualization of optical core network resources
  - This function virtualizes nodes, ports, links and set up path information, and registers these information as a network object of O3 Orchestrators suite. As a result, the state of the optical core network resources can be treated in the software application.
    - It is assumed that OCh and HO ODU paths are already set.
- Control of optical core network resources
  - "OPT-Transport Apps of O3 Orchestrator＆Controller suite " assigns the requested resources by writing these resources into network objects through ODENOS interface.
    - RYU[1] OTN extension is needed to control optical core network.
    - Separately, an application that emulates an optical core node is offered. This application establishes a session with RYU and receives control message.
  - The resource of LO ODU path can be assigned dynamically per client port (10Gbps).
  - The latency can be designated as one of the parameters in requesting optical core resources.

[1] RYU: RYU is an open source SDN Controller developed by NTT, Japan. Please refer section 7.2.

✧ A cut through path that does not pass through the electric layer in intermediate nodes can be assigned for a request of severe low latency (path computation function is needed in this case).

5 LIST OF THE OPEN SOURCE SOFTWARE

Main software (O3 Orchestrator & Controller Suite)

1. OCNRM — Optical core network resource manager

Supplemental software

2. PseudoManagementFunctions — Dummy software (Physical resource management, PCE)
3. RYU-OE — RYU OTN extension
4. DummyOptNode — Dummy optical node
5. Openflowj-otn — OpenFlowJ OTN extension

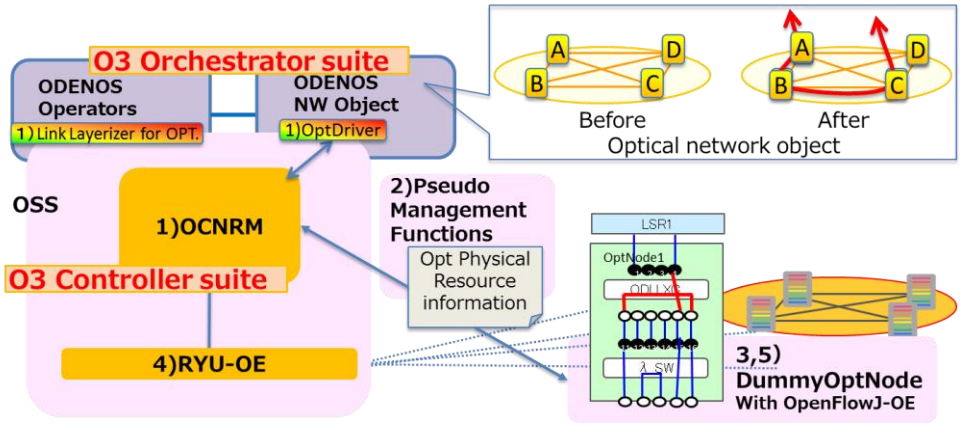


Figure 2 OSS software relationship

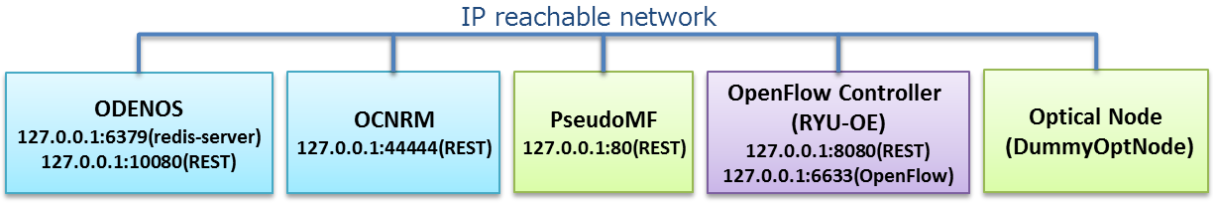


Figure 3 Sample Settings

6 OCNRM – OPT-TRANSPORT APPS OF O3 ORCHESTRATOR & CONTROLLER SUITE

6.1 WHAT'S OCNRM

OCNRM(Optical Core Network Resource Manager) is a software which achieves Software Defined Networking in OTN/WDM network. OCNRM works with ODENOS, PseudoMF(PseudoManagementFunctions) and RYU-OE(RYU OTN Extension), and control OTN/WDM network nodes which support OpenFlow OTN extension.

6.2 SOFTWARE STRUCTURE

OCNRM contains the following software.

- ODENOS logic components for the optical core network, named "LinkLayerizer" and "OptDriver"(O3 Orchestrator suite).
- Application that manages and controls virtualized resources of the optical core network (O3 Controller suite).

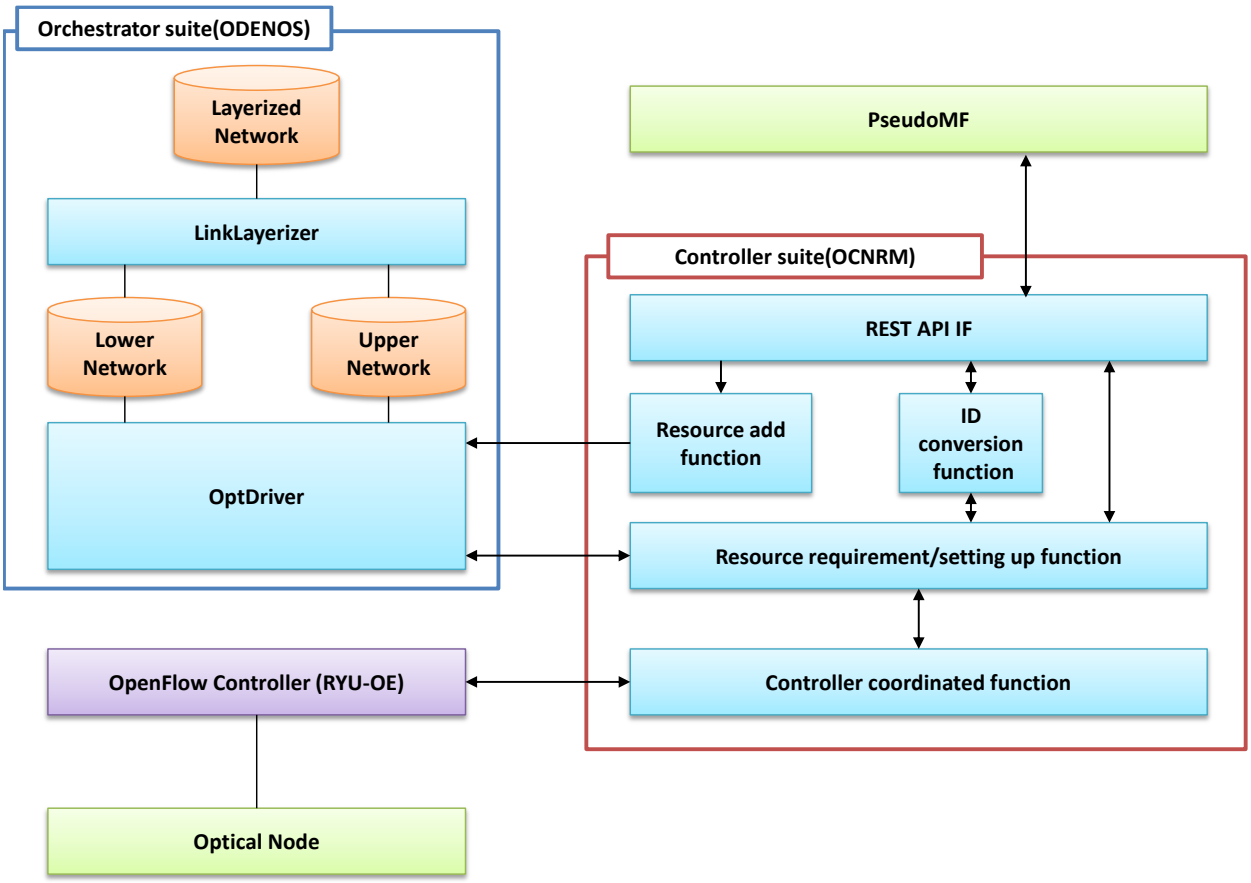


Figure 4 OCNRM component relationship

6.2.1 ORCHESTRATOR SUITE

Orchestrator suite is a set of programs based on ODENOS framework (https://github.com/o3project/odenos) that supports the development of SDN applications. OPT-Transport Apps of O3 Orchestrator & Controller suite implements the following two logic components based on ODENOS framework.

6.2.1.1 Link Layerizer

Link Layerizer is a logic component that abstracts different two layers (upper and lower layer) as one layer. Link Layerizer for the optical core network supports the ODU layer as the upper layer and the OCh layer as the lower layer. As a result, these two layers are combined as one layerized network.

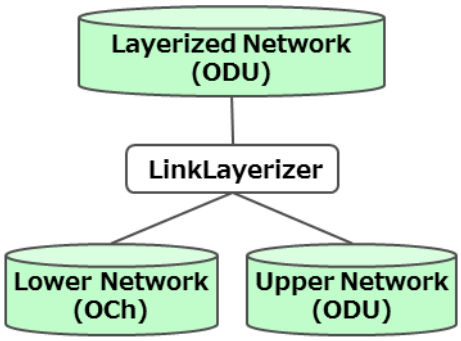


Figure 5 Link Layerizer

Link Layerizer virtualizes a lower layer flow as the upper layer link. Please see the ODENOS API document (https://github.com/o3project/odenos/blob/develop/doc/api/LinkLayerizer.md) in detail.

6.2.1.2 OptDriver

OptDriver is a logic component that operates when optical NEs are controlled by ODENOS and the information of NEs are registered.

- OptDriver receives events (ex. triggers of link/flow settings) from ODENOS, and passes them to RM
- OptDriver has a function that registers optical core information to ODENOS through REST interface

6.2.2 CONTROLLER SUITE

Controller suite is a set of logic components that controls each virtual network resource managed under the Orchestrator suite.

6.2.2.1 RM(Resource manager)

RM is the Controller suite for the optical core network.

- RM decides the control executed to a physical optical equipment according to the notification from OptDriver, and passes RYU-OE appropriate parameters for control

- OpenFlow 1.3 OTN extension is adopted as a southbound interface

- RM converts the information of optical core network resources (including link and flow settings) into ODENOS format, and sends it to OptDriver.

6.3 URL

https://github.com/o3project/ocnrm

6.4 ENVIRONMENT

Operation is validated in the following environments.

OS：Ubuntu 12.04.3(x64)

Memory: 1GB (without ODENOS)

Middleware: Java 7 and later, Maven2

ODENOS 1.0.0 is required

6.5 BUILD

```
$ cd ~
$ git clone https://github.com/o3project/ocnrm.git
$ bash ./build.sh
$ tar xvfz ./target/ocnrm-1.0.0-bin.tar.gz –C ~/
```

You can choose your install directory instead of ~/.

6.6 CONFIGURATION

Edit OCNRM.properties. In this document, parameters such as IP address/Port number in sample settings (see Figure 3) are used, for example.

```
$ vi ~/ocnrm-1.0.0-bin/OCNRM.properties
```

Set redis-server's host & port.

```
DISPATCHER_HOST=127.0.0.1
DISPATCHER_PORT=6379
```

Set pseudoMF's REST access points.

```
REQUEST_ODU_FLOW_URL=http://127.0.0.1:80/DEMO/Generate/L1Path
REQUEST_OCH_REPLACEMENT_PIECE_URL=http://127.0.0.1:80/DEMO/ID/L0Request
REQUEST_ODU_REPLACEMENT_PIECE_URL=http://127.0.0.1:80/DEMO/ID/L1Request
DELETE_ODU_FLOW_URL=http://127.0.0.1:80/DEMO/Delete/L1Path
```

set RYU-OE's REST access point.

```
OFCTL_SEND_URL=http://127.0.0.1:8080/stats/flowentry
```

6.7 START AND STOP

Starting OCNRM

```
$ ~/ocnrm-1.0.0-bin/ocnrm_mn -s
```

Stopping OCNRM

```
$ ~/ocnrm-1.0.0-bin/ocnrm_mn -q
```

7 ATTACHED SOFTWARE (PSEUDOMF, RYU-OE, DUMMYOPTNODE)

7.1 PSEUDOMANAGEMENTFUNCTIONS（PSEUDOMF）

7.1.1 WHAT'S PSEUDOMF

PseudoMF is a software which works instead of physical network elements management system (EMS), path computation elements (PCE).

PseudoMF provides optical core network resources information to OCNRM, ID mapping information between OpenFlow and internal ID (as we call Information Model ID), route information for new resource creation.

- Initial information registration function to ODENOS via OCNRM
- Simple route determination function
- ODENOS/OpenFlow Parameter conversion function

7.1.2 ENVIRONMENT

Same as OCNRM.

7.1.3 URL

https://github.com/o3project/pseudoMF

7.1.4 BUILD

```
$ cd ~
$ git clone https://github.com/o3project/pseudoMF.git
$ bash ./build.sh
$ tar xvfz ./target/pseudoMf-1.0.0-bin.tar.gz -C ~/
```

You can choose your install directory instead of ~/.

7.1.5 CONFIGURATION

Edit PseudoMf.properties. In this document, parameters such as IP address/Port number in sample settings (see Figure 3) are used, for example.

```
$ sudo vi ~/PseudoMf.properties
```

set OCNRM's REST access points.

```
REQUEST_INITIALIZE=http://127.0.0.1:44444/demo/node
```

7.1.6 START AND STOP

Starting PseudoMF

```
$ ~/pseudoMf-1.0.0-bin/pseudoMf.sh -s
```

Stopping PseudoMF

```
$ ~/pseudoMf-1.0.0-bin/pseudoMf.sh -q
```

7.2 RYU OTN EXTENSION (RYU-OE)

7.2.1 WHAT'S RYU-OE?

RYU-OE is based on RYU V3.9 developed by NTT.

In RYU-OE, some OTN parameters are added to the Match Fields of OpenFlow protocol (ver1.3) to support OTN. The detail of the extended OpenFlow specification is to be published by ONF in near future.

(1) ODU_SIGTYPE
ODU signal type (ODU0/1/2/2e/3/4 etc.) is set. This software only supports ODU2e.

(2) ODU_SIGID
ODU_SIGID contains in its payload the following parameters.
- TSLEN (the number of TS bits depending on ODU signal type)
- TSMAP (bitmap of TS)
- TPN (Tributary Port Number)

This software only supports TSLEN=8, TSMAP="1,1,1,1,1,1,1,1". TPN can be an arbitrary integer.

These parameters can be set in Action by using "Set Field" that already exists in OpenFlow protocol. RYU-OE also supports REST interface in its northbound, and flow entries including these parameters can be set by REST command as shown in the example below. In case of setting TSMAP by REST, please write the bit number of TS (counting from the first bit) on which client signal is mapped.

Example of REST command

curl -d '{"dpid":"2",

"match": {"in_port": "1" , "odu_sigtype": "ODU2E", "odu_sigid":{ "tpn": "1", "tsmap": "1,2,3,4,5,6,7,8", "tslen": "8" }},

"actions":[{"type": "SET_FIELD", "field": ["tpn","tsmap","tslen"],"value": ["2","1,2,3,4,5,6,7,8","8"]},{"type": "OUTPUT","port":"2"}]}' http://localhost:8080/stats/flowentry/add

7.2.2 URL

https://github.com/o3project/ryu-oe

7.2.3 BUILD

```
$ cd ~
$ git clone https://github.com/o3project/ryu-oe.git
$ cd ~/ryu-oe
$ sudo python ./setup.py install
```

7.2.4 START AND STOP

```
$ cd ~/ryu-oe/ryu/app
```

```
$ ryu-manager ./ofctl_rest.py
```

Press Ctrl+C to stop ryu-oe.

7.3 DUMMYOPTNODE (DON) WITH OPENFLOWJ-OTN

7.3.1 WHAT'S DUMMYOPTNODE WITH OPENFLOWJ-OTN

Since "OPT-Transport Apps of O3 Orchestrator& Controller Suite" are control optical core nodes (OTN/WDM), it is difficult to get such nodes. DummyOptNode(DON) is a software that emulates optical NE with OTN/WDM functions without data plane. DON is connected to RYU-OE, receives Flowmod and shows new cross connection status assigned by Flowmod.

Openflowj-otn is a software which modified OpenFlowJ-Loxi(Ver0.9.0). New OTN parameters are added into OpenFlow ver1.3 code. Openflowj-otn is used by DON in order to handle OpenFlow1.3 with OTN parameters.

1. DON sets up TCP session with RYU OTN extension, and receives the control command of OpenFlow protocol.
2. DON analyzes the content of flowmod (Please see Note below).
3. DON visualizes the ODU XC that is set up by flowmod.

Note: DON can only see the addition (OFPFC_ADD) of flow entry, but doesn't support deletion (OFPFC_MODIFY, OFPFC_MODIFY_STRICT), modification (OFPFC_DELETE, OFPFC_DELETE_STRICT).

7.3.2 ENVIRONMENT

Operation is validated in the following environments.

OS：Windows 7 Professional SP1 (x64)、Ubuntu desktop 12.04 (x64)

Middleware: Oracle Java VM jdk1.7.0_51、Maven 3

(Note) This software works with OCNRM, RYU-OE and PseudoMF.

7.3.3 URL

https://github.com/o3project/dummyOptNode

DON uses "OpenFlowJ OTN extension" as external library. The library can get by the following URL.

https://github.com/o3project/openflowj-otn

7.3.4 BUILD

It is necessary to build "OpenFlowJ OTN extension" before build DON because DON uses the extension as the external library.

```
$ git clone https://github.com/o3project/openflowj-otn.git
```

```
$ cd openflowj-otn
$ mvn clean install
```

```
$ git clone https://github.com/o3project/dummyoptnode.git
$ cd dummyoptnode
$ mvn clean install
$ tar xfvz ./target/dummyoptnode-1.0.0-bin.tar.gz –C ~/
```

You can choose your install directory instead of ~/.

7.3.5 CONFIGURATION

Edit dummyoptnode-1.0.0/config.properties. In this document, parameters such as IP address/Port number in sample settings (see Figure 3) are used, for example.

```
$ vi ~/dummyoptnode-1.0.0/config.properties
```

Set RYU-OE's host & port for OpenFlow session.

```
ofcHostname=127.0.0.1
ofcPortNumber=6633
```

7.3.6 START AND STOP

Starting DummyOptNode

```
$ cd ~/dummyoptnode-1.0.0/
$ java –jar dummyoptnode-1.0.0.jar
```

Stopping DummyOptNode

```
Just close Main GUI window.
```

7.3.7 SOFTWARE STRUCTURE

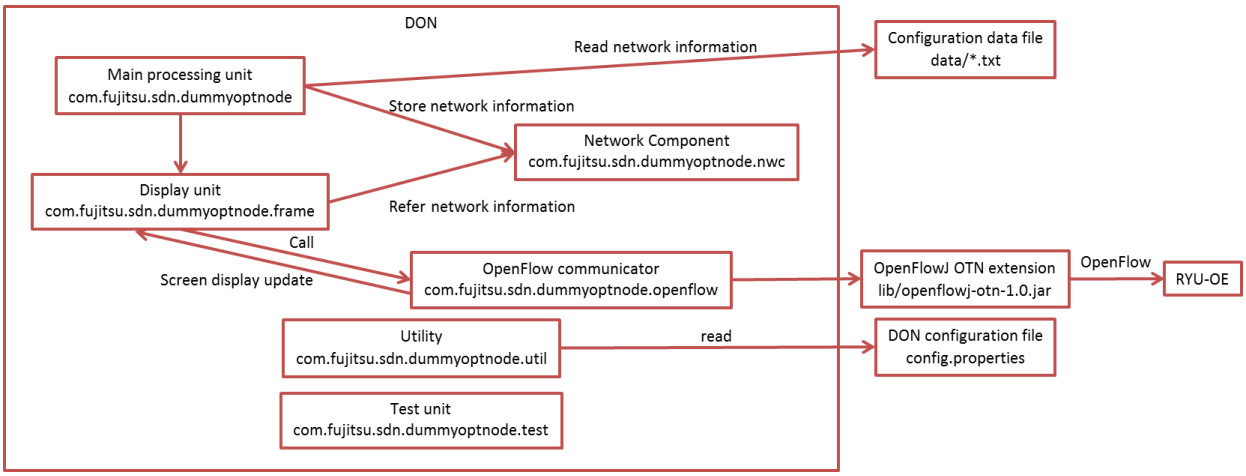
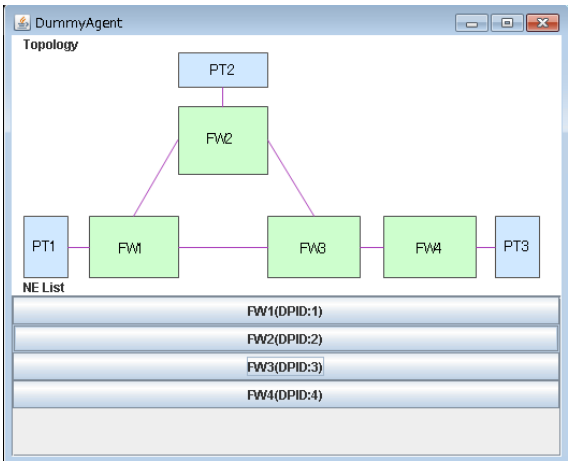


Figure 6 DummyOptNode software structure

- DON obtains the network configuration information from the definition file in data folder.
- DON communicates with RYU-OE (session initiation, receiving Flowmod and sending/receiving Echo Request) using the OpenFlowJ OTN extension (openflowj-otn).

7.3.8 GUI IMAGE

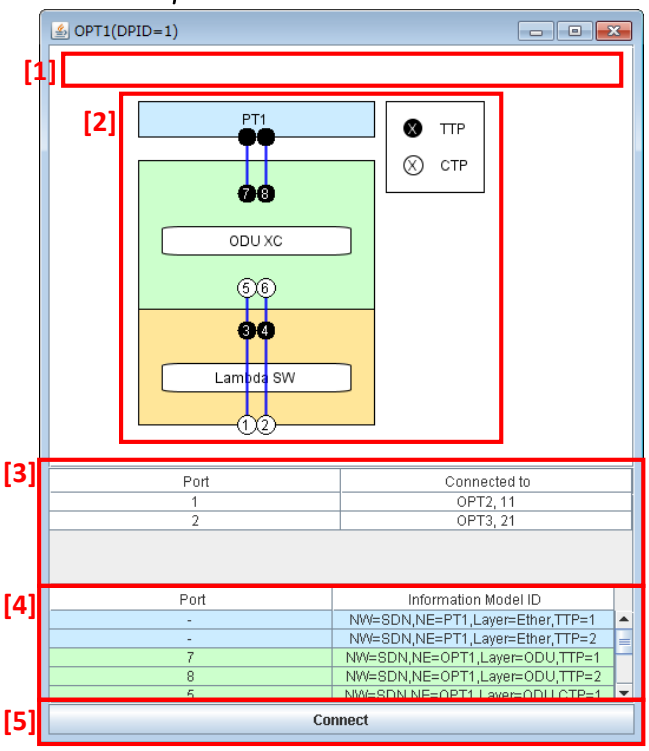
7.3.8.1 Main GUI



Buttons are displayed according to the number of optical core nodes. When the button is cricked, an OptNode GUI is opened.

Network topology and node configurations can be displayed in the GUI if such images are prepared as img/topology.png file.

7.3.8.2 OptNode GUI



- [1] Flowmod parameter display

The following parameters in match/actions are shown in this field. Only the newest Flowmod parameters are shown. Please refer the log file when you want to see the old Flowmod parameters.

Parameters		Explanation
[match]	in_port	Input port number
	odu_sigtype	ODU SIGTYPE (Number)
	odu_sigid	ODU SIGID (TPN, tslen, tsmap)
[actions]	Output	Output port number
	odu_sigtype	ODU SIGTYPE (Number)
	odu_sigid	ODU SIGID(TPN, tslen, tsmap)

The values shown in TPN, tslen, tsmap of ODU SIGID are extracted from the received packets, and expressed by the following formats.

- TPN: decimal number
- tslen: decimal number
- tsmap: binary number(bitmap)

- [2] Internal connection display

It shows the connection of ODU XC according to Flowmod.

- [3] Adjacent node/port display

It shows the port lists connecting to the other NE.

Row	Content
Port	Source port
Connected to	The NE and port number of destination port Ex. OPT1,11

- [4] Internal ID Display

It shows the internal ID that corresponds to the port number shown in the figure. Internal ID is expressed as Information model ID that is based on the internal naming rule in RM and PseudoMF.

- [5] Connect button

When you click the Connect button, RYU will be connected.

8 GETTING STARTED

8.1 OUTLINE

- Sample target network configuration
- Start programs
- Confirm the status of optical core nodes
- Let's request optical core resources

8.2 SAMPLE TARGET NETWORK CONFIGURATION

A definition file that includes the sample network configuration here is included. By changing the definition file, the different network can be configured. How to change the definition file will be shown in near future.

- Topology

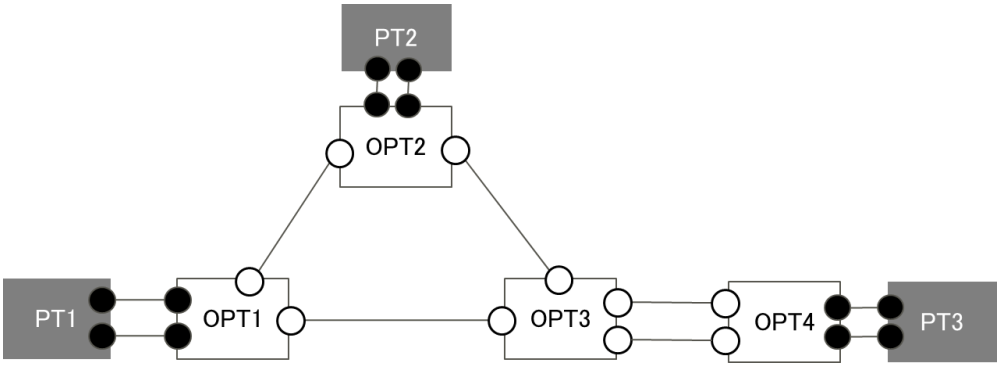


Figure 7 Sample Target Network topology

3 Packet transport node (PT#1-3) is connected
to the optical core network that is consist of 4 nodes (OPT#1-4)

- OCh path set up

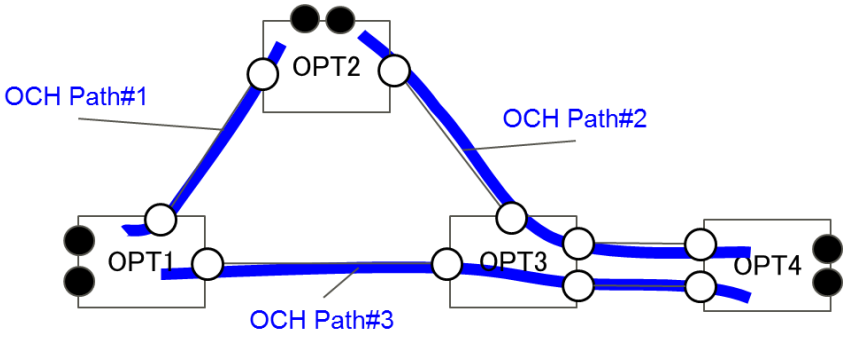


Figure 8 OCh path set up in Sample Target Network topology

It is assumed that 3 OCh paths are set up in the optical core network.

Files that define the sample network are shown below.

Table 1 network resource definition files

File Name	Content	Application using the file
Och_link.txt	OCh path configuration information	DummyOptNode ~/dummyoptnode-1.0.0/data
ll1.txt	Inter-layer boundary information (ODU layer and OCh layer)	DummyOptNode ~/dummyoptnode-1.0.0/data
ll2.txt	Inter-layer boundary information (packet transport node and ODU layer)	DummyOptNode ~/dummyoptnode-1.0.0/data
idex.txt	ID conversion information	PseudoMF, DummyOptNode ~/dummyoptnode-1.0.0/data ~/pseudoMF-1.0.0/data
lower.txt	Lower layer(OCh) resource information	PseudoMF ~/pseudoMF-1.0.0/data
upper.txt	Upper layer(ODU) resource information	PseudoMF ~/pseudoMF-1.0.0/data
route.txt	Route information	PseudoMF ~/pseudoMF-1.0.0/data

NOTE: Please don't change file name.

8.3 START PROGRAMS

- Start ODENOS

  $ *odenos_install_dir*/odenos –s

- Start OCNRM

  $ ~/ocnrm-1.0.0-bin/ocnrm_mn –s

- Start PseudoMF

  $ ~/pseudoMf-1.0.0-bin/pseudoMf.sh -s

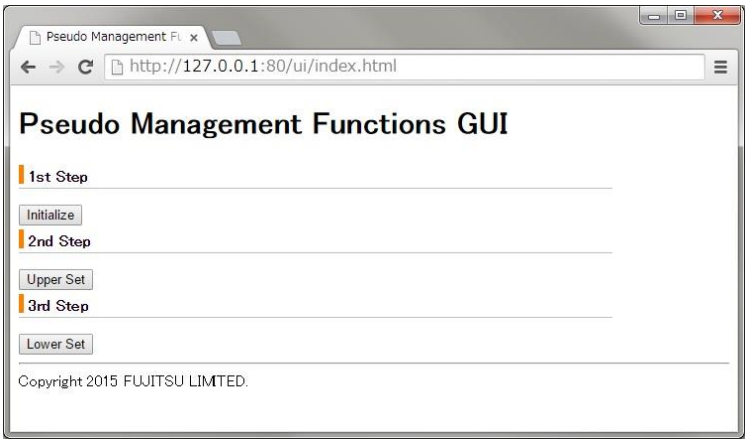
- System configuration (by execute a prepared shell script)

  $ ~/ocnrm-1.0.0-bin/rm_startup.sh

  - Create component managers
  - Create network components
  - Create and connect to OptDriver
  - Create and connect to LinkLayerizer
  - Set up boundary conditions for LinkLayerizer

- Allocate initial resources(L0,L1,L2) using PseudoMF GUI

1. Access PseudoMF via GUI (http://127.0.0.1:80/ui/index.html)
2. Push GUI 1st , 2nd, 3rd buttons in order



- Start RYU-OE

```
$ ryu-manager ~ryu-oe/ryu/app/ofctl_rest.py
```

- Start Dummy Opt Node and connect to RYU-OE
  1. $ java –jar ~/dummyoptnode-1.0.0/dummyoptnode-1.0.0.jar
  2. Push button with network entity name of NE List in Main GUI
  3. Push connect button at each OptNode GUI

8.4 CONFIRM STATUS OF OPT NODE

Confirm initial set up of Opt Node via DummyOptNode GUI

- You can see 4 core nodes with sample configuration
- You can see connection between OPT node and PT node, and initial connections of 3 OCh Paths (Bidirectional)
- Port numbers shown in DummyOptNode GUI are the same as those used in OpenFlow messages.

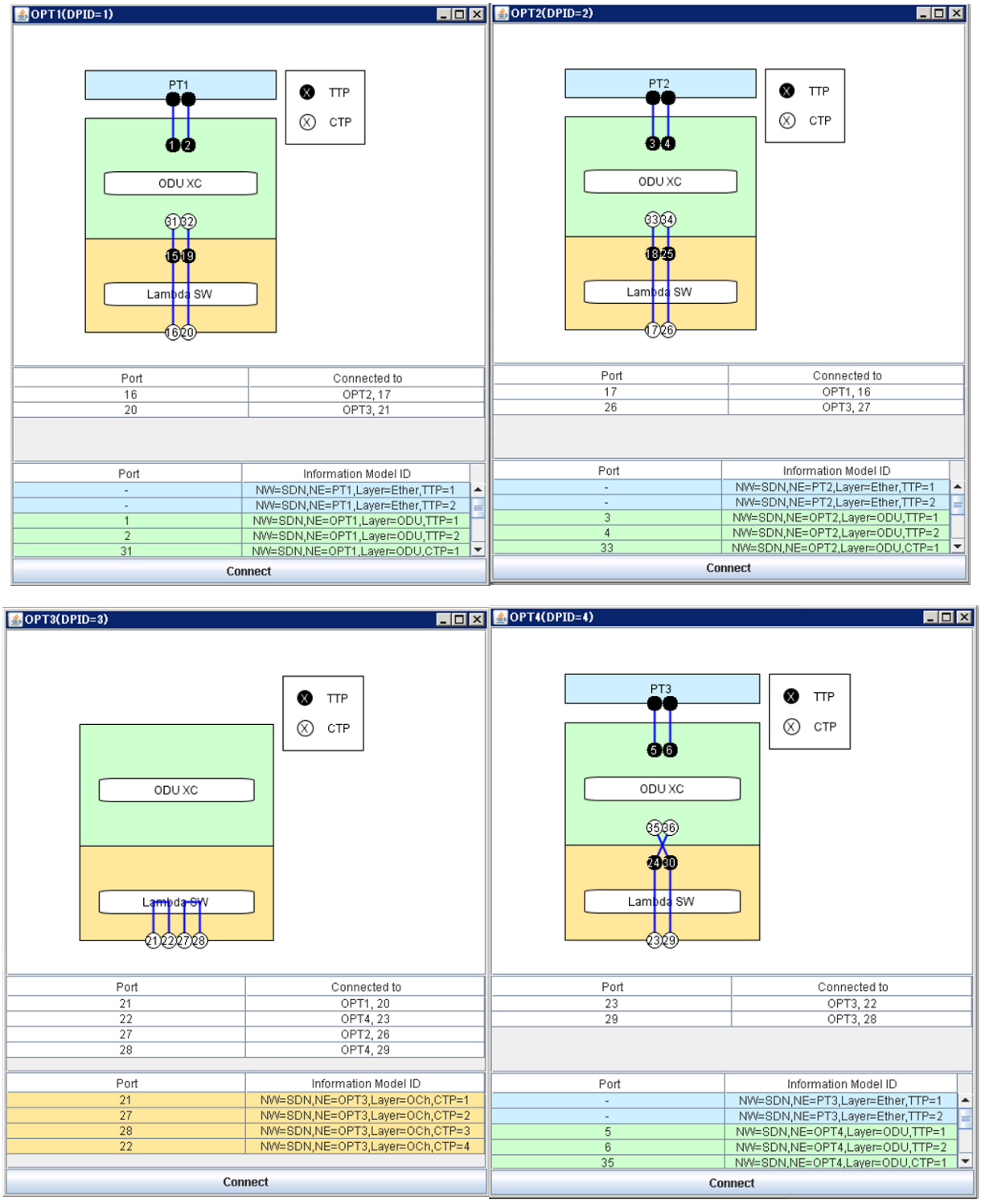


Figure 9 Initial status with sample configuration

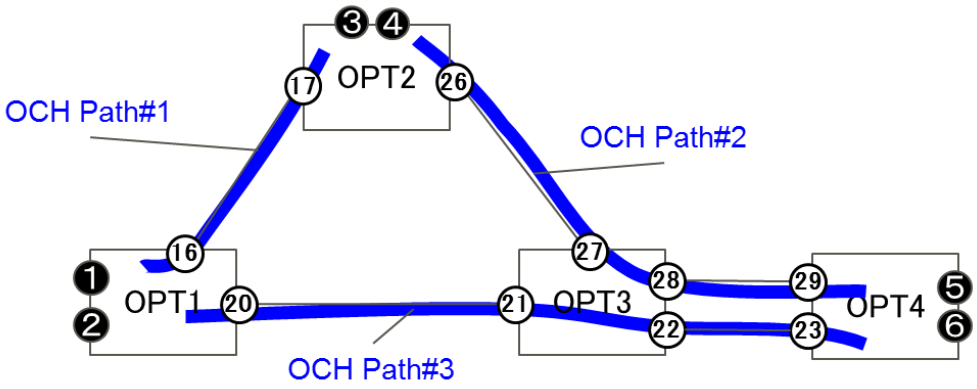


Figure 10 OCh path set up in Sample Target Network topology with port numbers for GUI

8.5 LET'S REQUEST OPTICAL CORE RESOURCE (1)

< Create LO ODU path without delay constraints >

The following example shows how to create LO ODU (optical core resource to which client signal is mapped) without delay constraints on demand.

In concrete, curl command is used to request a flow (named Flow1) in network component in ODU layer (named L01).

- Designate port 1 of ingress node (OPT1) as matches, and port 5 of egress node (OPT4) as edge_actions (Caution: It's needed to designate the Information Model ID of those ports such as "NW=SDN,NE=OPT1,Layer=ODU,TTP=1").
  - "in_node":"NW=SDN,NE=OPT1","in_port":"NW=SDN,NE=OPT1,Layer=ODU,TTP=1"
  - "output":"NW=SDN,NE=OPT4,Layer=ODU,TTP=1"

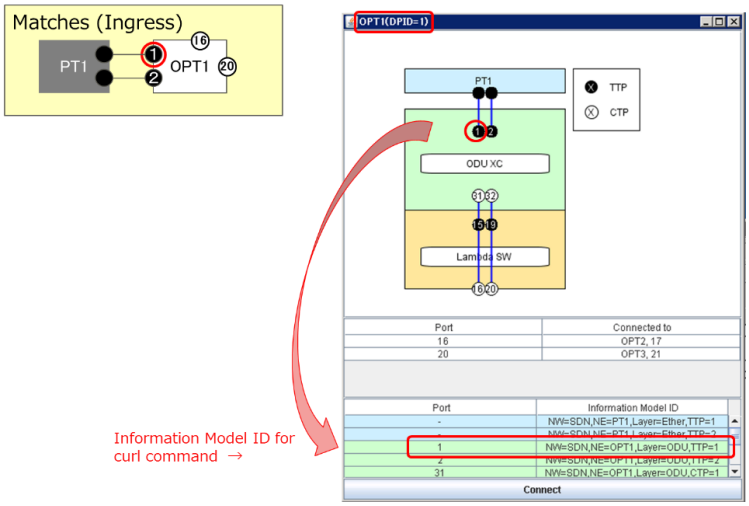


Figure 11 Ingress port-name used for LO ODU creation

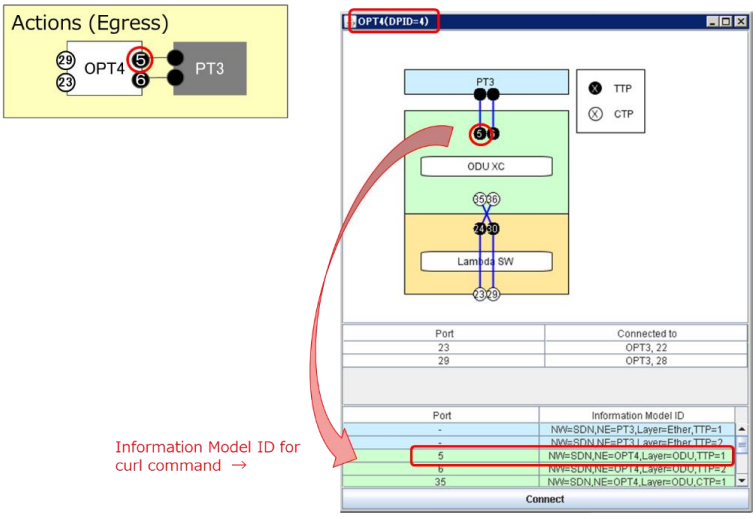


Figure 12 Egress port-name used for LO ODU creation

- Bandwidth [Mbps] and delay [msec] can be designated. Bandwidth is fixed as 10000 (ODU0 is assumed).
  - "req_bandwidth":"10000","req_latency":"9999"
- Setting the status “Establishing” means that flows are to be created.
  - "status":"establishing"

- Command (ODENOS REST API)
  This command is very long, so please copy & paste below;

curl -X PUT http://127.0.0.1:10080/L01/flows/Flow1 -d '{"type":"BasicFlow","version":"1","flow_id":"Flow1","owner":"ANY","enabled":true,"status":"establishing","matches":[{"type":"BasicFlowMatch","in_node":"NW=SDN,NE=OPT1","in_port":"NW=SDN,NE=OPT1,Layer=ODU,TTP=1"}],"path":[],"edge_actions":{"NW=SDN,NE=OPT4":[{"type":"FlowActionOutput","output":"NW=SDN,NE=OPT4,Layer=ODU,TTP=1"}]},"attributes":{"direction":"unidirectional","req_bandwidth":"10000","req_latency":"9999"}}'

[Reference] https://github.com/o3project/odenos/blob/develop/doc/api/Network.md#PUTflow_id

- Confirmation

In DummyOptNode GUI, Flowmod command is shown in upper side, and the new setting of the cross connection is shown in red line. LO ODU is created between the designated ports by ODU XC and OCh path#1 and #2.

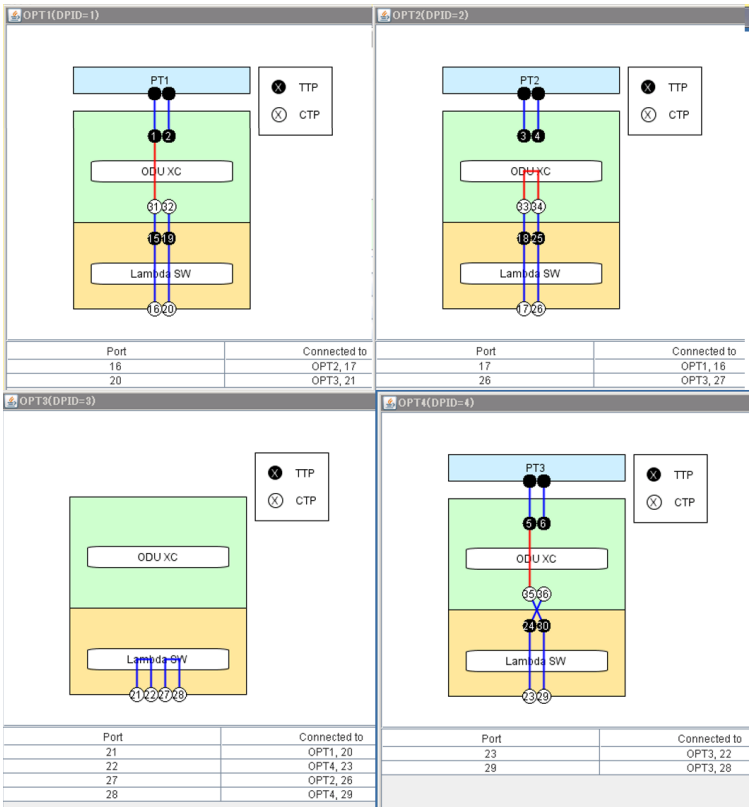


Figure 13 GUI showing the cross connection (red line) set up for the request (1).

8.6 LET'S REQUEST OPTICAL CORE RESOURCE (2)

< Create LO ODU path with small delay >

The following example shows how to create LO ODU with delay constraints.

In concrete, it can be done by just changing the QoS parameters at the request in 9.5. Curl command is used to set up a flow (named Flow2) in network component in ODU layer (named networkcomponent01).

- Command

curl -X PUT http://127.0.0.1:10080/L01/flows/Flow2 -d '{"type":"BasicFlow","version":"1","flow_id":"Flow1","owner":"ANY","enabled":true,"status":"establishing","matches":[{"type":"BasicFlowMatch","in_node":"NW=SDN,NE=OPT1","in_port":"NW=SDN,NE=OPT1,Layer=ODU,TTP=2"}],"path":[],"edge_actions":{"NW=SDN,NE=OPT4":[{"type":"FlowActionOutput","output":"NW=SDN,NE=OPT4,Layer=ODU,TTP=2"}]},"attributes":{"direction":"unidirectional","req_bandwidth":"10000","req_latency":"10"}}'

- Confirmation

In DummyOptNode GUI, Flowmod command is shown in upper side, and the new setting of the cross connection is shown in red line. LO ODU is created between the designated ports by ODU XC and OCh path#3.

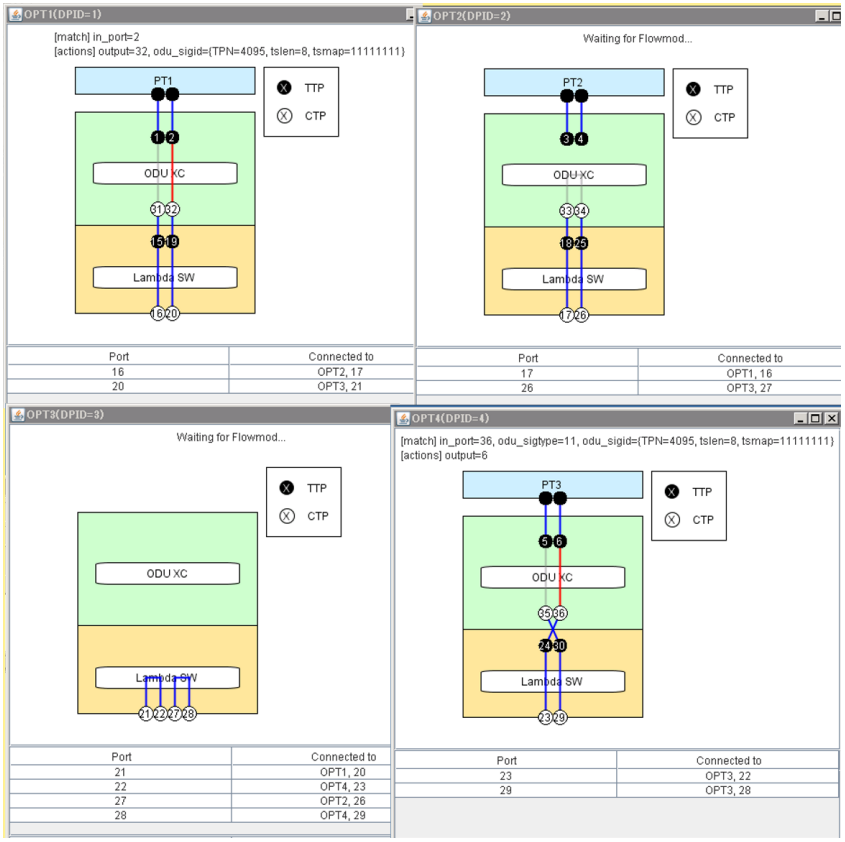


Figure 14 GUI showing the cross connection (red line) set up for the request (2).