COSMOS Optical Demo

https://wiki.cosmos-lab.org/wiki/tutorials/optical-network-example

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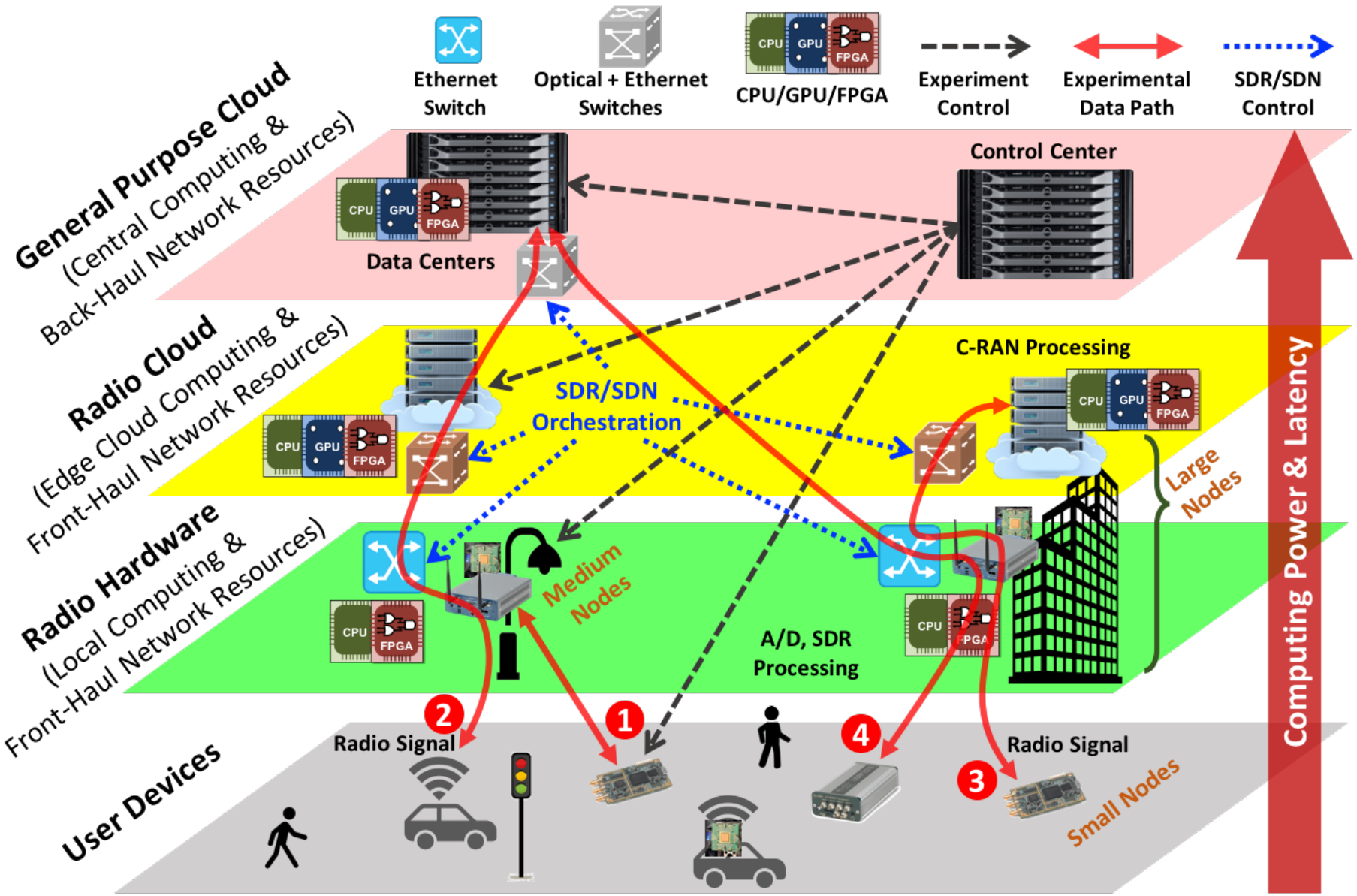

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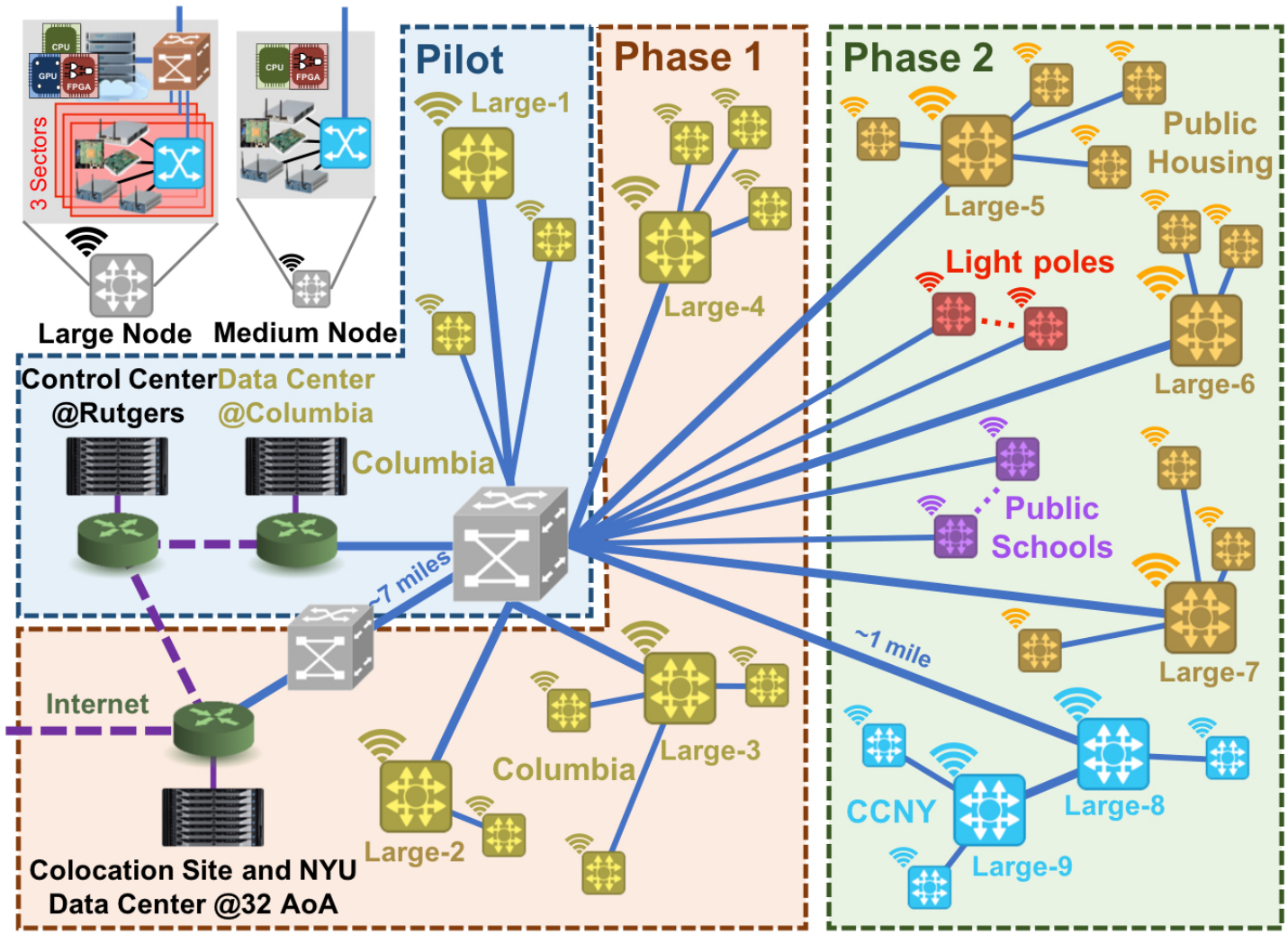
COSMOS Network Infrastructure



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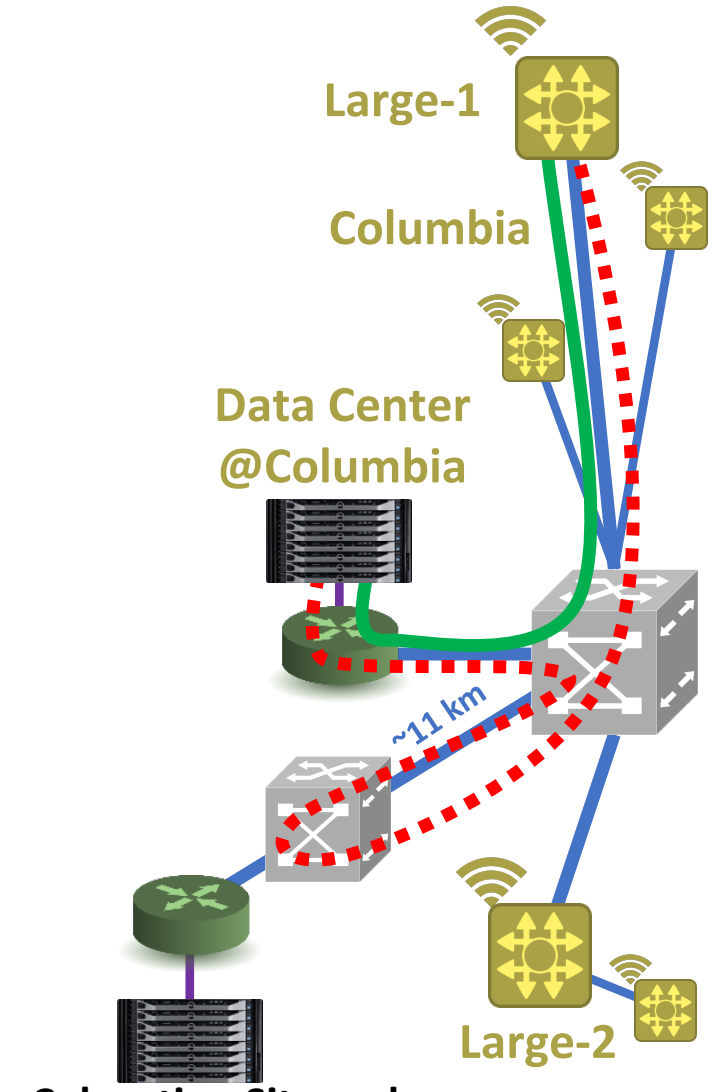
COSMOS Network Infrastructure

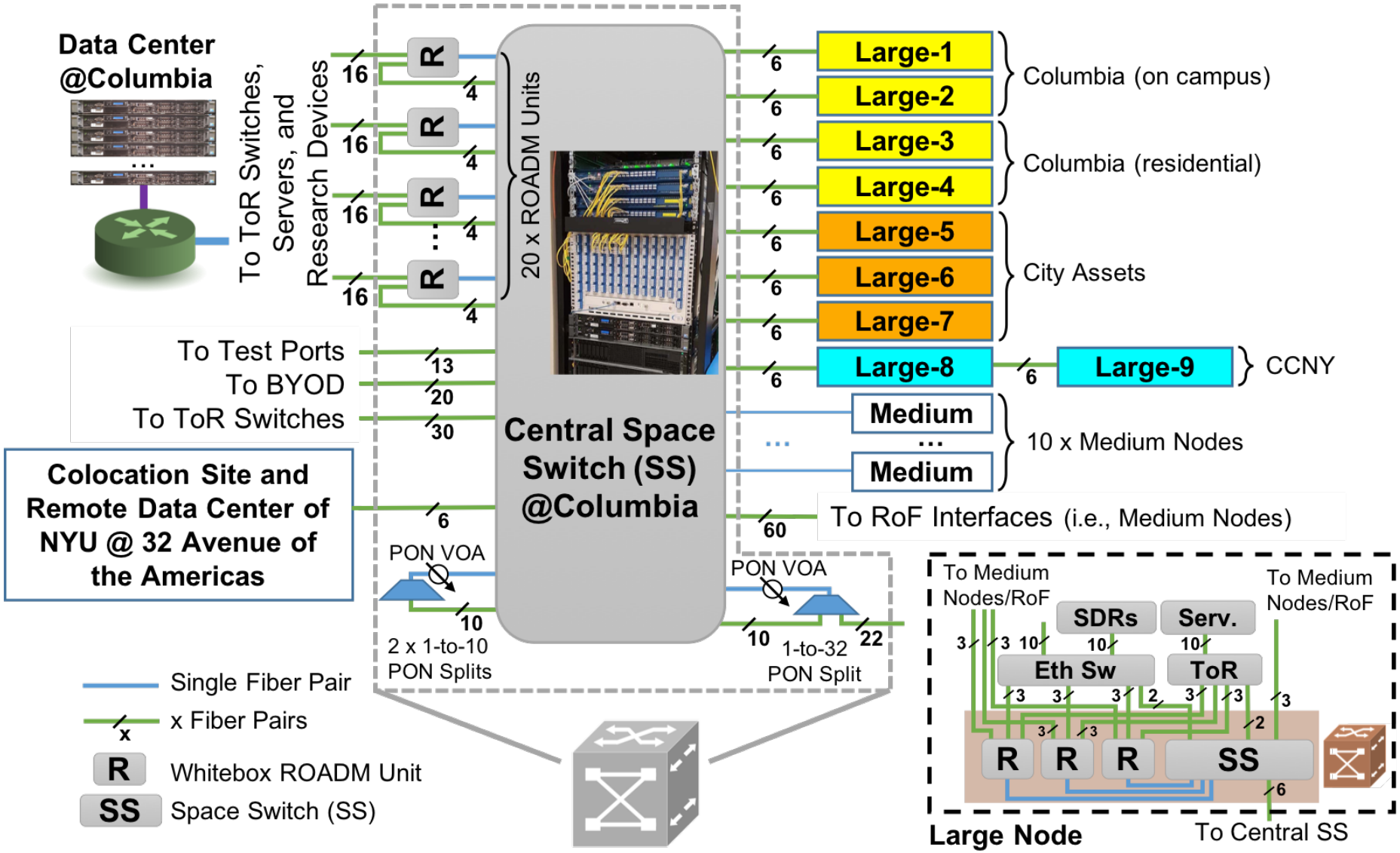


Colocation Site and Data Center @32 AoA

Optical Architecture

- Enables configurable optical network
  - C-RAN
  - Edge computing
  - AR and VR applications
- Components
  - 10G Tunable Transceiver
  - 25G Ethernet interfaces
  - 100G FPGA connection
  - 320x320 Space Switch
  - Optical ROADMs (Reconfigurable Optical Add-Drop Multiplexer)

Optical Architecture



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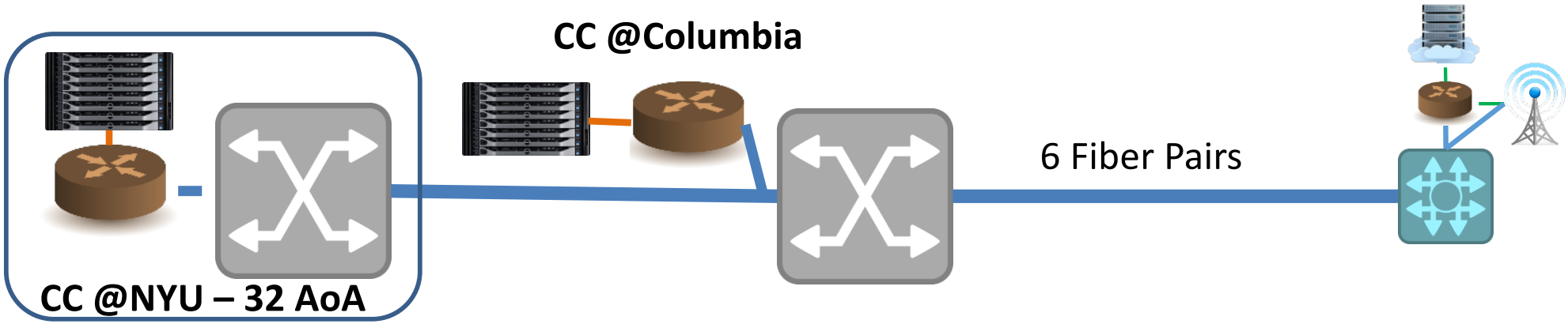
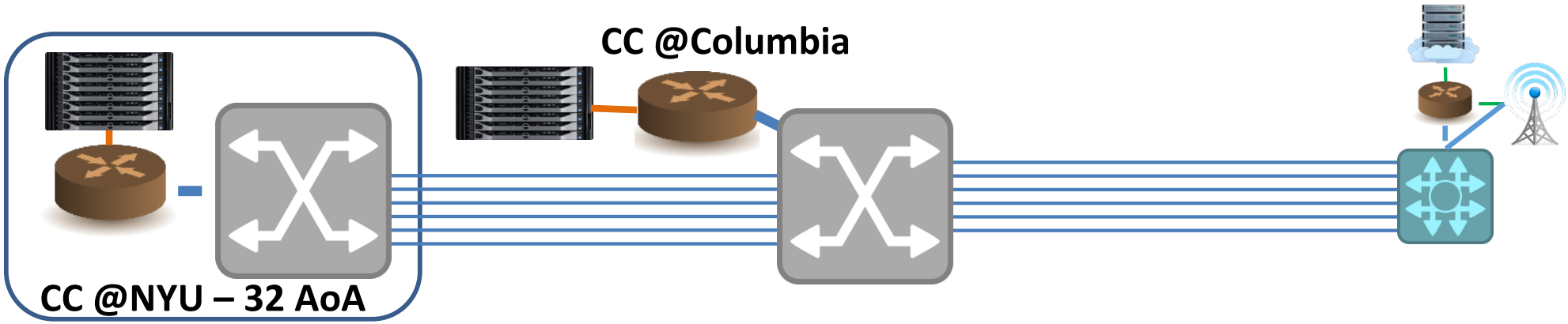
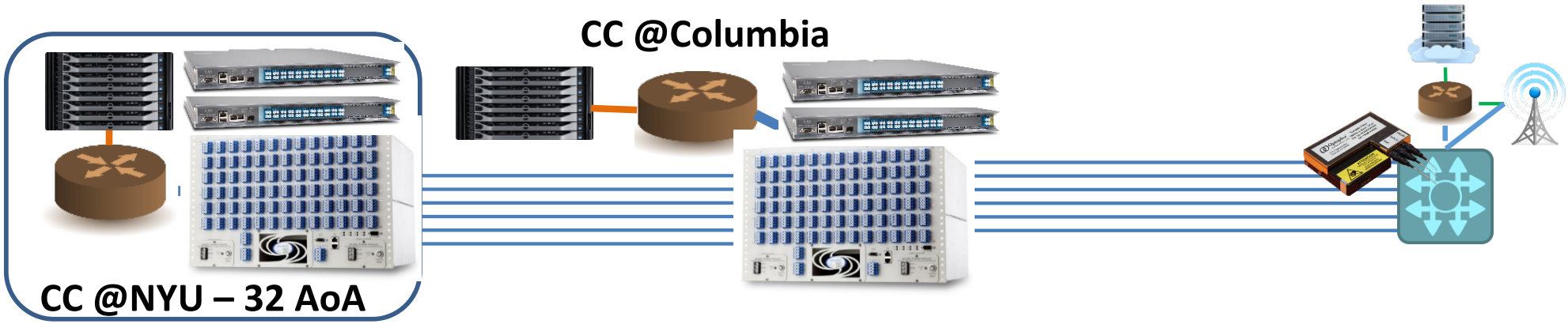
Programmable Topologies



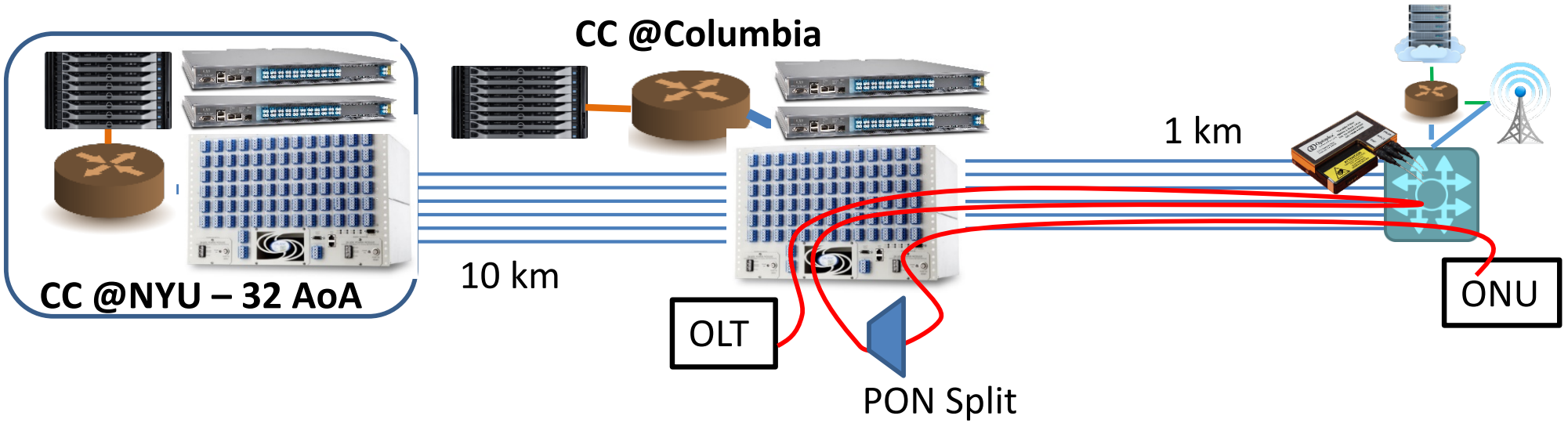
Programmable Topologies



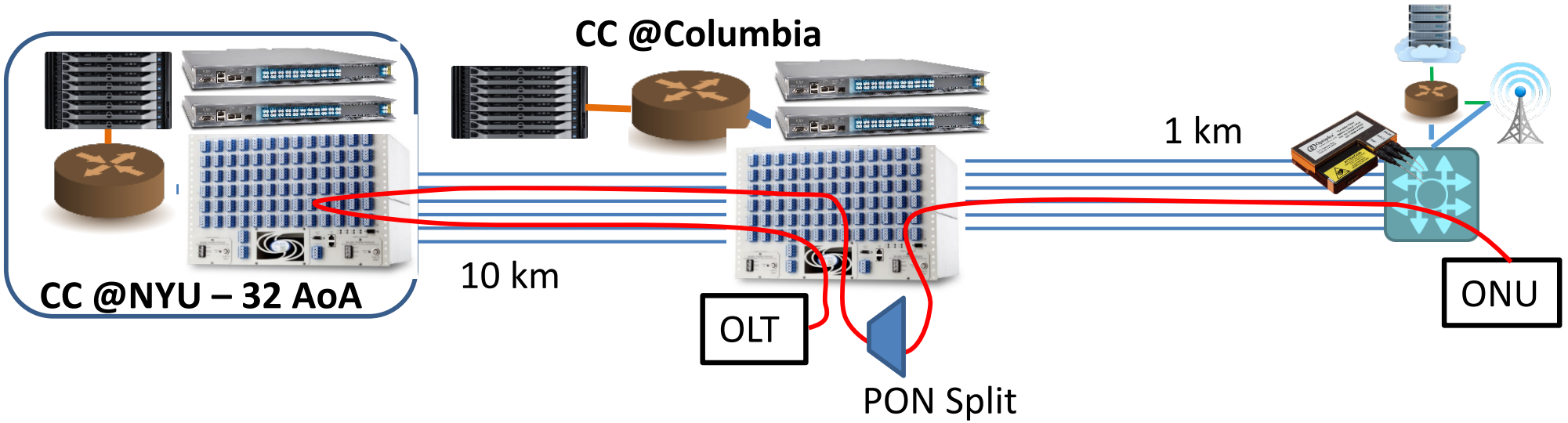
Programmable Topologies



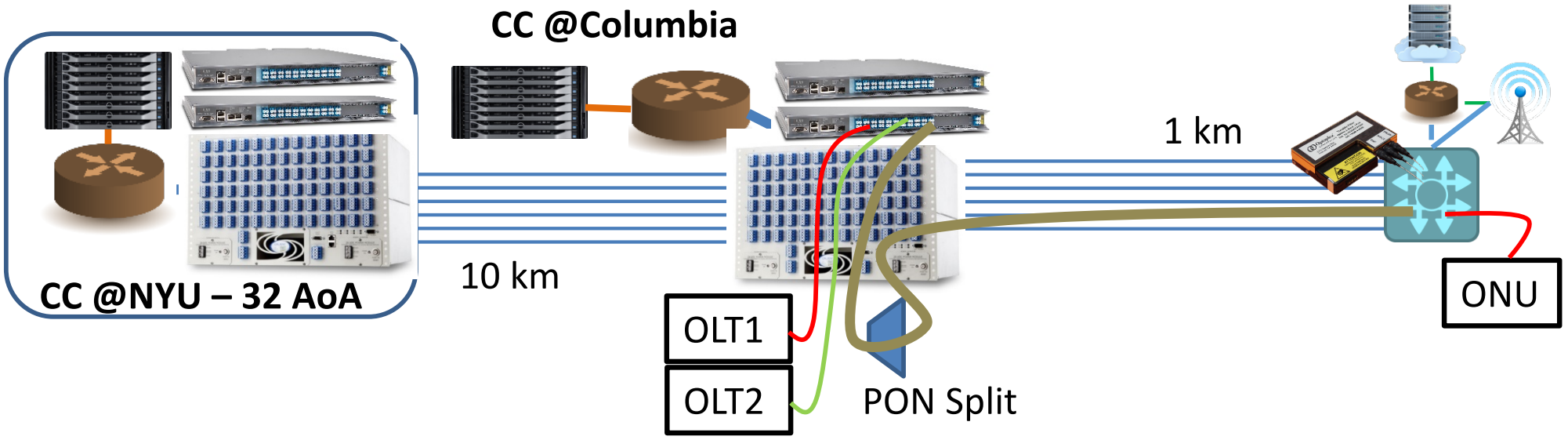
PON



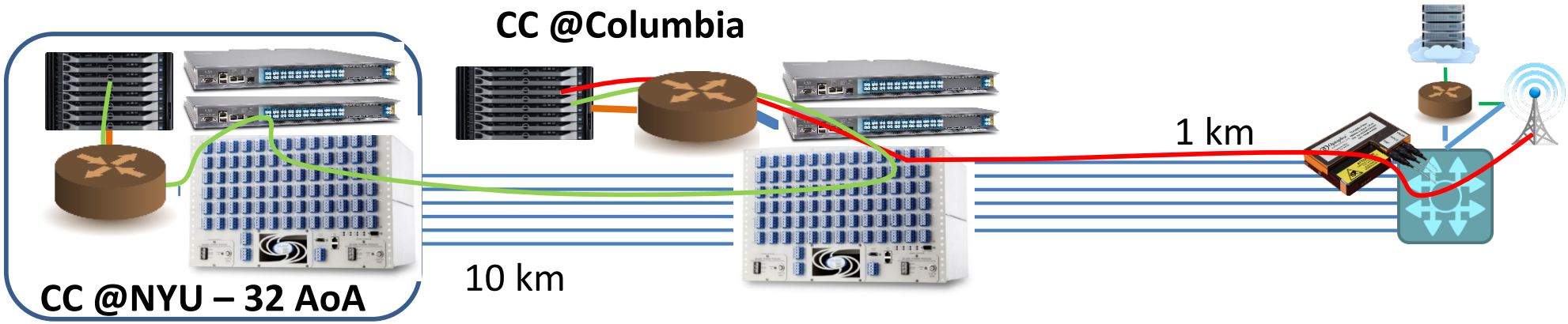
Long Reach PON



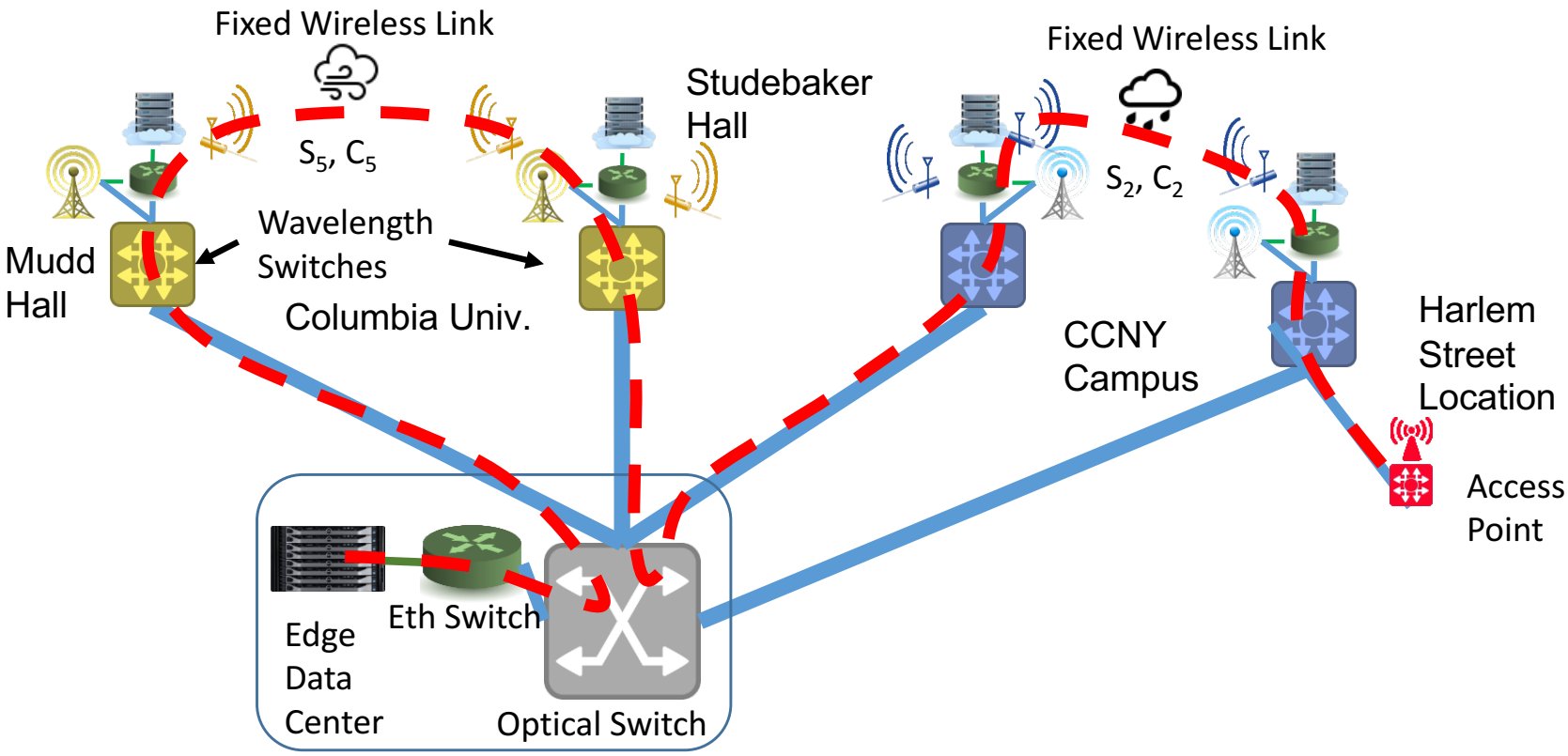
WDM PON



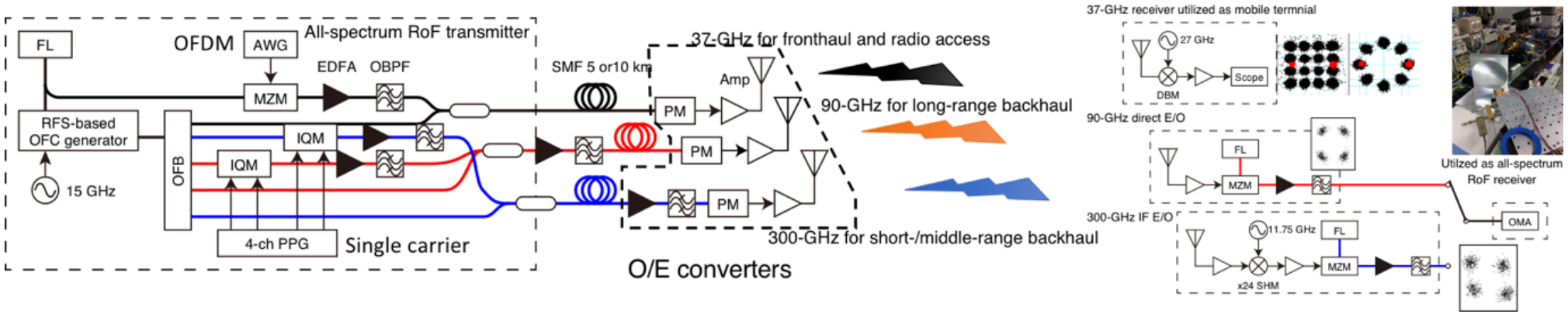
MidHaul Network



Converged mmWave/Fiber Transmission



mmWave Analog RoF



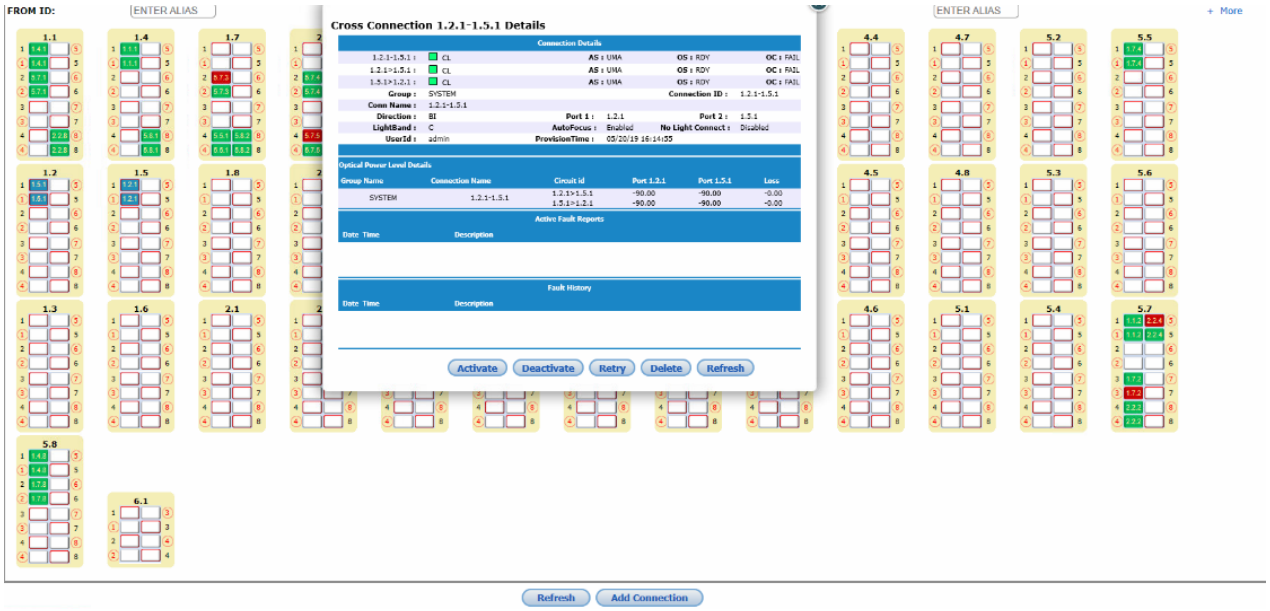
- Ultra-low latency, simple radio head
  - No digitization until data center
- COSMOS: Sub-6 GHz, plus select routes to 40 GHz
  - Can mix down from higher frequencies

(Figure courtesy of A. Kanno, NICT)

Optical Operation

- Remote experimentation
- User device insertion
- Today: configurable on request
- Future: user configurable
  - Basic topology controls
  - Advanced topology, power, components
    - Requires training to avoid damage to system
- Channels and links may be blocked for management purposes or due to other user reservations

Calient Space Switch



Home >> Summary

Alarms/Events | Status Symbol Key | REST API | Change Password | Logout

admin [05-20-2019 09:41:8]

Cross Connections Summary

Group Filter: All

Export CSV

Count	Group	Connection Name	Connection ID	Dir	Band	Conn - Half	IN Power (dBm)	OUT Power (dBm)	Loss (dB)	Alarm	AS	OS	OC
1	SYSTEM	1.1.1-1.4.1	1.1.1-1.4.1	BI	CBAND	1.1.1>1.4.1	-5.60	-7.09	1.50	CL	IS	IS	OK
						1.4.1>1.1.1	-10.60	-12.02	1.42	CL	IS	IS	OK
2	SYSTEM	1.1.2-5.7.1	1.1.2-5.7.1	BI	CBAND	1.1.2>5.7.1	-90.00	-90.00	-90.00	CL	UMA	RDY	FAIL
						5.7.1>1.1.2	-0.19	-1.85	1.66	CL	UMA	RDY	OK
3	SYSTEM	1.4.8-5.8.1	1.4.8-5.8.1	BI	CBAND	1.4.8>5.8.1	1.82	-0.04	1.87	CL	IS	IS	OK
						5.8.1>1.4.8	-16.89	-17.98	1.09	CL	IS	IS	OK
4	SYSTEM	1.7.2-5.7.3	1.7.2-5.7.3	BI	CBAND	1.7.2>5.7.3	-8.61	-10.18	1.57	CL	IS	IS	OK
						5.7.3>1.7.2	-0.15	-1.90	1.74	CL	IS	IS	OK
5	SYSTEM	1.7.4-5.5.1	1.7.4-5.5.1	BI	CBAND	1.7.4>5.5.1	-15.84	-18.18	2.34	CL	IS	IS	OK
						5.5.1>1.7.4	-18.34	-19.88	1.54	CL	IS	IS	OK
6	SYSTEM	2.2.8-1.1.8	2.2.8-1.1.8	BI	CBAND	2.2.8>1.1.8	-3.49	-5.05	1.55	CL	IS	IS	OK
						1.1.8>2.2.8	-1.24	-2.96	1.71	CL	IS	IS	OK
7	SYSTEM	5.7.4-2.2.2	5.7.4-2.2.2	BI	CBAND	5.7.4>2.2.2	-0.21	-2.31	2.10	CL	IS	IS	OK
						2.2.2>5.7.4	-6.10	-7.76	1.66	CL	IS	IS	OK
8	SYSTEM	5.7.5-2.2.4	5.7.5-2.2.4	BI	CBAND	5.7.5>2.2.4	0.18	-1.10	1.28	CL	IS	IS	OK
						2.2.4>5.7.5	-11.78	-13.44	1.65	CL	IS	IS	OK
9	SYSTEM	5.8.2-1.7.8	5.8.2-1.7.8	BI	CBAND	5.8.2>1.7.8	-17.20	-18.46	1.26	CL	IS	IS	OK
						1.7.8>5.8.2	1.78	-0.03	1.81	CL	IS	IS	OK

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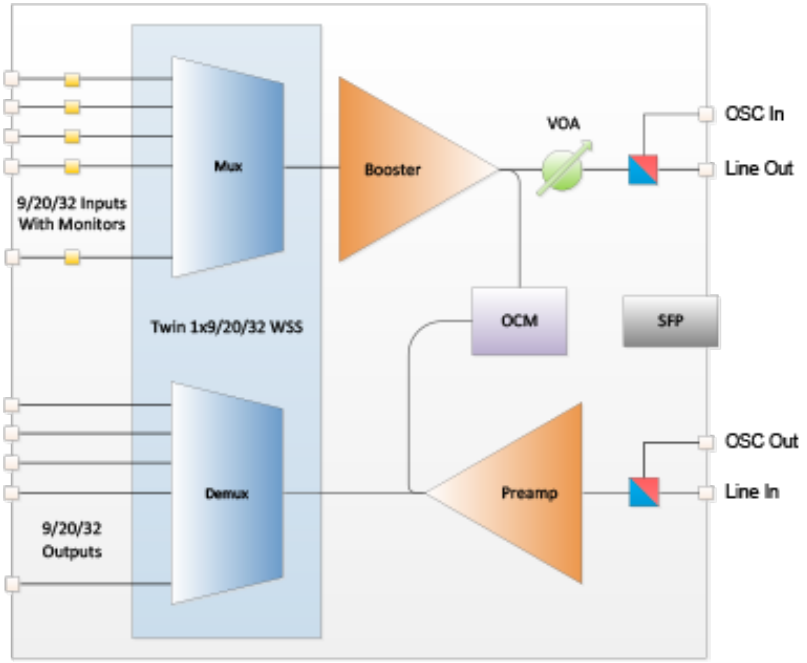
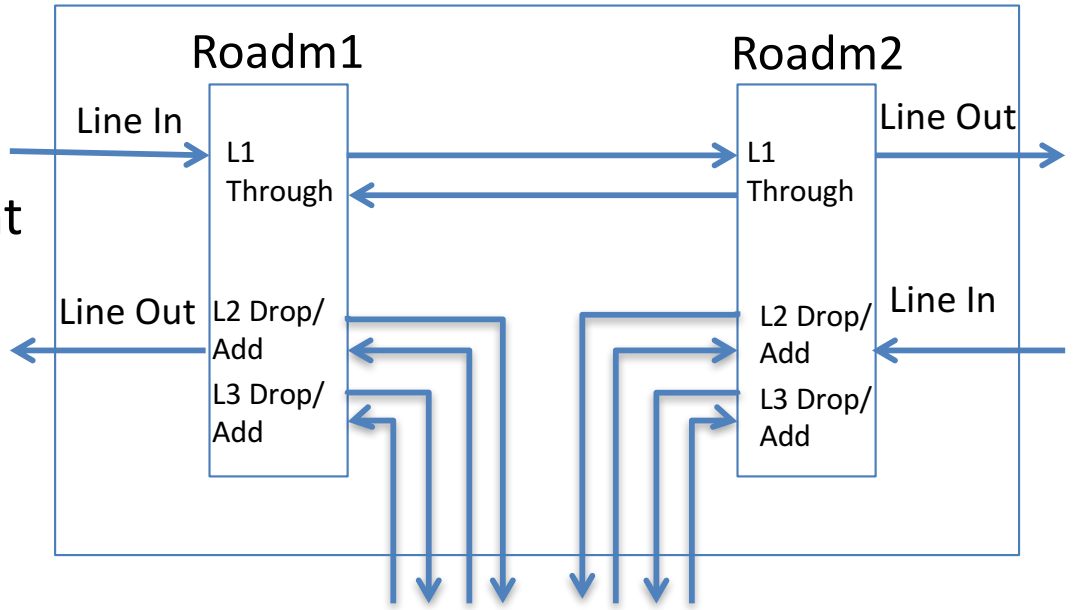
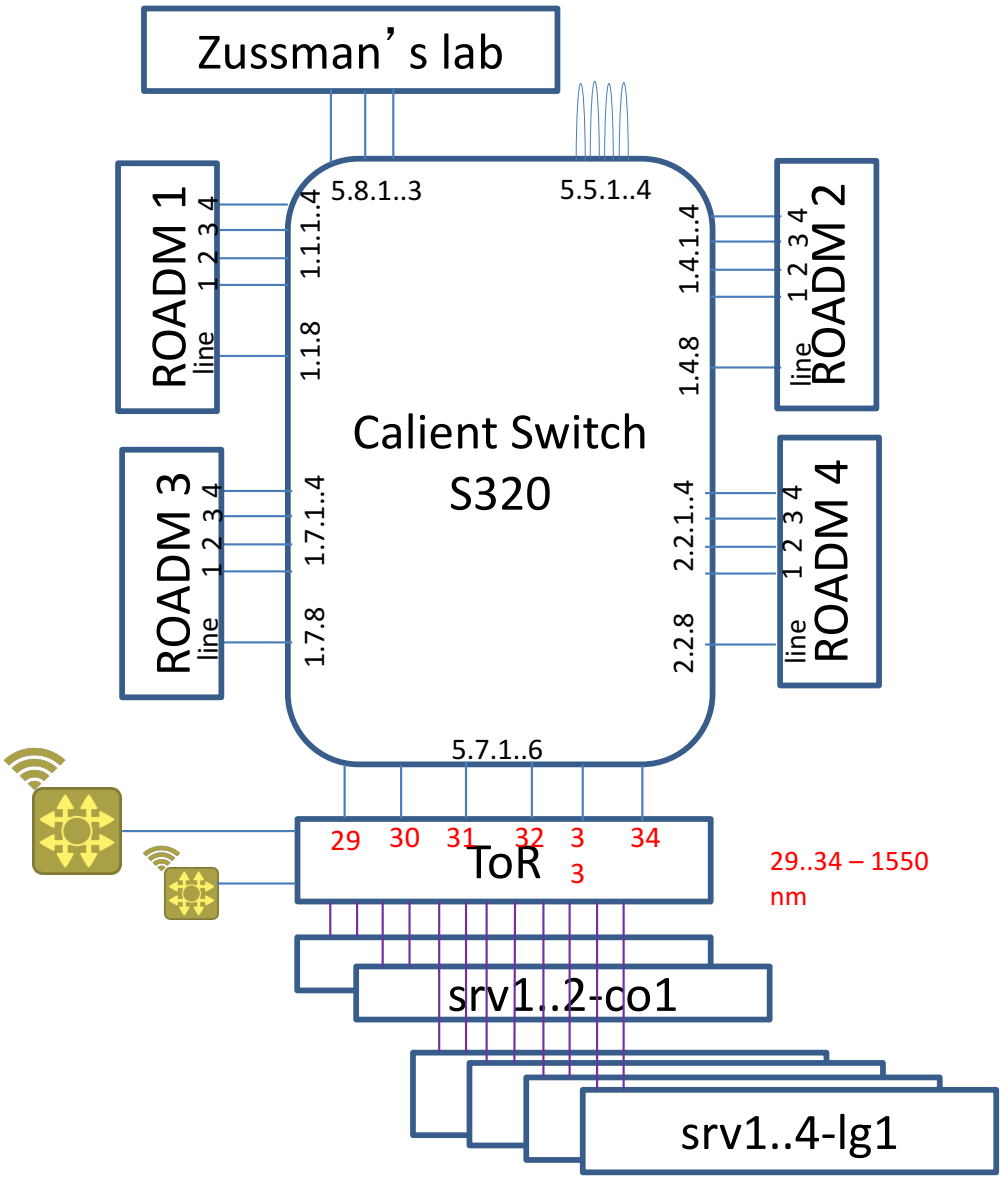
ROADM

- 3 Basic Sections
  - 96 chn MUX/DEMUX (WSS)
  - Booster Amplifier
  - Pre-Amplifier
- Single degree,bi-dir. ROADMs
  - Combine to form multi-degree
- Python scripts
  - Booster/Preamp control
  - Booster/Preamp monitor
  - WSS connection Management
  - WSS connection monitor
- RYU SDN Controller



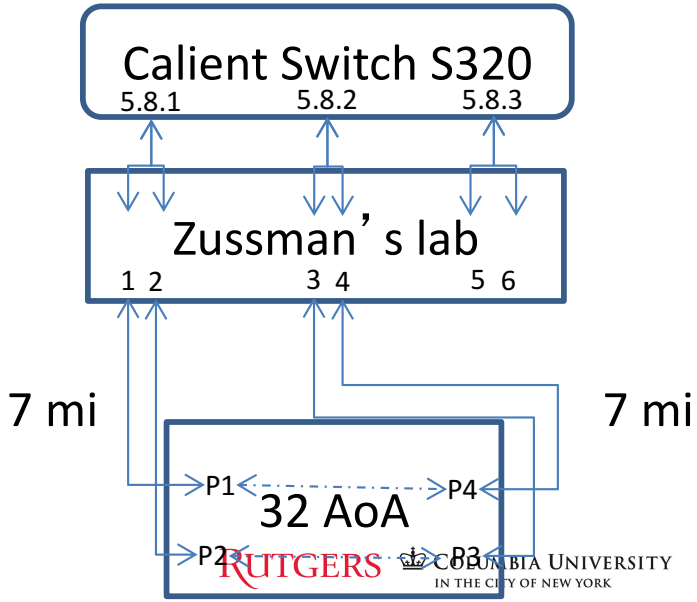


COSMOS Current State: Columbia Uni.



COSMOS Current State: 32 AoA

- Fiber to 32 Ave of Americas facilitated by the city and ZenFi



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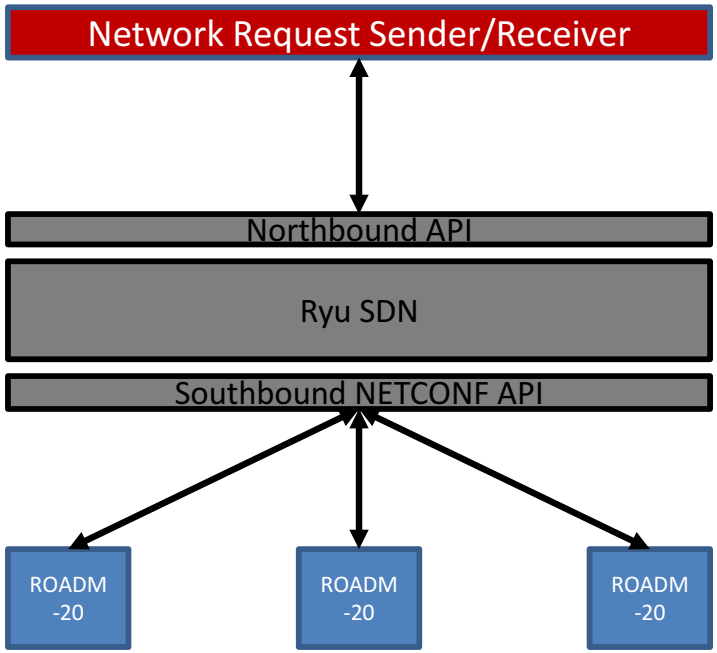
Software Defined Optical Network

Optical Networks built in COSMOS could be SDN-controlled



Request types:

1. EDFA configuration
2. Ports configuration
3. Wavelength configuration

SDN functions:

1. RWA algorithm
2. NETCONF message
3. Resource allocation

Request Definition

1. EDFA configuration

traffic ID	*message type*	*Node ID/IP*	*EDFA ID*	+	*configuration*
1	EDFAconfig	10.104.1.1	1 or 2		gain/power values
					in-service/out-of-service

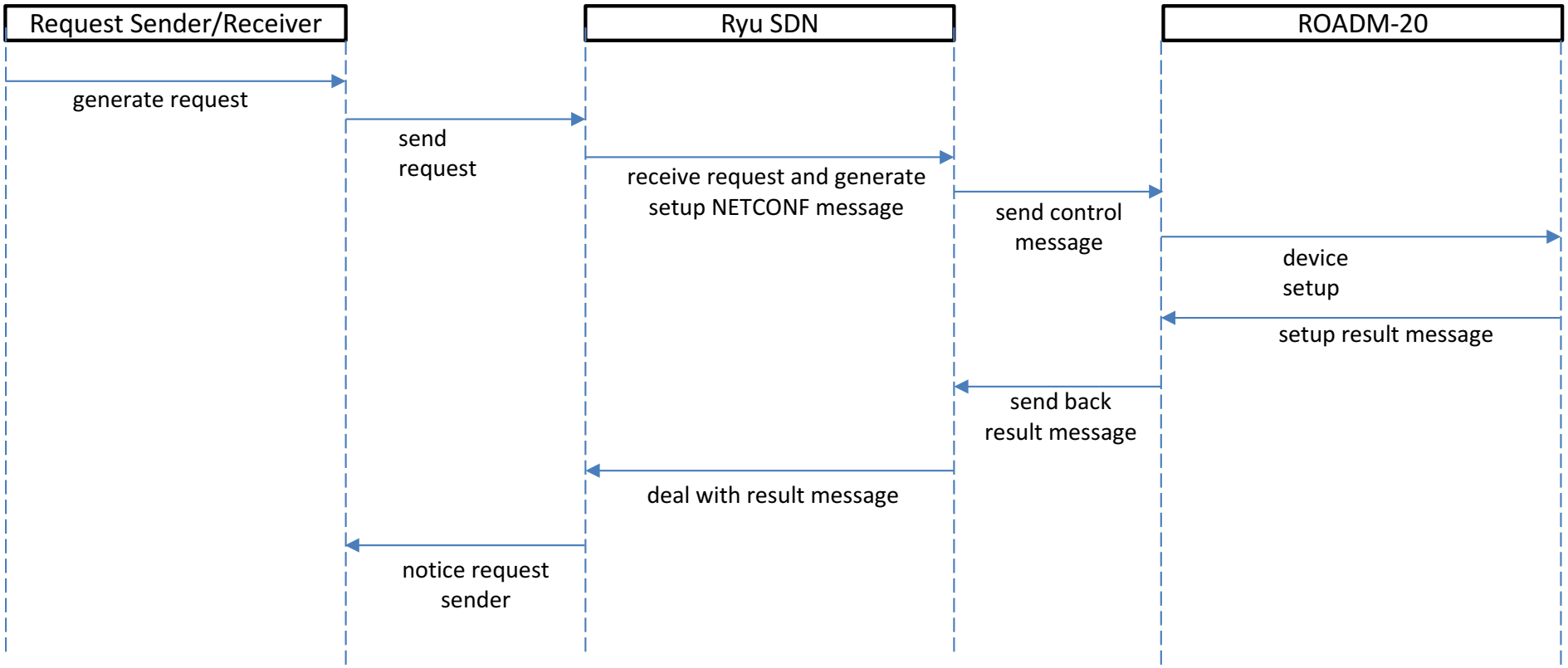
2. Ports configuration

traffic ID	*message type*	*Node ID/IP*	*port ID*	+	*configuration*
1	Portconfig	10.104.1.1	4101-4120 (4201)		in-service/out-of-service
			5101-5120 (5201)		

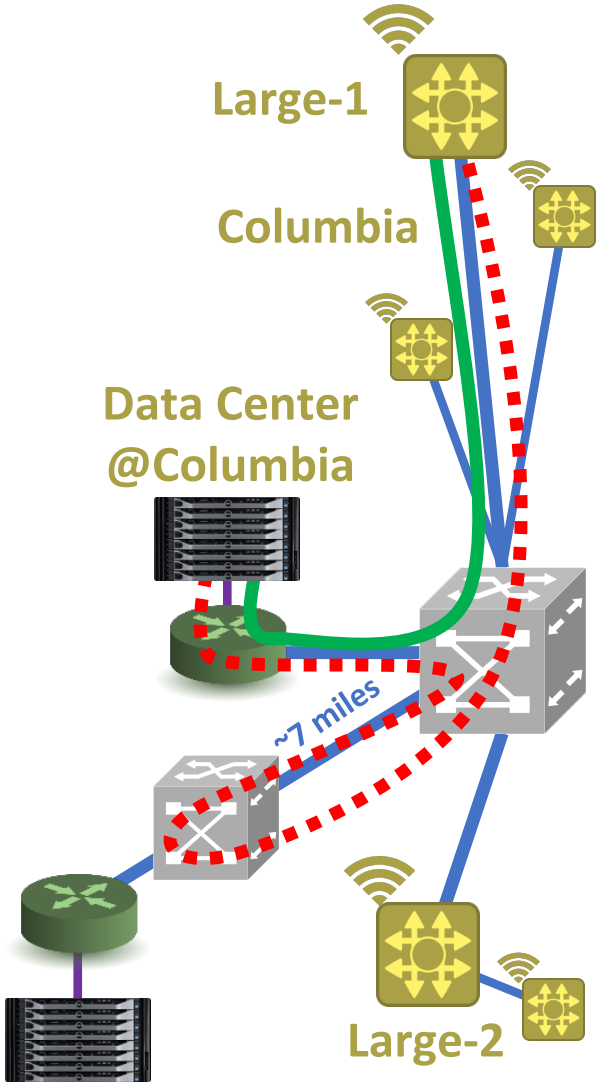
3. Wavelength configuration

traffic ID	*message type*	*Node ID/IP*	*Mux/Demux ID*	+	*configuration*
1	Add/TearDown	10.104.1.1	1 or 2		in-service/out-of-service
					block/not block
					start freq/end freq
					input-port/output-port
					connection ID

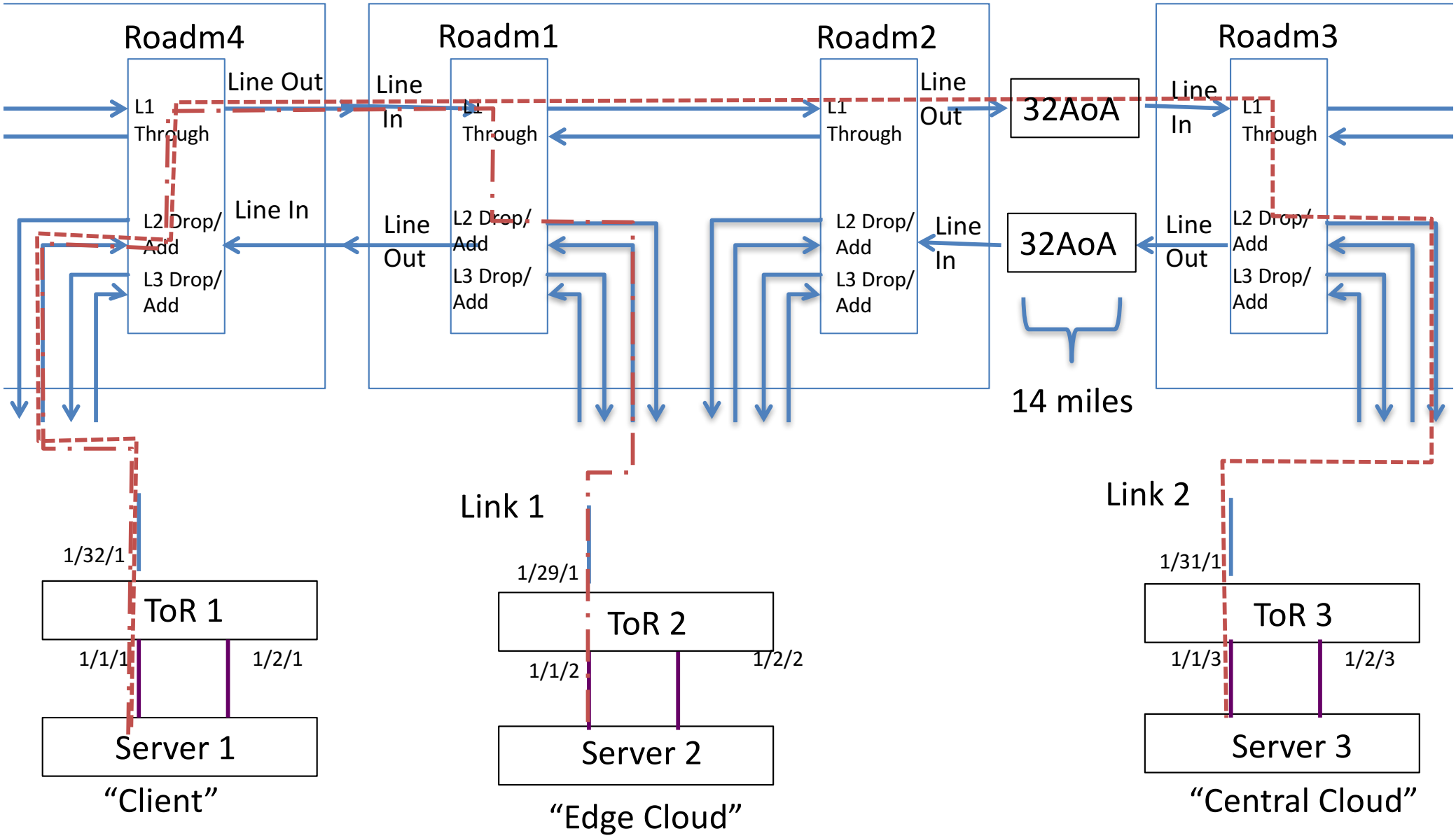
Optical SDN Control Flow



Experiment



Colocation Site and Data Center @32 AoA



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Set up TOR Switch

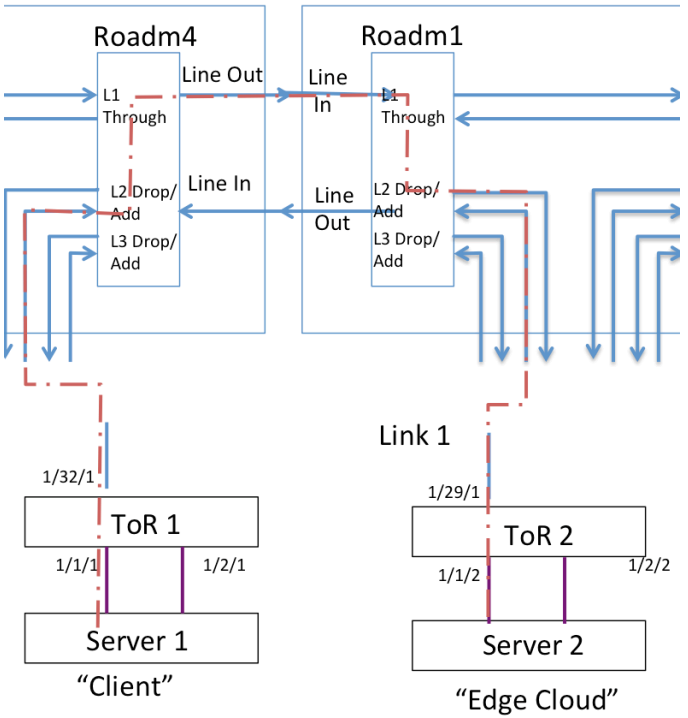
- Each compute node has 2 25-Gb Ethernet connections to the TOR switch
- Configure the Interfaces to be set as VLAN switch ports
- Assign TOR and transceivers interfaces to VLANS
- Assign a wavelength (e.g., 1553.3 nm/193 Thz) to each transceiver
- Check VLANS

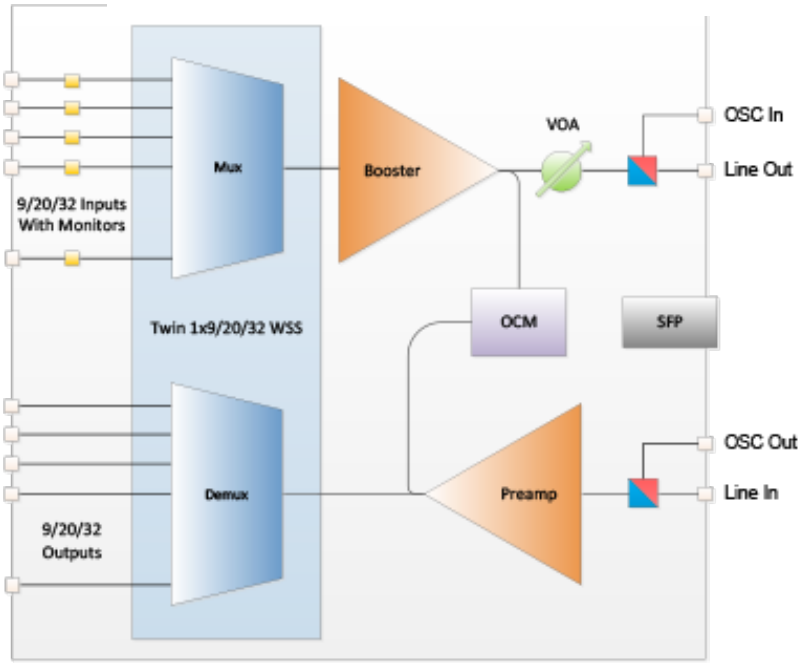
NUM	Status	Description	Q Ports
121	Active		U Te 1/32/1
			U Tf 1/1/1
122	Active		U Te 1/29/1
			U Tf 1/1/2
123	Active		U Te 1/31/1
			U Tf 1/1/3

- Configure VM interfaces and IP addresses

Establish Link 1

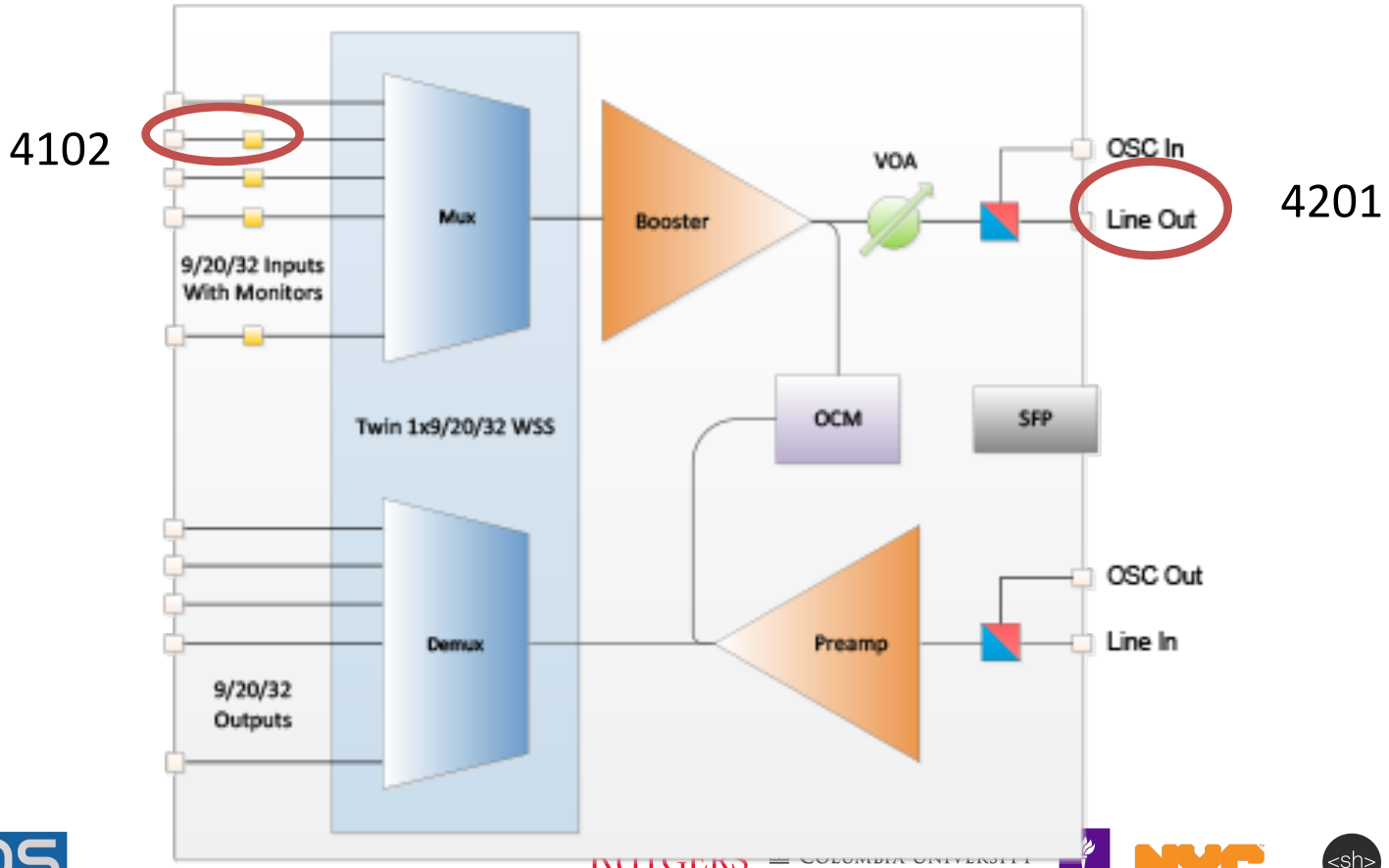
- Preliminary Steps
  - Connect line ports of ROADM4 and ROADM1 using the Calient Switch
  - Connect line Ports of ROADM2 and ROADM3 using the Calient Switch
- Steps
  - Add MUX/DEMUX connection from ROADM4 to TOR1
  - Add MUX/DEMUX connection from ROADM1 to TOR2
- Example code
  - python add_connection.py 10.104.1.4 1 10 in-service false 4102 4201 192950 193050 0 Exp1-FromTor1
  - python add_connection.py 10.104.1.4 2 10 in-service false 5101 5202 192950 193050 0 Exp1-TorwardTor1
  - python add_connection.py 10.104.1.1 1 10 in-service false 4102 4201 192950 193050 0 Exp1-FromTor2
  - python add_connection.py 10.104.1.1 2 10 in-service false 5101 5202 192950 193050 0 Exp1-TorwardTor2





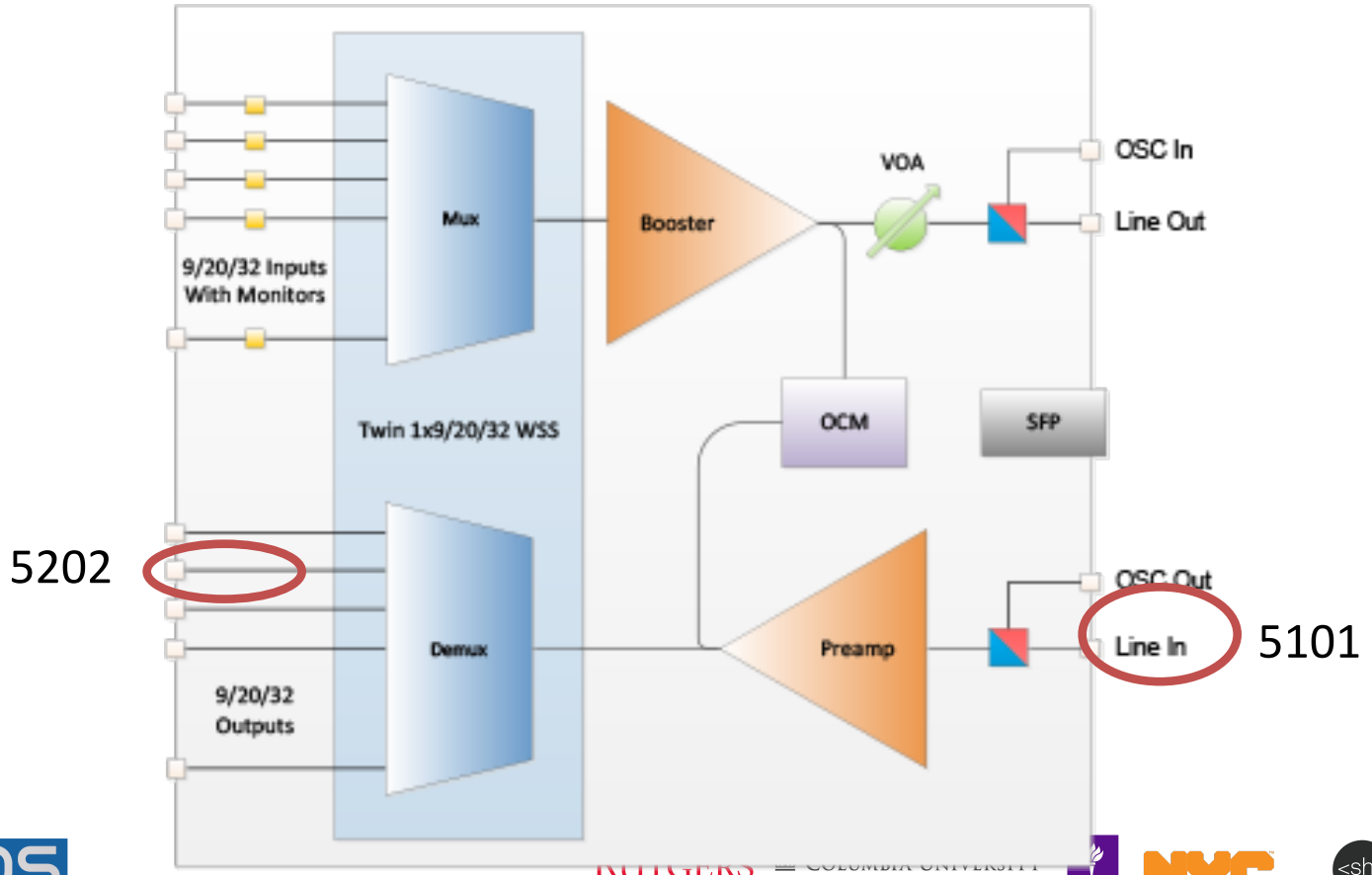
Establish Link 1

python add_connection.py 10.104.1.4 1 10 in-service false 4102 4201 192950 193050 0 Exp1-FromTor1



Establish Link 1

python add_connection.py 10.104.1.4 2 10 in-service false 5101 5202 192950 193050 0 Exp1-TowardTor1



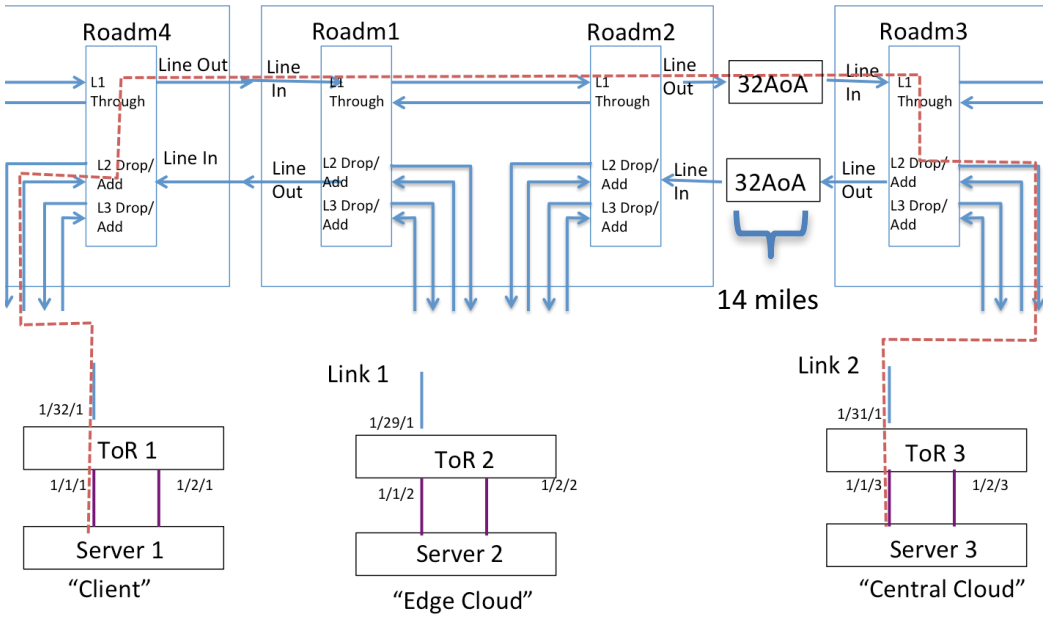
Establish Link 1

native@srv2-lg1:~$ ping 192.168.1.1
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_seq=1 ttl=64 time=0.131 ms
64 bytes from 192.168.1.1: icmp_seq=2 ttl=64 time=0.104 ms
64 bytes from 192.168.1.1: icmp_seq=3 ttl=64 time=0.105 ms
64 bytes from 192.168.1.1: icmp_seq=4 ttl=64 time=0.102 ms
64 bytes from 192.168.1.1: icmp_seq=5 ttl=64 time=0.106 ms
64 bytes from 192.168.1.1: icmp_seq=6 ttl=64 time=0.104 ms
64 bytes from 192.168.1.1: icmp_seq=7 ttl=64 time=0.104 ms
64 bytes from 192.168.1.1: icmp_seq=8 ttl=64 time=0.106 ms
64 bytes from 192.168.1.1: icmp_seq=9 ttl=64 time=0.105 ms
64 bytes from 192.168.1.1: icmp_seq=10 ttl=64 time=0.105 ms

--- 192.168.1.1 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9222ms
rtt min/avg/max/mdev = 0.102/0.107/0.131/0.010 ms

Establish Link 2

- Steps
  - Add MUX/DEMUX connection from ROADM4 to TOR1
  - Add MUX/DEMUX connection from ROADM1 to ROADM2
  - Add MUX/DEMUX connection from ROADM2 to ROADM1
  - Add MUX/DEMUX connection from ROADM3 to TOR3



- Example code
  - python add_connection.py 10.104.1.4 1 10 in-service false 4102 4201 192950 193050 0 Exp1-FromTor1
  - python add_connection.py 10.104.1.4 2 10 in-service false 5101 5202 192950 193050 0 Exp1-TorwardTor1
  - python add_connection.py 10.104.1.1 1 10 in-service false 4101 4201 192950 193050 0 Exp1-ROADM2
  - python add_connection.py 10.104.1.1 2 10 in-service false 5101 5201 192950 193050 0 Exp1-ROADM2
  - python add_connection.py 10.104.1.2 1 10 in-service false 4101 4201 192950 193050 0 Exp1-ROADM1
  - python add_connection.py 10.104.1.2 2 10 in-service false 5101 5201 192950 193050 0 Exp1-ROADM1
  - python add_connection.py 10.104.1.3 1 10 in-service false 4102 4201 192950 193050 0 Exp1-FromTor3
  - python add_connection.py 10.104.1.3 2 10 in-service false 5101 5202 192950 193050 0 Exp1-TorwardTor3

Establish Link 2

native@srv3-lg1:~$ ping 192.168.1.1
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_seq=1 ttl=64 time=0.449 ms
64 bytes from 192.168.1.1: icmp_seq=2 ttl=64 time=0.432 ms
64 bytes from 192.168.1.1: icmp_seq=3 ttl=64 time=0.434 ms
64 bytes from 192.168.1.1: icmp_seq=4 ttl=64 time=0.433 ms
64 bytes from 192.168.1.1: icmp_seq=5 ttl=64 time=0.425 ms
64 bytes from 192.168.1.1: icmp_seq=6 ttl=64 time=0.435 ms
64 bytes from 192.168.1.1: icmp_seq=7 ttl=64 time=0.434 ms
64 bytes from 192.168.1.1: icmp_seq=8 ttl=64 time=0.425 ms
64 bytes from 192.168.1.1: icmp_seq=9 ttl=64 time=0.426 ms
64 bytes from 192.168.1.1: icmp_seq=10 ttl=64 time=0.434 ms

--- 192.168.1.1 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9221ms
rtt min/avg/max/mdev = 0.425/0.432/0.449/0.025 ms