Scitags At 1.2 Tbps NRE Demonstration At IEEE/ACM International Conference On High Performance Computing, Networking, Storage, and Analytics, St Louis Mo, Nov 2025

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Director, Metropolitan Research and Education Network (www.mren.org)
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PI: StarLight SDX, Co-PI Chameleon, PI-iGENI, PI-OMNINet

LHCOPN/LHCONE Meeting
Karlsruhe Institute of Technology
Karlsruhe, Germany
October 7-9, 2025

The GRP: A Platform For Global Science

A Next Generation, Software Defined, Globally Distributed, Multi-Domain Computational Science Environment

STARLIGHT℠

Global Research Platform: Global Lambda Integrated Facility
Available Advanced Network Resources

Next Generation eScience Ecosystem

Visualization courtesy of Bob Patterson, NCSA; data compilation by Maxine Brown, UIC.

www.glif.is

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STARLIGHT℠

AutoGOLE Open R&E Exchanges

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Selected Applications/Instruments

Open Storage Network
www.openstorage network.org

OSG
www.openscience grid.org

Polar Geospatial Center
www.pgc.umn.edu

LSST
www.lsst.org

ISS
www.nasa.gov/ station

Virgo
www.virgo-gw.eu

LHC
home.cern/science/ accelerators/large-hadron-collider

GRP
theglobalresearch platform.net/

IceCube
icecube.wisc.edu

Pierre Auger Observatory
www.auger.org

LIGO
www.ligo.caltech. edu

SKA
www.skatelescope. org

GLEON
www.gleon.org

OSiRIS
www.osris.org

XSEDE
www.xsede.org

PRP
pacificresearch platform.org

Chameleon
www.chameleon cloud.org

LHCONE
twiki.cern.ch/twiki/bin /view/LHCONE/ WebHome

USGS EROS
www.usgs.gov/ centers/eros

Blue Waters
bluewaters.ncsa. illinois.edu

CHASE-CI
www.calit2.net/ newsroom/artic le.php?id=2910

Jetstream
www.jetstream-cloud.org

Belle II
www.belle2.org

XENON
xenon.astro. columbia.edu

SDSS
www.sdss.org

LHCOPN
twiki.cern.ch/twiki/bin /view/LHCOPN/ WebHome

PRAGMA
www.pragma-grid.net

NEON
www.neonscience. org

Genomic Science Program
genomicscience. energy.gov

LBNF/DUNE/ ProtoDUNE
lbnf.fnal.gov

NOvA
novaexperiment. fnal.gov

ALMA
www.alma observatory.org

CENTRA
www.global centra.org

SAGE2
sage2.sagecommons. org

IVOA
www.ivoa.net

Compilation by Maxine Brown and Joe Mambretti

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Scitags

- ***Why:*** **The Research Networking Technical Working Group Was Charged With Enhancing The Visibility Of R&E Network Data Traffic.**
- ***What:*** **Scitags Is An Open System, Open Source Initiative Promoting The Identification of Science Domains And Their Network High Level Activities**
- ***How:*** **Add a Label At the Packet Level Identifying The Specific Research Project Traffic Using IPv6 Flow Label**
- ***Who:*** **Research Group Led By Marian Babik, Shawn McKee (Multiple Open Collaboration Partners)**
- ***Ref:*** **IETF RFC-Informational Draft Submitted June 2023: Suggests Using IPv6 Extension Headers**

Scientific Network Tags

Packet Marking for Data Intensive Scientific Workflows

Shawn McKee (University of Michigan), Dale W. Carder (LBNL/ESnet), Eli Dart (LBNL/ESnet), Yatish Kumar (ESnet), Mariam Kiran (ESnet), Andrew Lake (ESnet), Marian Babik (CERN), Carmen Misa Moreira (CERN), Edoardo Martelli (CERN), Tristan Sullivan (University of Victoria), Joe Mambretti (StarLight, iCAIR NU, MREN), Jim Chen (StarLight, iCAIR NU), Fei Yeh (StarLight, iCAIR NU), Ting-Yu Lin (StarLight, iCAIR NU), Andrew Hanushevsky (SLAC), Bruno Hoeft (SCC) DE-KIT, Tom Lehman (ESnet), Garhan Attebury (University of Nebraska), Neil McKee (inMon Corp.), Tim Chown (Jisc), Duncan Rand (Jisc), Marcos Schwarz (RNP)

Managing large scale scientific workflows over networks is becoming increasingly complex, especially as multiple science projects share the same resources but have diverse requirements, constraints, configurations and so on. Amongst the many problems is the lack of understanding about the end-to-end characteristics of the many different traffic flows, both overall and for a given science domain. This demonstration showcases Scientific Network Tags (Scitags), an initiative aimed at addressing this problem, i.e., identifying and then characterising network flows from end-to-end. Scitags utilises open-source technologies to provide a two-fold benefit: enabling Research and Education networks to understand network resource utilisation and providing information to scientific communities about the behaviour of their multiple different network flows.

Scitags

Offset	Octet	0								1								2								3							
Octet	Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	0	*Version*				*Traffic class*								*Flow label*																			
4	32	*Payload length*																*Next header*								*Hop limit*							

- Scitag added by eBPF when the kernel sends a packet to the NIC, not at the time of packet creation
- Overwriting flow label lightest-weight option
- Adding extension header requires changing next header field and inserting new header
- Next header values:
  - 0: Hop-By-Hop
  - 6: TCP
  - 60: Destination Options

Source: Tristan Sullivan

Monitoring

- Monitoring is Based On a Prometheus Dashboard For Bandwidth And DTN CPU Usage
- An InMon Dashboard Based On sflow Is Used For Actual Decoding of the Flow Label and DO Header.
- As An Interesting Addition To the Demonstration, Consideration Is Being Given To the Potential For Incorporating Netlink Data Collected By Flowd-go. (Ref Pablo Collado, Tristan Sullivan)

Will Scitags Scale To 1.2 Tbps?

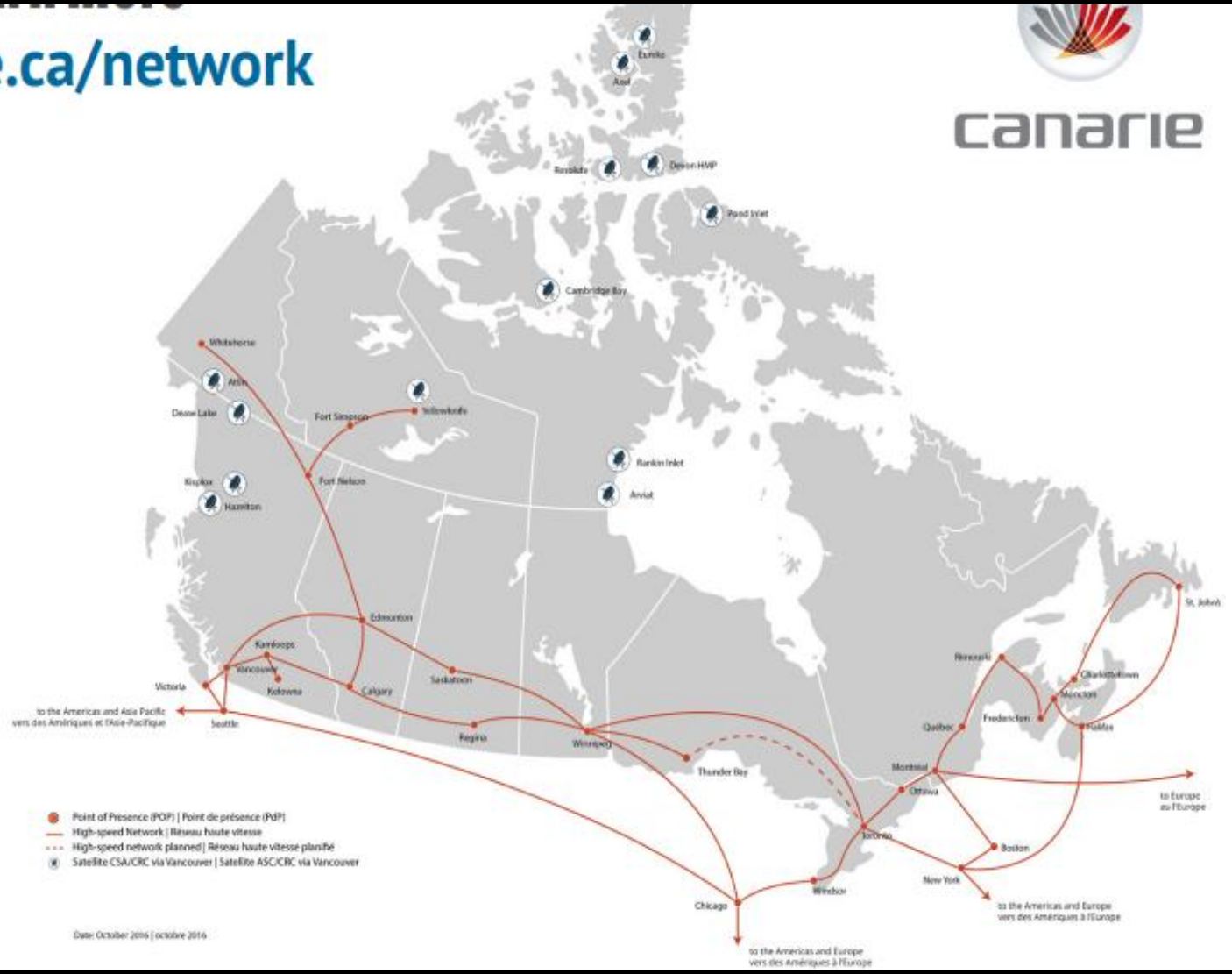
- Requires International 1.2 Tbps Testbed
- For Reliable, Optimized High-Performance WAN Data Transfers Methods Include Software Defined Networking (SDN), 400 Gbps Smart NICs, NVMe over Fabric, RDMA,Techniques For Kernel Bypass Using Zero-Copy for Memory and Disk Copy (To Avoid Bottlenecks in Large Scale Data Transfers Over 1.2 Tbps WANs), GPU Acceleration, Optimal Affinity Bindings for NUMA Architecture for Higher Resource Utilization, Middleware For Orchestrating Infrastructure Resources.
- Also Required: Measurement Techniques for Real-Time Monitoring, Benchmarking and Evaluation

IEEE/ACM International Conference On High Performance Computing, Networking, Storage, and Analytics, St Louis Mo, Nov 2025

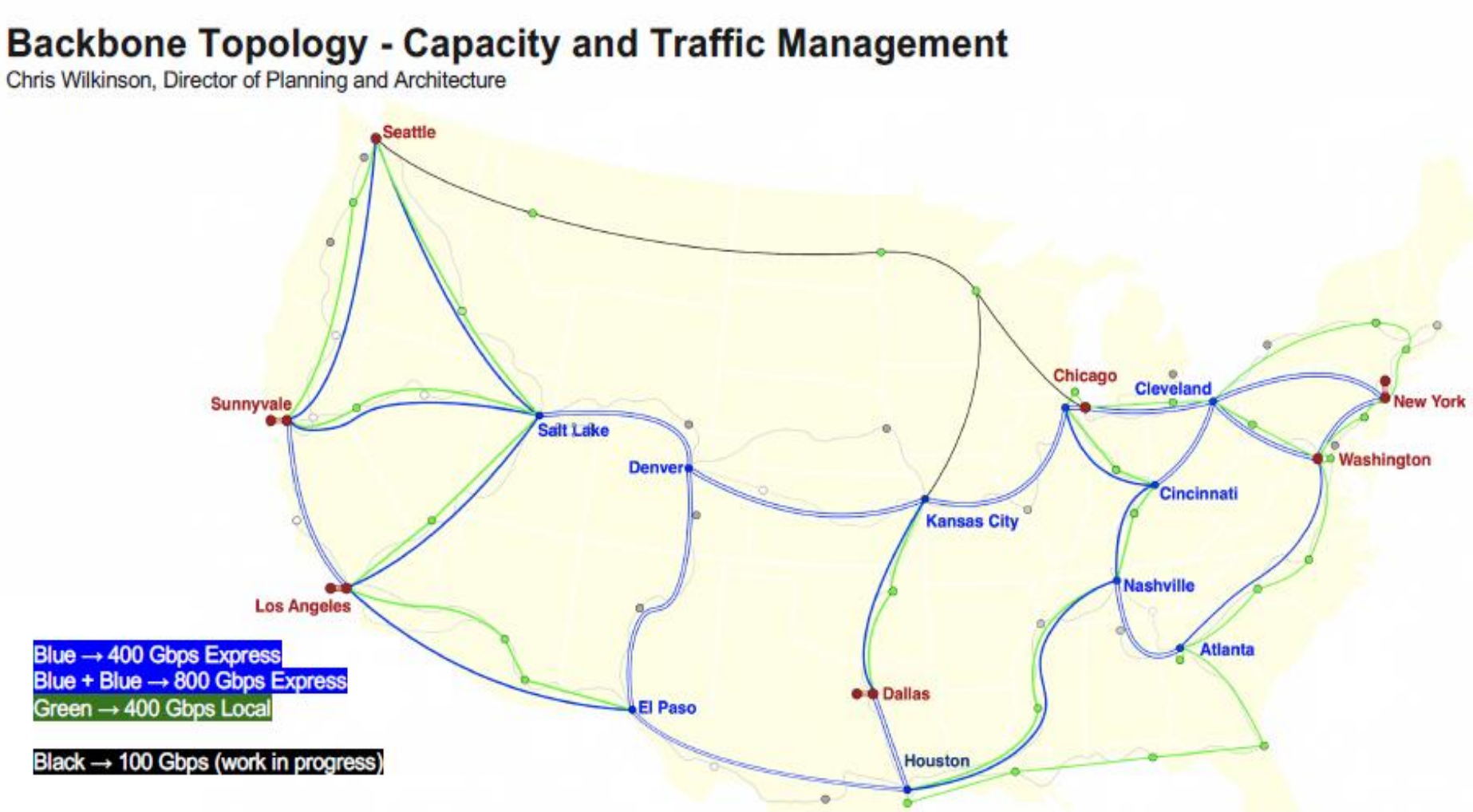
- As In Previous Years, With Its International Partners, SCinet In Designing and Implementing a National/International WAN Testbed With International Extensions To Support Demonstrations And Experiments, Many Related To Data Intensive Science
- A Key Current Focus Is 400, 800, and 1.2 Tbps Path Services and Interconnections, Including Direct Connections To Edge Nodes, Primarily High Performance Gen5 DTNs
- The SCinet Testbed Uses Multiple Elements Of Existing Production Networks And Testbeds
- NRE: Network Research Exhibition, Showcases of Experiments and Demonstrations

1.2 Tbps Via CANARIE To Pacific Wave Seattle

canarie.ca/network



Internet2 Backbone Topology

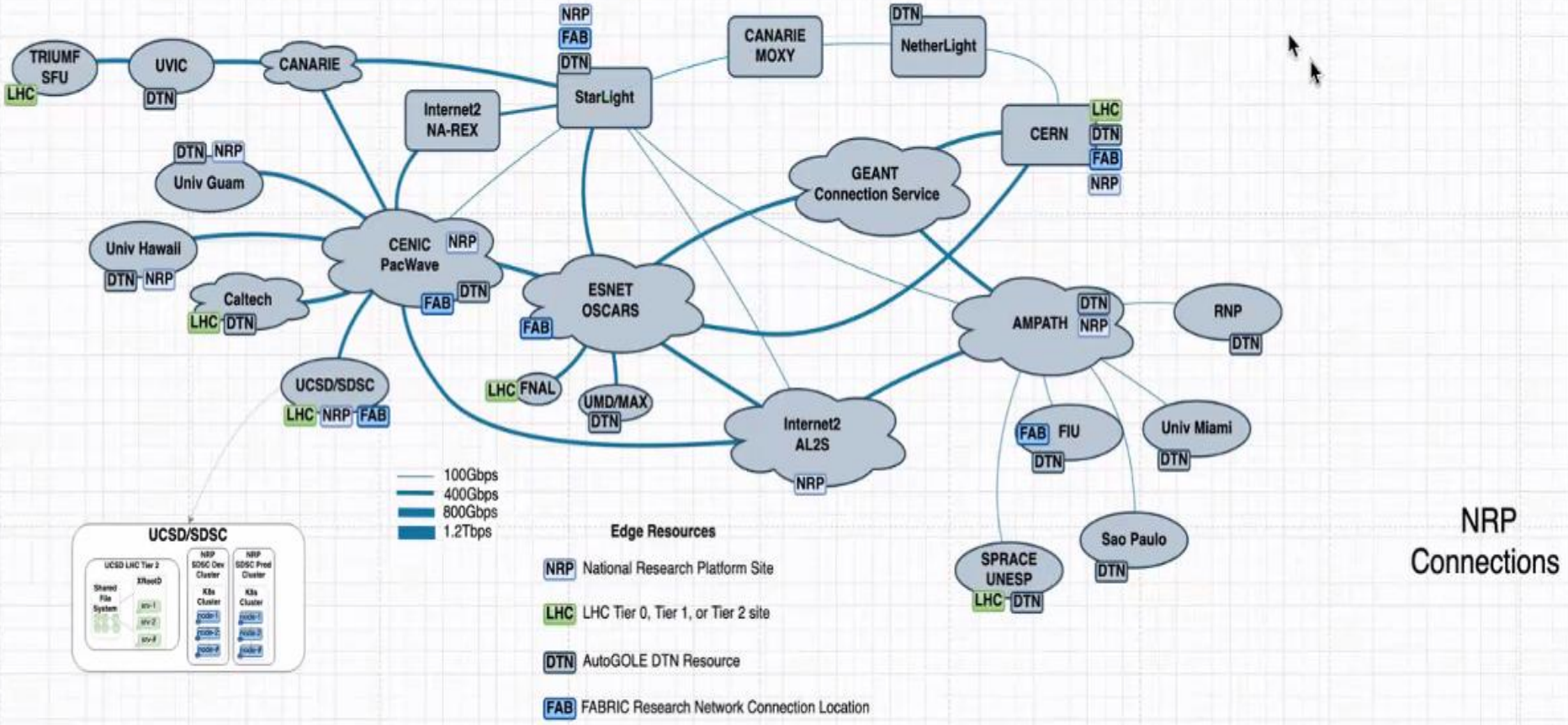


NA-REX North America Research & Education Exchange Collaboration

AMPATH PATHWAY TO THE AMERICAS
canarie
ESnet ENERGY SCIENCES NETWORK
INTERNET2
International Networks at Indiana University
STARLIGHT The Optical STAR TAP
CENIC
PACIFIC NORTHWEST GIGAPOP
PACIFIC WAVE

November 2023

AutoGOLE/SENSE



SENSE: Software-Defined Network for End-to-end Networked Science at the Exascale

P4 Testbed Site/End System Data

StarLight – "By Researchers For Researchers"

StarLight: Experimental Optical Infrastructure/Proving Ground For Next Gen Network Services

Optimized for High Performance Data Intensive Science

Multiple 100 Gbps (110+ Paths)

StarWave

100 G Exchange

World's Most Advanced Exchange

Multiple First of a Kind Services and Capabilities

View from StarLight

2*1.2 TbpsPersistent Testbeds Connecting To McLean Va (JBDT)

Abbott Hall, Northwestern University's Chicago Campus

Currently: 26+ 400 Gbps Paths Prototyping 800 Gbps Tbps

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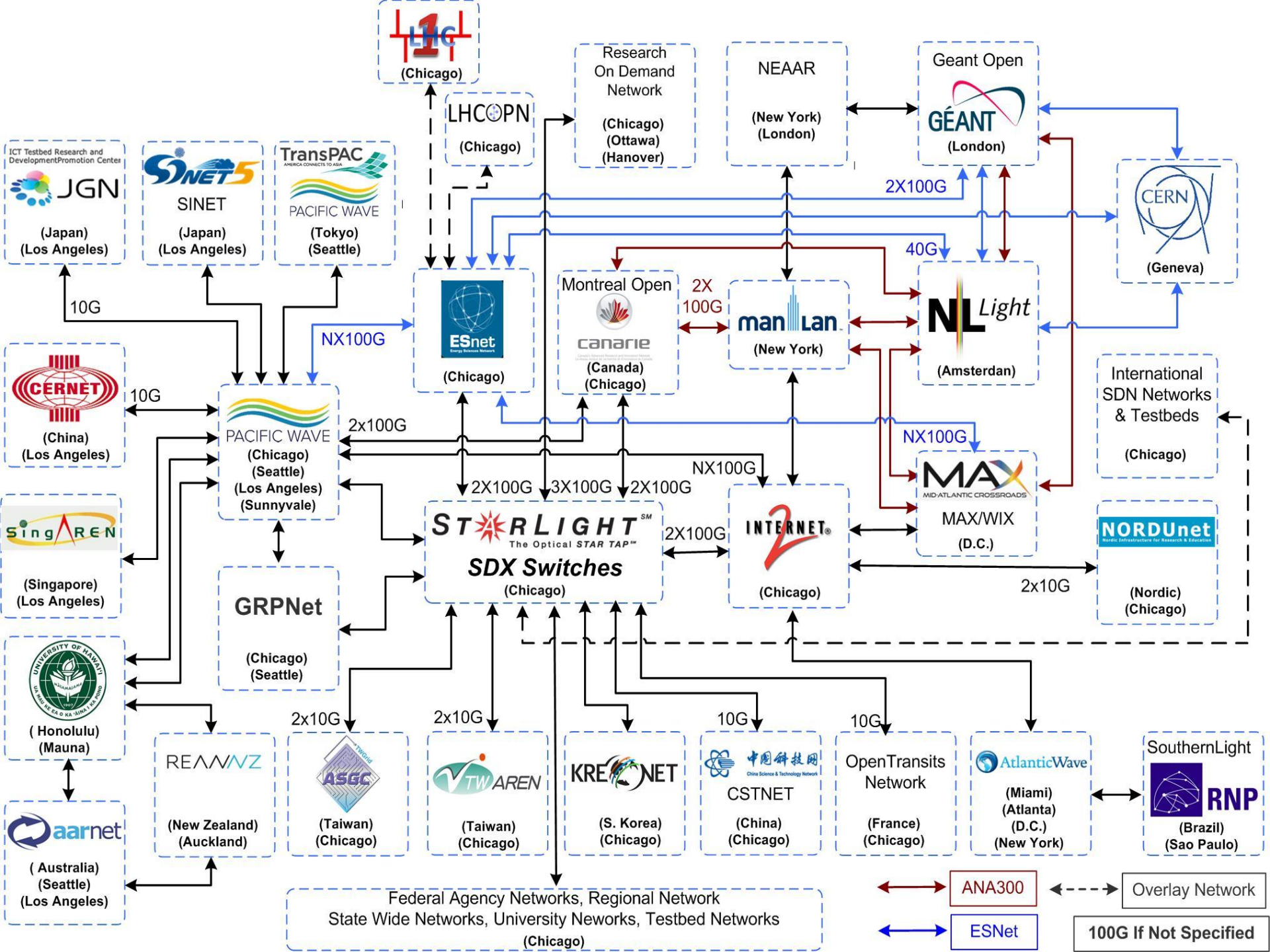

LHC
(Chicago)
LHCOPN
(Chicago)
Research
On Demand
Network
(Chicago)
(Ottawa)
(Hanover)
NEAAR
(New York)
(London)
Geant Open
GÉANT
(London)
2X100G
CERN
(Geneva)
40G
ICT Testbed Research and DevelopmentPromotion Center
JGN
(Japan)
(Los Angeles)
SINET
(Japan)
(Los Angeles)
TransPAC
PACIFIC WAVE
(Tokyo)
(Seattle)
10G
NX100G
ESnet
(Chicago)
Montreal Open
canarie
(Canada)
(Chicago)
2X
100G
manLan
(New York)
NL Light
(Amsterdan)
CERNET
(China)
(Los Angeles)
10G
PACIFIC WAVE
(Chicago)
(Seattle)
(Los Angeles)
(Sunnyvale)
2x100G
International
SDN Networks
& Testbeds
(Chicago)
NX100G
MAX
MID-ATLANTIC CROSSROADS
MAX/WIX
(D.C.)
NX100G
2X100G
3X100G
2X100G
STARLIGHT
The Optical STAR TAP
SDX Switches
(Chicago)
2X100G
INTERNET2
(Chicago)
2x10G
NORDUnet
(Nordic)
(Chicago)
SingAREN
(Singapore)
(Los Angeles)
GRPNet
(Chicago)
(Seattle)
(Honolulu)
(Mauna)
2x10G
2x10G
10G
10G
REANNZ
(New Zealand)
(Auckland)
ASGC
(Taiwan)
(Chicago)
TWAREN
(Taiwan)
(Chicago)
KREONET
(S. Korea)
(Chicago)
CSTNET
(China)
(Chicago)
OpenTransits
Network
(France)
(Chicago)
AtlanticWave
(Miami)
(Atlanta)
(D.C.)
(New York)
SouthernLight
RNP
(Brazil)
(Sao Paulo)
aarnet
(Australia)
(Seattle)
(Los Angeles)
Federal Agency Networks, Regional Network
State Wide Networks, University Neworks, Testbed Networks
(Chicago)
ANA300
ESNet
Overlay Network
100G If Not Specified

International Federated Testbeds As Instruments for Computer Science/Network Science

- The StarLight Communications Exchange Facility Supports ~ 28 Network Research Testbeds (Instruments For Computer Science/Networking Research)
- StarLight Supports Two Software Defined Exchanges (SDXs)
- An NSF IRNC SDX & A Network Research SDX
- The Research SDX Supports National and International Federated Testbeds

Example SC25 SCinet Network Research Exhibitions

- Global Research Platform (GRP)
- SDX 1.2 Tbps WAN Infrastructure
- SDX E2E 1.2 Tbps WAN Services
- SDX E2E 400 Gbps 800 Gbps WAN Services
- 400 Gbps DTNs & Smart NICs
- Orchestration With Packet Marking (SciTags) at 1.2 Tbps
- Coherent Optics Over WANs
- Real Time FPGA Based Network Measurements
- NA REX Continental Backbone For Data Intensive Science
- SDX International Testbed Integration
- StarLight SDX for Petascale Science
- DTN-as-a-Service For Data Intensive Science With Scitags
- NASA Goddard Space Flight Center HP WAN Transport Services (800 G Dsk-Dsk)
- **Resilient Distributed Processing & Rapid Data Transfer**
- AutoGOLE/SENSE E2E Orchestration Net Services And Workflow Integration
- Open Science Grid Demonstrations
- National Research Platform Demonstrations
- Chameleon FABRIC/FAB Integration
- SciStream Multi Site Data Streaming Orchestration
- Distributed Pipelines Over WANs For On-Line Data Analysis

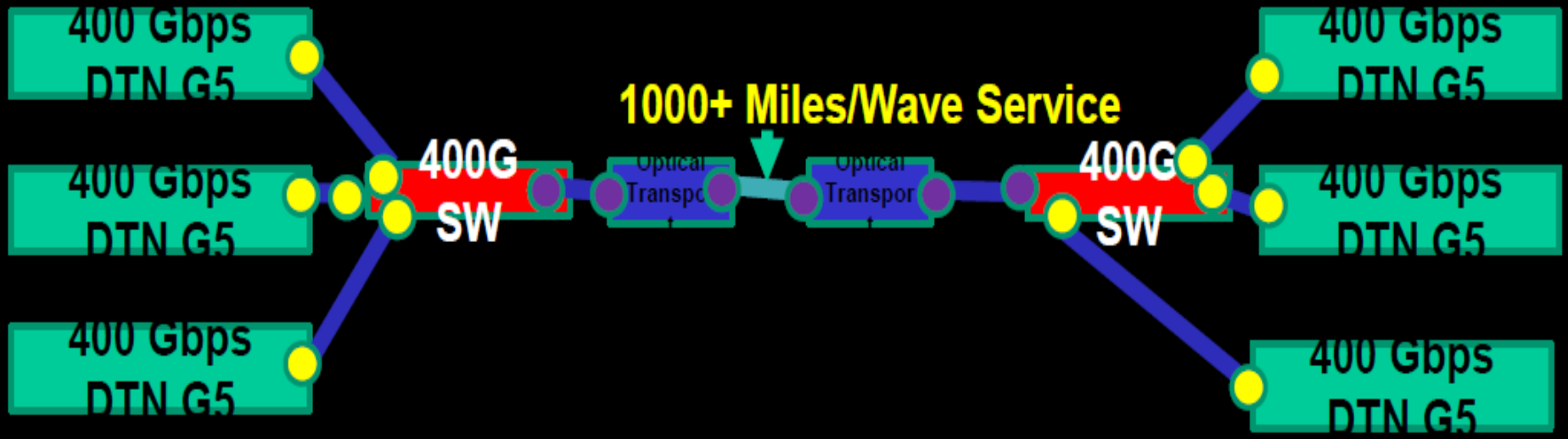
STARLIGHT SM

2*1.2 Tbps WAN Service Prototype for Data Intensive Science

Based On 2*1.2 Tbps Persistent Testbeds Between StarLight and JBDT

StarLight International/National Communications Exchange Facility, Chicago, Il

Joint Big Data Testbed McLean, Va



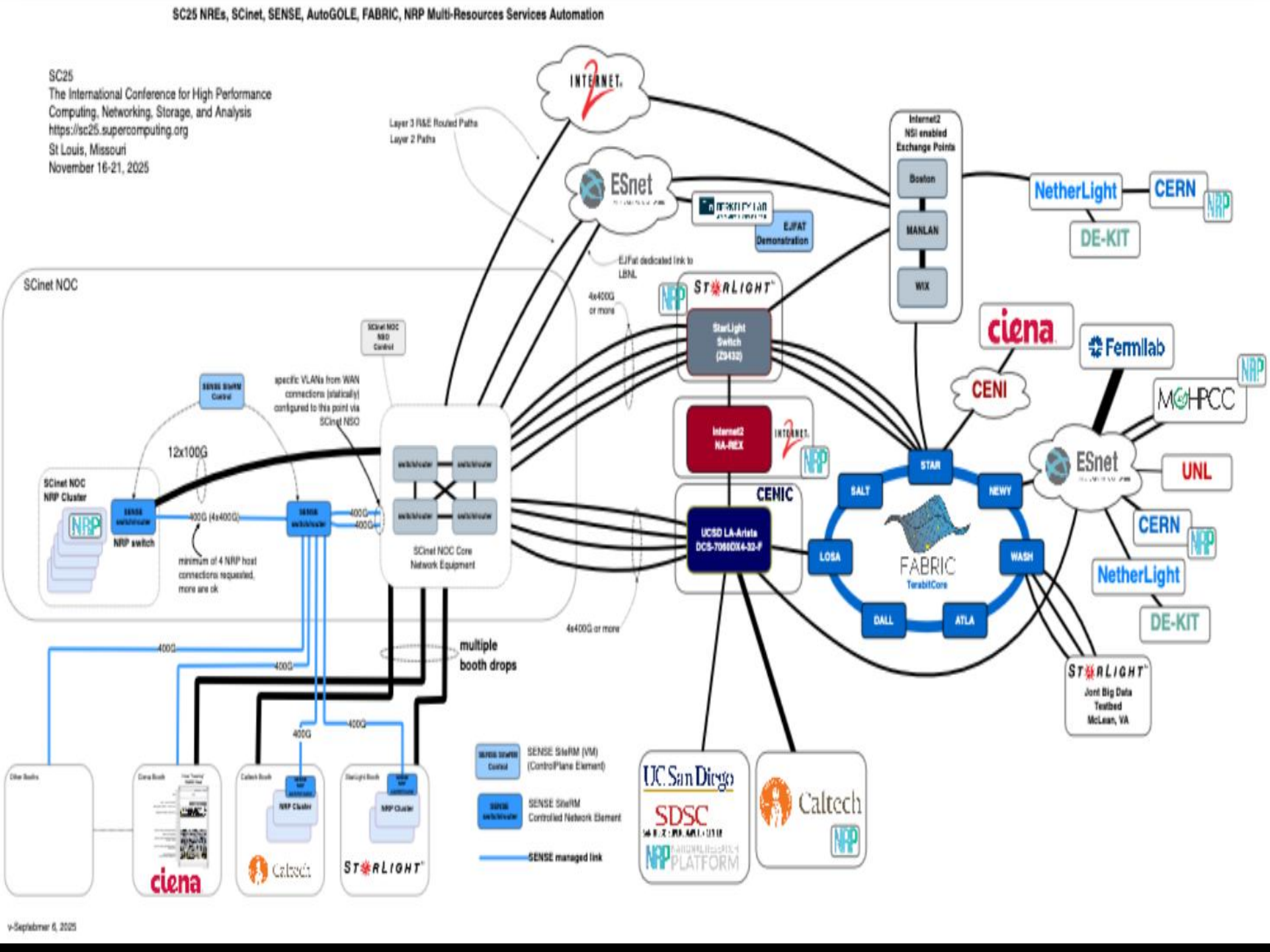
NB: G5=>G6

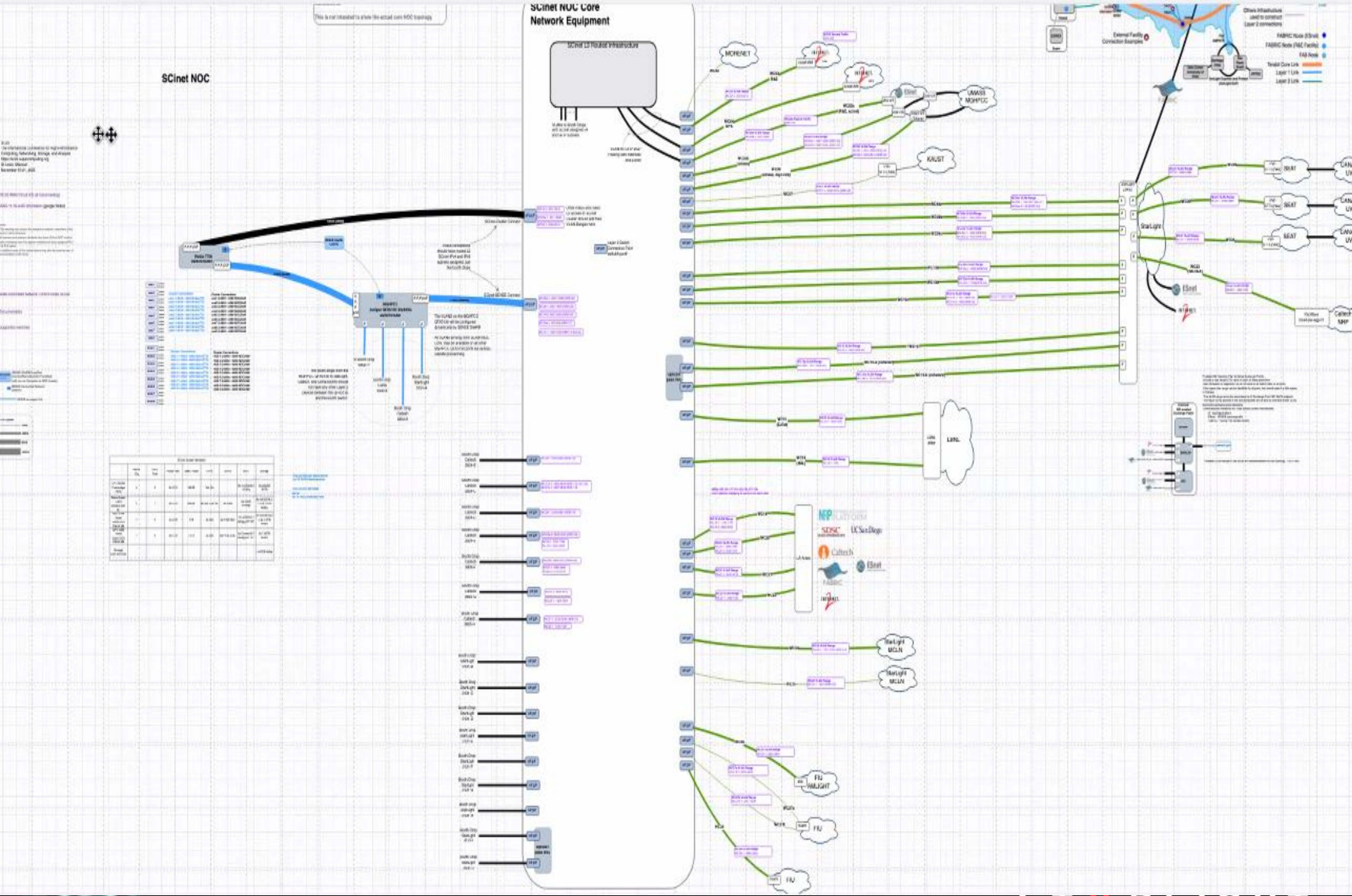
CX7>CX8

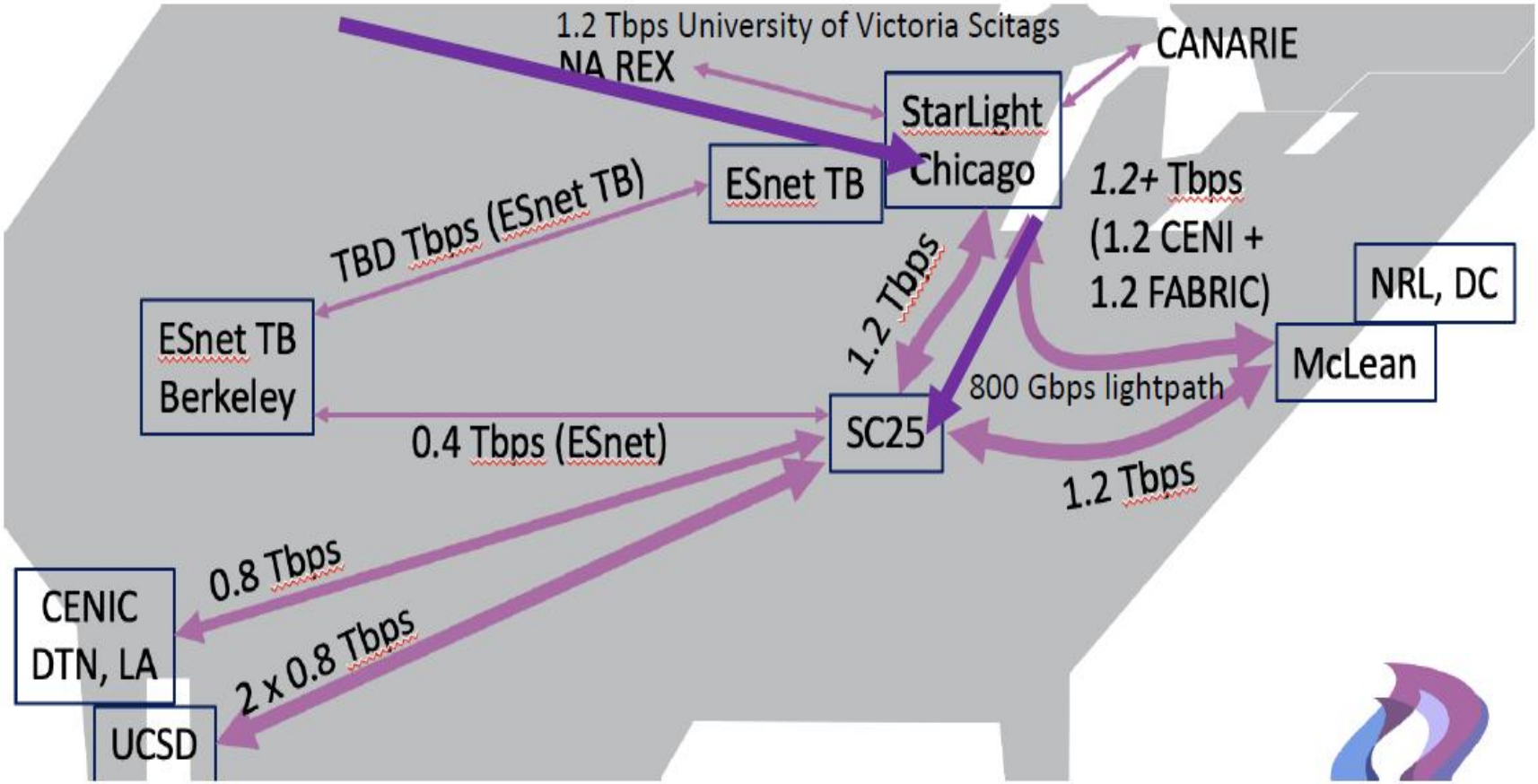
ZR/ZR+ Coherent Optics

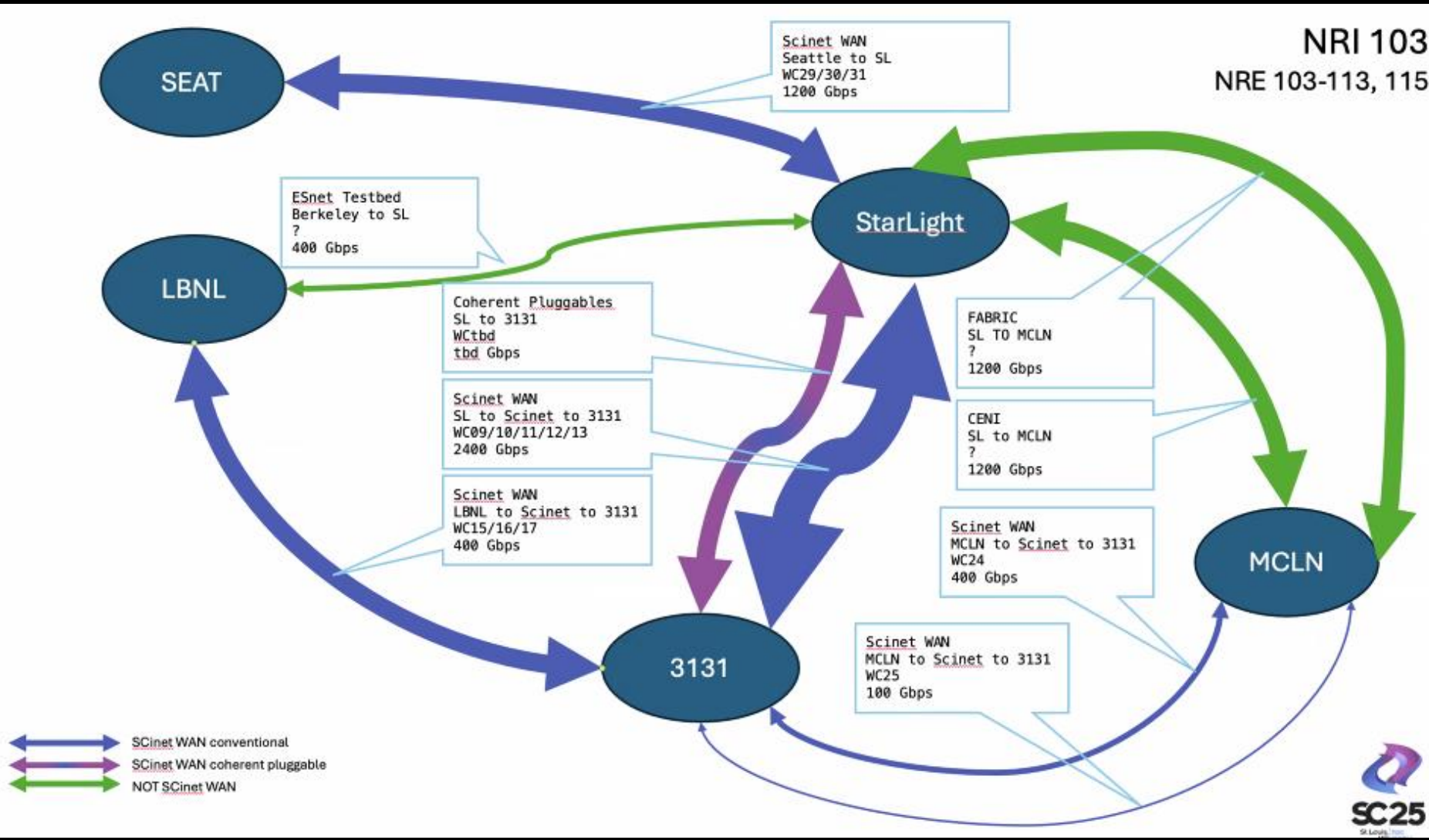
LR4 Transceiver + Smart NIC, e.g., CX7

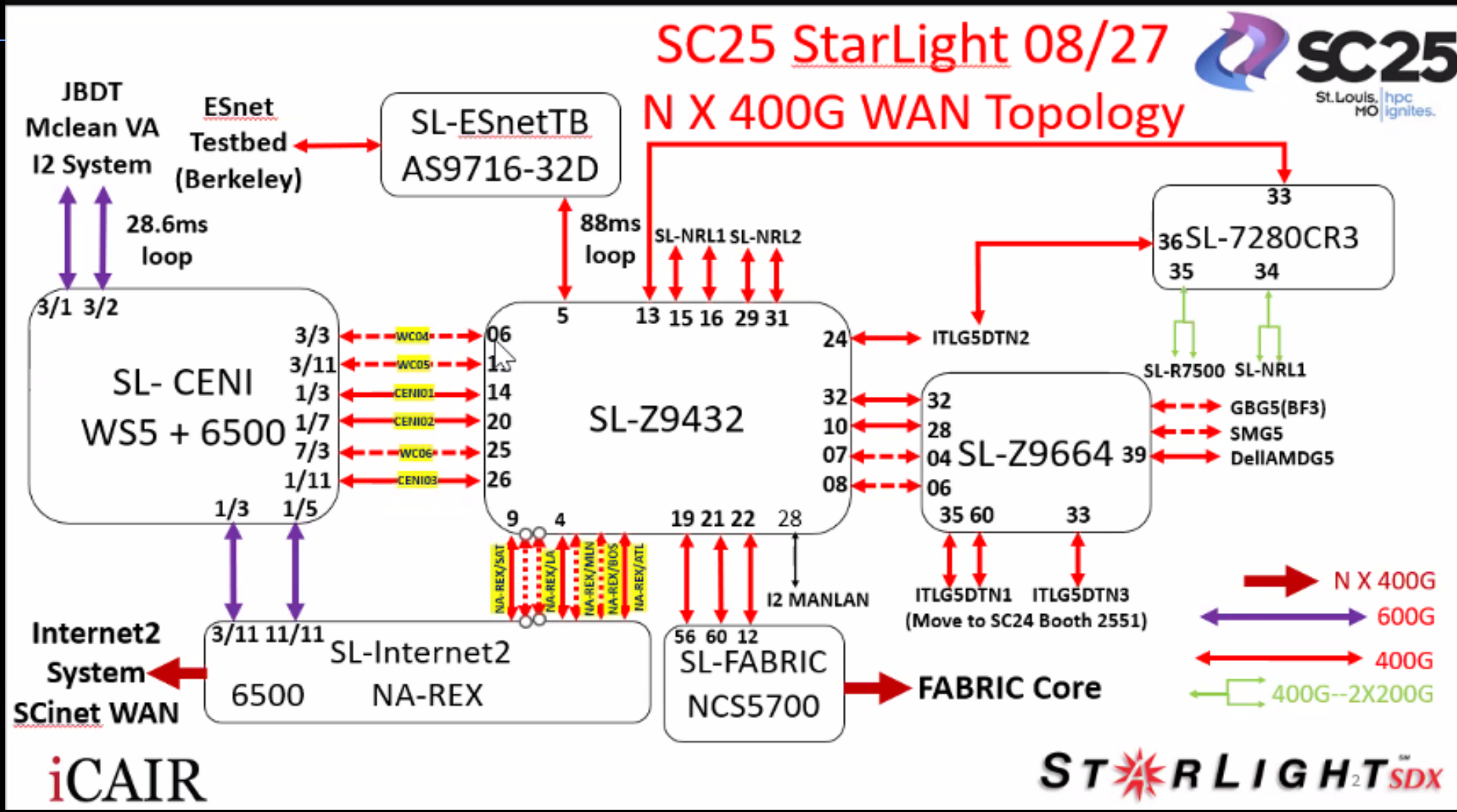
Transceivers/QSFPs

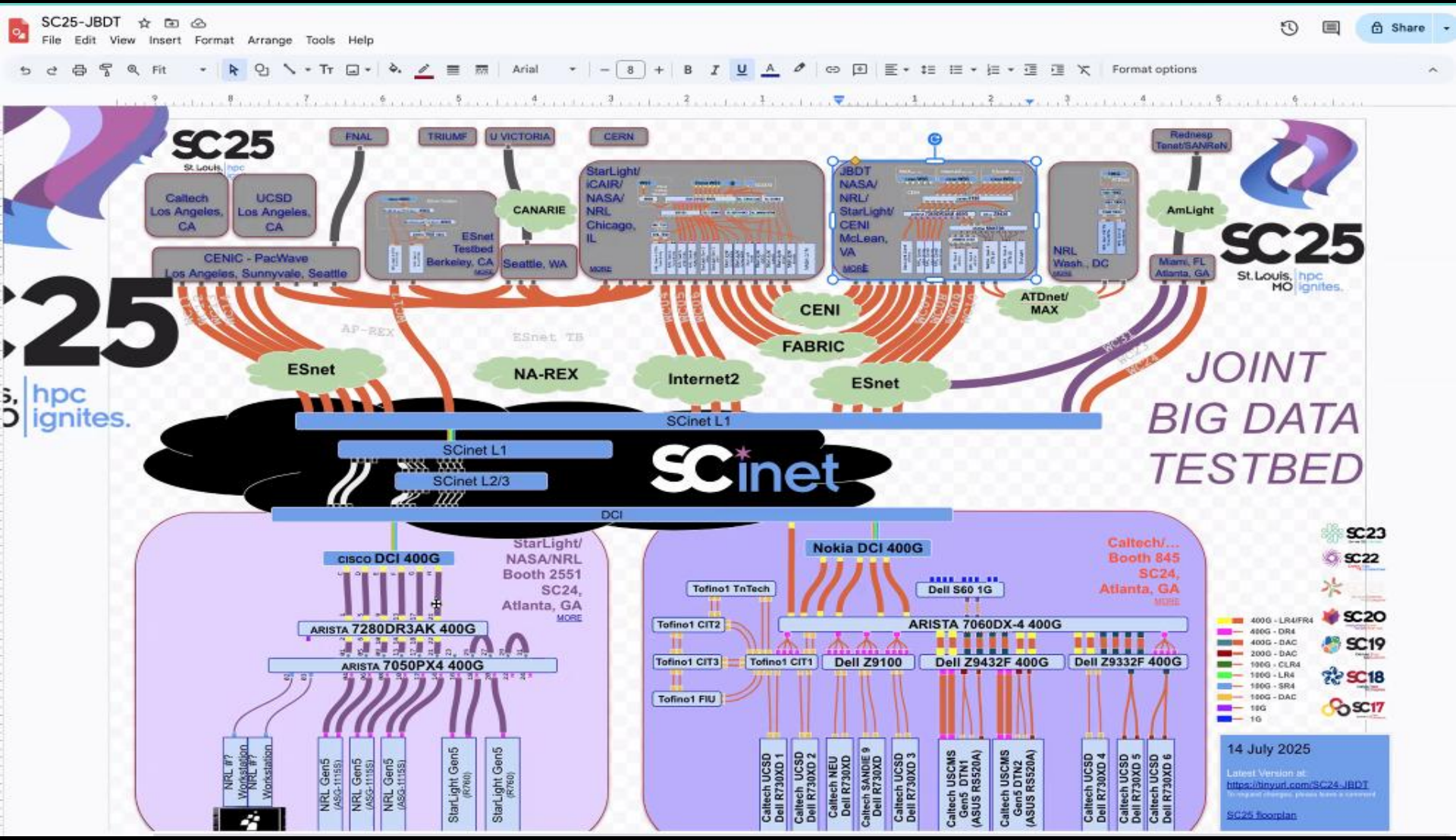

SC25 NREs, SCinet, SENSE, AutoGOLE, FABRIC, NRP Multi-Resources Services Automation
SC25
The International Conference for High Performance Computing, Networking, Storage, and Analysis
https://sc25.supercomputing.org
St Louis, Missouri
November 16-21, 2025
Layer 3 R&E Routed Paths
Layer 2 Paths
INTERNET2
ESnet
Internet2 NSI enabled Exchange Points
Boston
MANLAN
WIX
NetherLight
CERN
DE-KIT
EJFAT Demonstration
EJFat dedicated link to LBNL
SCinet NOC
4x400G or more
STARLIGHT
StarLight Switch (Z9432)
ciena
Fermilab
CENI
MOHPCC
UNL
Internet2 NA-REX
CENIC
UCSD LA-Arista DCS-7060DX4-32-F
STAR
NEWY
SALT
LOSA
WASH
DALL
ATLA
FABRIC
TeraBitCore
SCinet NOC Core Network Equipment
specific VLANs from WAN connections (statically) configured to this point via SCinet NSO
12x100G
SCinet NOC NRP Cluster
NRP switch
400G (4x400G)
minimum of 4 NRP host connections requested, more are ok
400G
multiple booth drops
Joint Big Data Testbed
McLean, VA
SENSE SiteRM (VM) (ControlPlane Element)
SENSE SiteRM Controlled Network Element
SENSE managed link
UC San Diego
SDSC
PLATFORM
Caltech
v-September 6, 2025


SCinet NOC
SCinet NOC Core
Network Equipment
SCinet L3 Routed Infrastructure
This is not intended to show the actual core NOC topology
MOREnet
UMASS
MGHPCC
KAUST
StarLight
CANARIE
UVIC
SEAT
ESnet
LBNL
NRP
SDSC
UC San Diego
Caltech
FABRIC
StarLight
MCLN
FIU
AMLIGHT


1.2 Tbps University of Victoria Scitags
NA REX
CANARIE
StarLight
Chicago
ESnet TB
TBD Tbps (ESnet TB)
1.2+ Tbps
(1.2 CENI +
1.2 FABRIC)
NRL, DC
McLean
1.2 Tbps
ESnet TB
Berkeley
800 Gbps lightpath
0.4 Tbps (ESnet)
SC25
1.2 Tbps
0.8 Tbps
CENIC
DTN, LA
2 x 0.8 Tbps
UCSD


NRI 103
NRE 103-113, 115
SEAT
Scinet WAN
Seattle to SL
WC29/30/31
1200 Gbps
ESnet Testbed
Berkeley to SL
?
400 Gbps
StarLight
LBNL
Coherent Pluggables
SL to 3131
WCtbd
tbd Gbps
FABRIC
SL TO MCLN
?
1200 Gbps
Scinet WAN
SL to Scinet to 3131
WC09/10/11/12/13
2400 Gbps
CENI
SL to MCLN
?
1200 Gbps
Scinet WAN
LBNL to Scinet to 3131
WC15/16/17
400 Gbps
Scinet WAN
MCLN to Scinet to 3131
WC24
400 Gbps
MCLN
3131
Scinet WAN
MCLN to Scinet to 3131
WC25
100 Gbps
SCinet WAN conventional
SCinet WAN coherent pluggable
NOT SCinet WAN
SC25


SC25 StarLight 08/27
N X 400G WAN Topology
SC25
St.Louis, MO hpc ignites.
JBDT
Mclean VA
I2 System
ESnet
Testbed
(Berkeley)
SL-ESnetTB
AS9716-32D
28.6ms
loop
88ms
loop
SL-NRL1 SL-NRL2
33
36 SL-7280CR3
35 34
SL-R7500 SL-NRL1
3/1 3/2
SL- CENI
WS5 + 6500
3/3
3/11
1/3
1/7
7/3
1/11
WC04
WC05
CENI01
CENI02
WC06
CENI03
1/3 1/5
5 13 15 16 29 31
06
1
14
20
25
26
SL-Z9432
24
32
10
07
08
ITLG5DTN2
32
28
04
06
SL-Z9664
39
GBG5(BF3)
SMG5
DellAMDG5
35 60 33
9 4
19 21 22 28
NA-REX/SAT
NA-REX/LA
NA-REX/MLN
NA-REX/BOS
NA-REX/ATL
I2 MANLAN
ITLG5DTN1
(Move to SC24 Booth 2551)
ITLG5DTN3
Internet2
System
SCinet WAN
3/11 11/11
SL-Internet2
6500 NA-REX
56 60 12
SL-FABRIC
NCS5700
FABRIC Core
N X 400G
600G
400G
400G--2X200G
iCAIR
STARLIGHT SDX


SC25-JBDT
File Edit View Insert Format Arrange Tools Help
Share
Format options
SC25
St.Louis, hpc
FNAL
TRIUMF
U VICTORIA
CERN
Caltech Los Angeles, CA
UCSD Los Angeles, CA
CENIC - PacWave Los Angeles, Sunnyvale, Seattle
ESnet Testbed Berkeley, CA
CANARIE
Seattle, WA
StarLight/ iCAIR/ NASA/ NRL Chicago, IL
JBDT NASA/ NRL/ StarLight/ CENI McLean, VA
NRL Wash., DC
Rednesp Tenet/SANReN
AmLight
Miami, FL Atlanta, GA
SC25 St.Louis, MO hpc ignites.
CENI
FABRIC
ATDnet/ MAX
ESnet
NA-REX
Internet2
ESnet
JOINT BIG DATA TESTBED
SCinet L1
SCinet L1
SCinet L2/3
SCinet
DCI
CISCO DCI 400G
StarLight/ NASA/NRL Booth 2551 SC24, Atlanta, GA
ARISTA 7280DR3AK 400G
ARISTA 7050PX4 400G
NRL #? Workstation
NRL Gen5 (ASG-1115S)
StarLight Gen5 (R760)
Nokia DCI 400G
Caltech/... Booth 845 SC24, Atlanta, GA
Tofino1 TnTech
Tofino1 CIT2
Tofino1 CIT3
Tofino1 FIU
Tofino1 CIT1
Dell S60 1G
ARISTA 7060DX-4 400G
Dell Z9100
Dell Z9432F 400G
Dell Z9332F 400G
Caltech UCSD Dell R730XD 1
Caltech UCSD Dell R730XD 2
Caltech NEU Dell R730XD
Caltech SANDIE 9 Dell R730XD
Caltech UCSD Dell R730XD 3
Caltech USCMS Gen5 DTN1 (ASUS R5520A)
Caltech USCMS Gen5 DTN2 (ASUS R5520A)
Caltech UCSD Dell R730XD 4
Caltech UCSD Dell R730XD 5
Caltech UCSD Dell R730XD 6
400G - LR4/FR4
400G - DR4
400G - DAC
200G - DAC
100G - CLR4
100G - LR4
100G - SR4
100G - DAC
10G
1G
SC23
SC22
SC20
SC19
SC18
SC17
14 July 2025
Latest Version at
https://tinyurl.com/SC24-JBDT
SC25 floorplan

DTN-as-a-Service

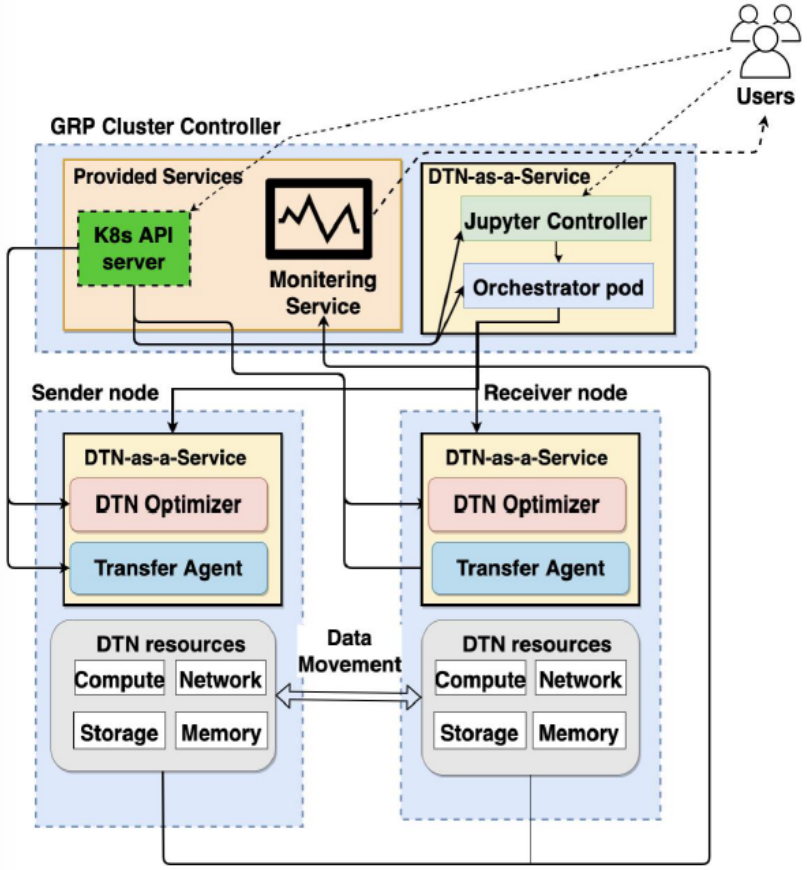
GRP Cluster with DTN-as-a-Service

DTN-as-a-Service(DTNaaS) provides a data movement workflow in GRP k8s cluster:

1. Deploy DTNaaS workloads via k8s API server
2. Use Jupyter to optimize and run transfers
3. Observe performance from monitoring service

GRP DTNaaS Components:

- Orchestrator: controller of DTNaaS to manage agent and optimizer pods via REST API.
- Transfer Agent: run transfer jobs
- DTN Optimizer: optimize the DTN resources for workflow
- Jupyter: web interface to run DTNaaS interactively



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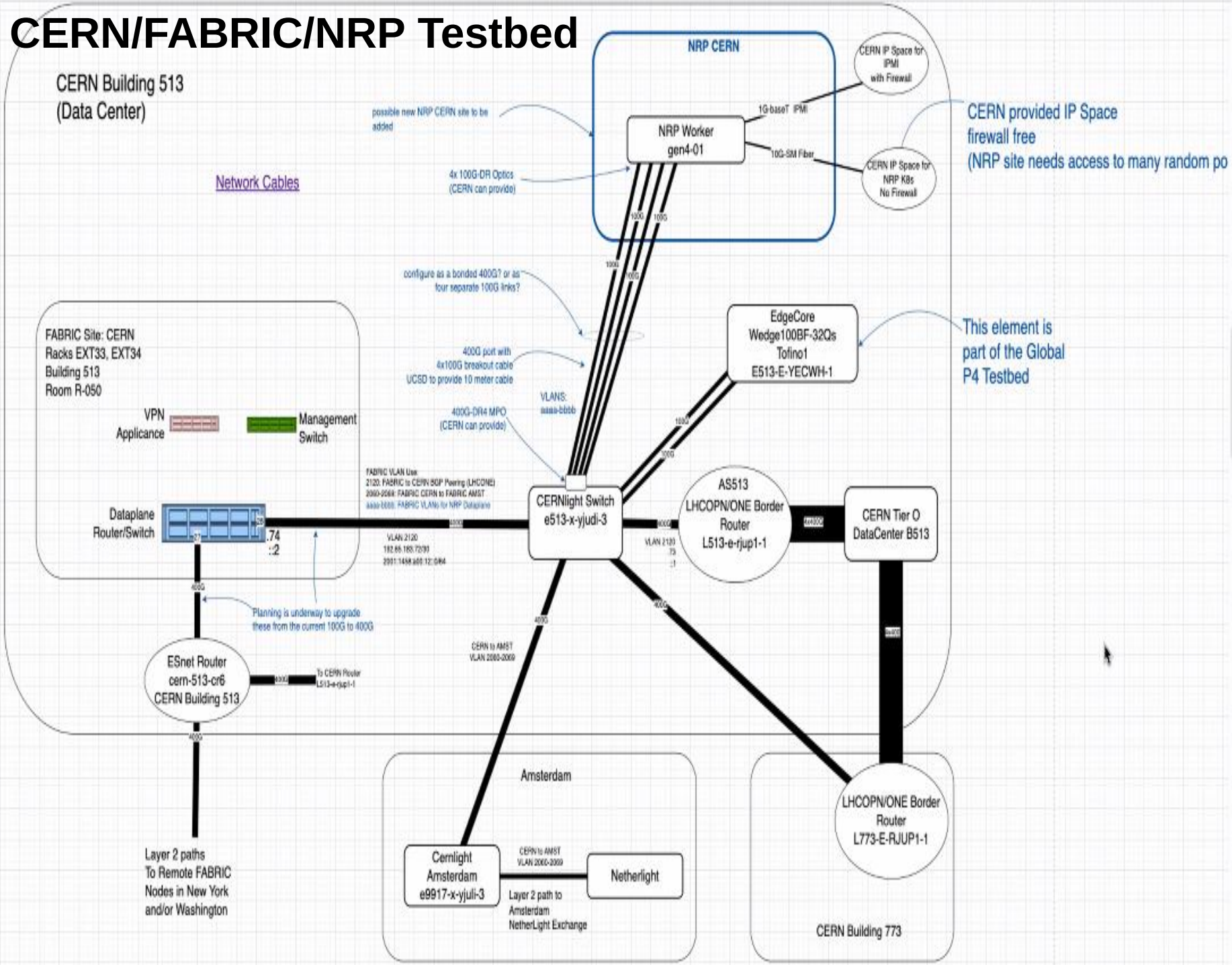
STARLIGHT SDX

STARLIGHT

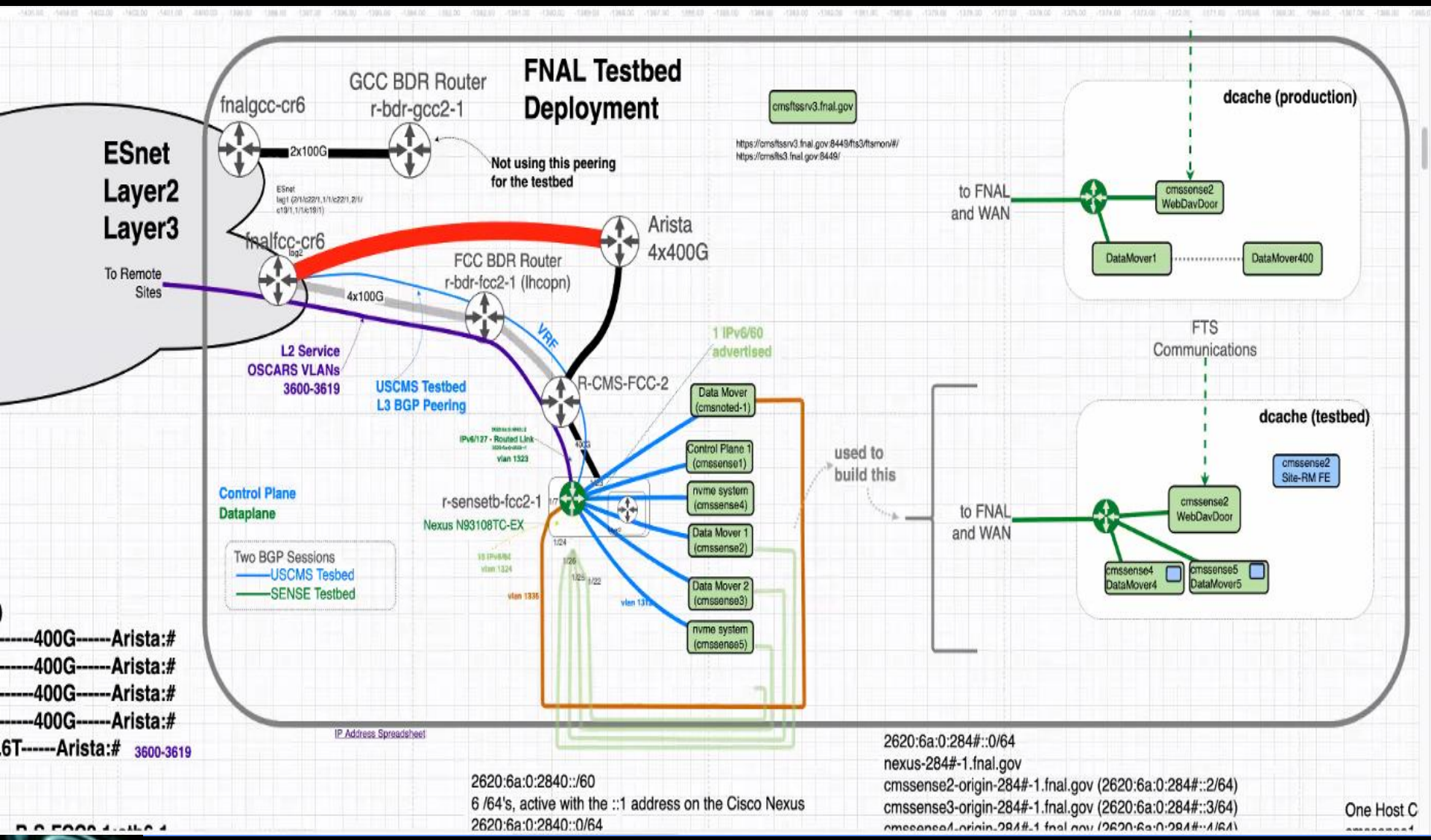
Potential Testbed Expansions?

- Several Additional/Expansion Testbed Options Exist
- SC26 Chicago, Illinois
- CERN Networking Testbed
- Fermi Lab Networking Testbed
- OFCnet 2027
- Data Mover Challenge (Supercomputing Asia Conference – Perhaps 400 Gbps – Although Ref NICT 10*100 Gbps NREs)
- NSF Chameleon Testbed
- ESnet Testbed
- Coherent Optics (e.g., ZR/ZR+) Testbeds

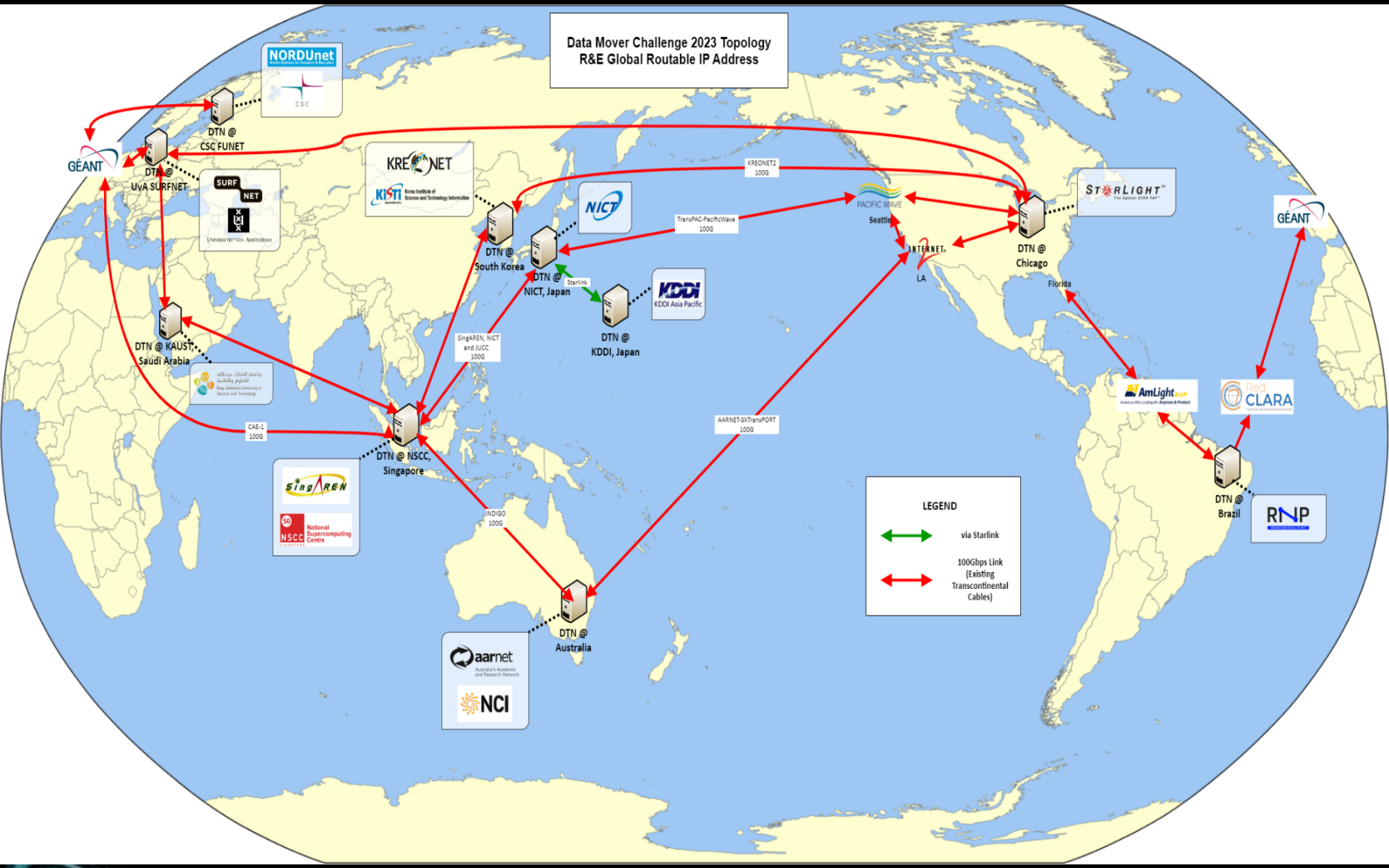
CERN/FABRIC/NRP Testbed

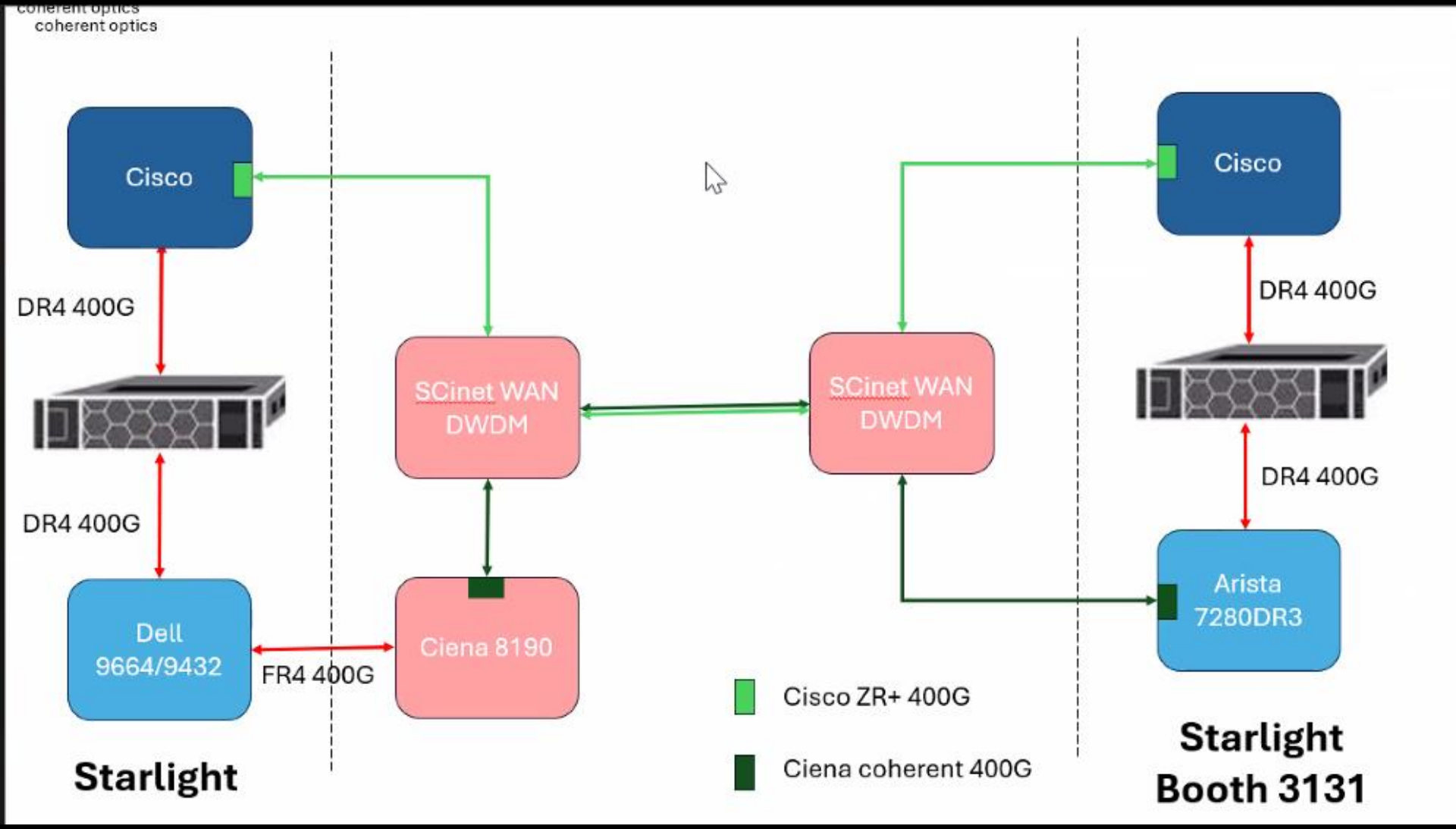


Fermi Lab Networking Testbed

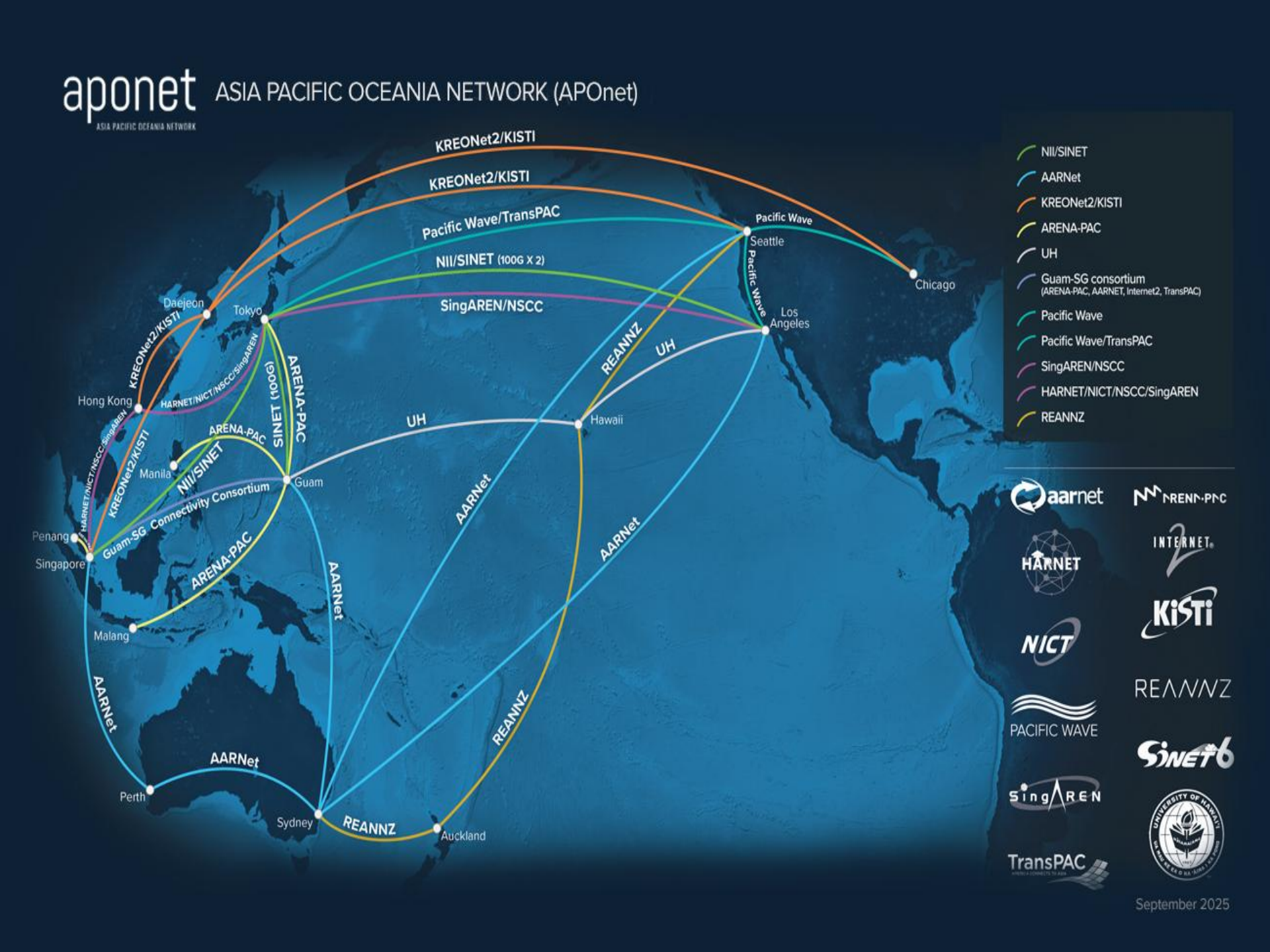


Data Mover Challenge SCAsia




coherent optics
coherent optics
Cisco
DR4 400G
DR4 400G
Dell
9664/9432
FR4 400G
Ciena 8190
SCinet WAN
DWDM
SCinet WAN
DWDM
Cisco
DR4 400G
DR4 400G
Arista
7280DR3
Cisco ZR+ 400G
Ciena coherent 400G
Starlight
Starlight
Booth 3131

aponet ASIA PACIFIC OCEANIA NETWORK (APOnet)



September 2025


PACIFIC WAVE
NATIONAL & INTERNATIONAL PEERING EXCHANGE
Pacific Wave is a project of CENIC & PNWGP
Fairbanks
PACIFIC WAVE
Vancouver
Seattle
PACIFIC WAVE
Tokyo
PACIFIC WAVE
Guam
PACIFIC WAVE
Oahu
Eureka
Cal Poly Humboldt
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Chicago
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Denver
Albuquerque
El Paso
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MOXY
Boston
BIX
New York
MAN/LAN
DC Area
WIX
Atlanta
AMPATH
Miami
AMPATH
Korea
Japan
China
Hong Kong
Taiwan
Philippines
Singapore
Indonesia
Australia
New Zealand
KISTI/KREONET
CSTNET
JGN (Seattle & Tokyo
TransPAC/Pacific Wave
WIDE
ARENA-PAC
PACIFIC WAVE
AARNET
REANNZ
UH
PIREN-UH
PREGINET
IGN/SINGAREN
SINET
TWAREN/TANET
CERNET
CANARIE
PNWGP
FABRIC
ESnet
Internet2
DREN
NREN
(NASA Ames)
CENIC
UltraLight
(Caltech)
ABQG
NA-REX
FRGP
ANA
CUDI
Flō Networks
Pacifc Wave Backbone
Pacific Wave Participant Links
Partner Exchange Links
In-Service Early 2026
Pacific Wave PoP
Partner Exchange
CENIC-AIR (AI Resource)
AutoGOLE/SENSE
Commercial Peering Points
(Amazon, Google, & Microsoft)
Western Regional Network
States served by WRN members:
• ABQG: New Mexico
• CENIC: California
• FRGP: Colorado, & Wyoming
• PNWGP: Washington, Montana, Alaska, Oregon, & Idaho
• UH: Hawaii
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