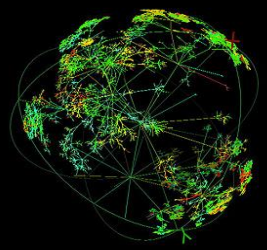
SC23 NREs Focused on Global Science

Joe Mambretti, Director, (j-mambretti@northwestern.edu)
International Center for Advanced Internet Research (www.icair.org)
Northwestern University
Director, Metropolitan Research and Education Network (www.mren.org)
Director, StarLight International/National Communications Exchange Facility (www.startap.net/starlight),
PI: StarLight SDX, Co-PI Chameleon, PI-iGENI, PI-OMNINet

Internet2 Community Exchange 2024
Chicago, Illinois
March 4-7, 2024



NSF's Cyberinfrastructure Framework for the 21st Century (CIF21)

- ***"This vision of the near future shows clearly the urgent need for a comprehensive, scalable, cyberinfrastructure that bridges diverse scientific communities and integrates high--performance computing, data, software, and facilities in a manner that brings theoretical, computational, experimental, and observational approaches together to advance the frontier."***

Large Scale Science Ecosystems

- Science Domains Create Cyberinfrastructure Ecosystems, Some Distributed World Wide, Some Devoted To Domains, Some Shared Among Domains
- GRP Provides Opportunities For Information Sharing: Cyberinfrastructure Architecture, Implementation, Technologies and Operations Among Projects (Especially Useful For Cross Disciplinary Research)
- Projection/Definition of Future, Specialized Requirements, Architecture, Services, Techniques, Technologies, Processes Described In Cyberinfrastructure "Blueprints"
- Cambrian Explosion Of Requirements and Innovations
- Techniques and Technologies Emerge from Multiple Sources (Academic, Commercial, Government Labs, Utilitarian Imperatives, e.g., Commercial Clouds)
- Macro-Trend: "Software Eating The World" - Software Defined Everything
- ***Multiple Software Building Blocks For Data-Intensive Science (Modules/Components) Are Emerging***

Global Collaborative Research Communities

- Science Is Global
- Open Information Sharing, A Cornerstone of The Science Process
- Concepts, Experiments, Instruments, Methods, Techniques, Data, Technologies And Results Are Openly Communicated and Shared Among Collaborative Science Communities World-Wide
- The Global Research Platform Is An International Collaborative Partnership Creating A Distributed Environment for International Data Intensive Science
- The GRP Facilitates High Performance Data Gathering, Analytics, Transport (100 Gbps-Tbps E2E), Computing, And Storage
- www.theglobalresearchplatform.net

Selected Applications

GENI
www.geni.net

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

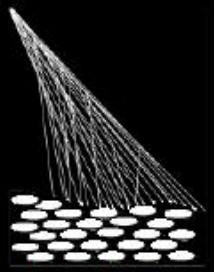
Virgo
www.virgo-gw.eu

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

GLEON
www.gleon.org

GRP
theglobalresearch platform.net/

IceCube
icecube.wisc.edu



Pierre Auger Observatory
www.auger.org

SKA
www.skatelescope. org

LIGO
www.ligo.caltech. edu

USGS EROS
www.usgs.gov/ centers/eros

Blue Waters
bluewaters.ncsa. illinois.edu

PRAGMA
www.pragma-grid.net

NEON
www.neonscience. org

CENTRA
www.global centra.org

SAGE2
sage2.sagecommons. org

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

Jetstream
www.jetstream-cloud.org

Chameleon
www.chameleon cloud.org

PRP
pacificresearch platform.org

Genomic Science Program
genomicscience. energy.gov

Belle II
www.belle2.org

LBNF/DUNE/ ProtoDUNE
lbnf.fnal.gov

XENON
xenon.astro. columbia.edu

NOvA
novaexperiment. fnal.gov

SDSS
www.sdss.org

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

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

ALMA
www.alma observatory.org

IVOA
www.ivoa.net

Compilation by Maxine Brown and Joe Mambretti

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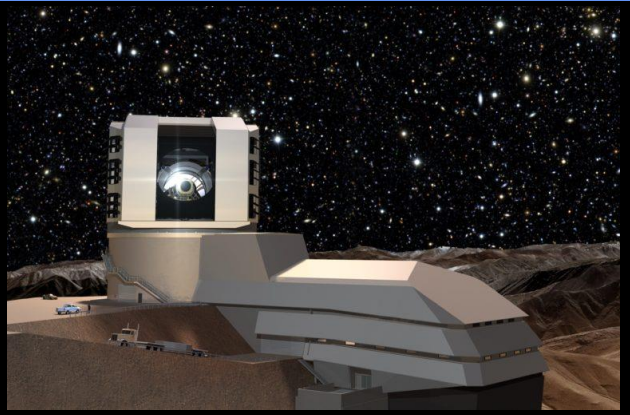
Instruments: Exebytes Of Data

High Luminosity LHC

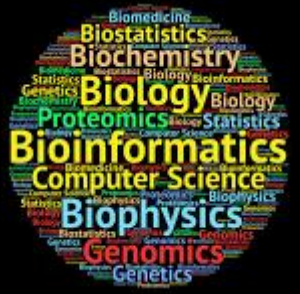
SKA Australia Telescope Facility



Vera Rubin Observatory

KSTAR Korea Superconducting Tokamak

Next Gen Advanced Photon Source



Bioinformatics/Genomics

The GRP: A Platform For Global Science

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

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

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

www.glif.is

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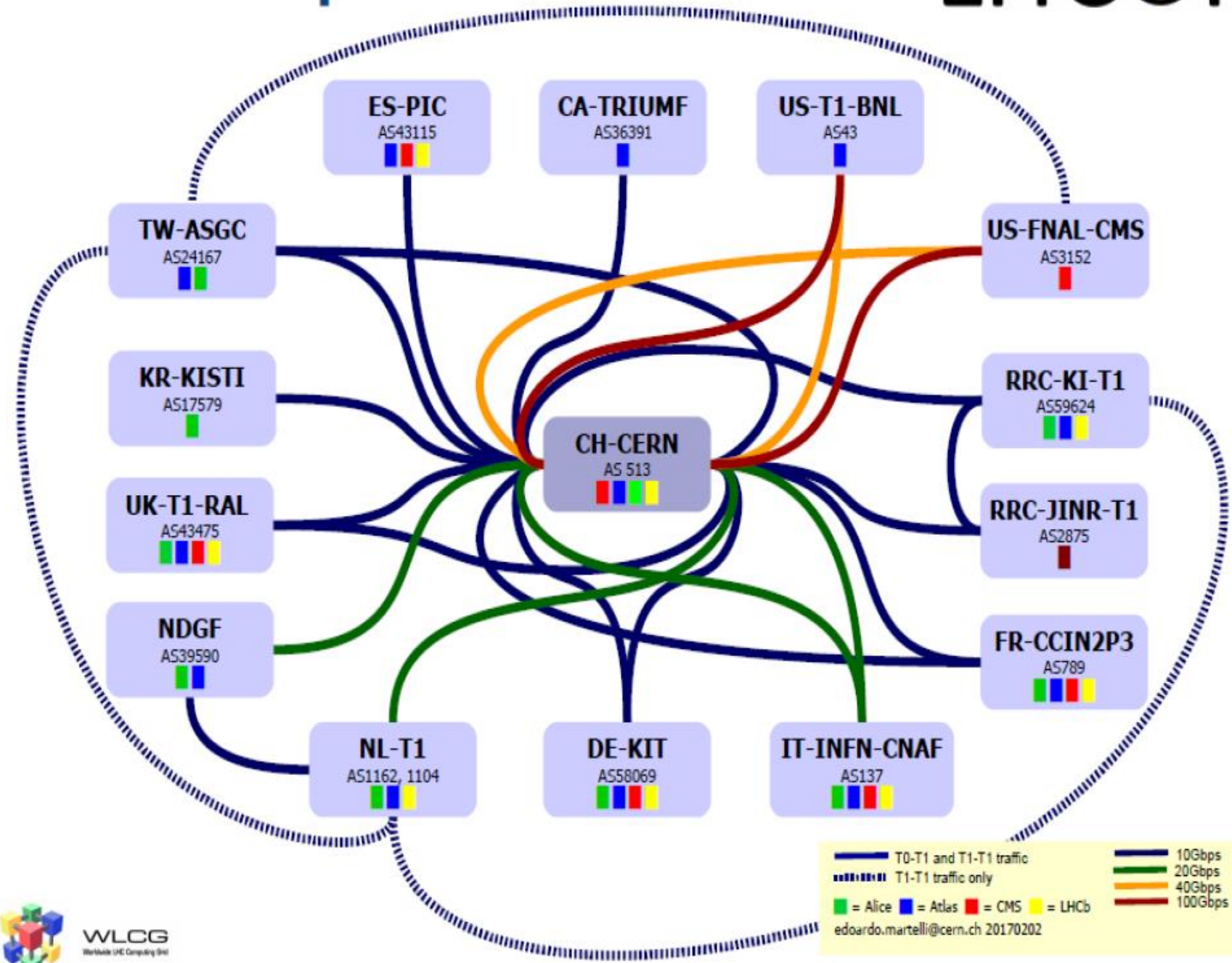
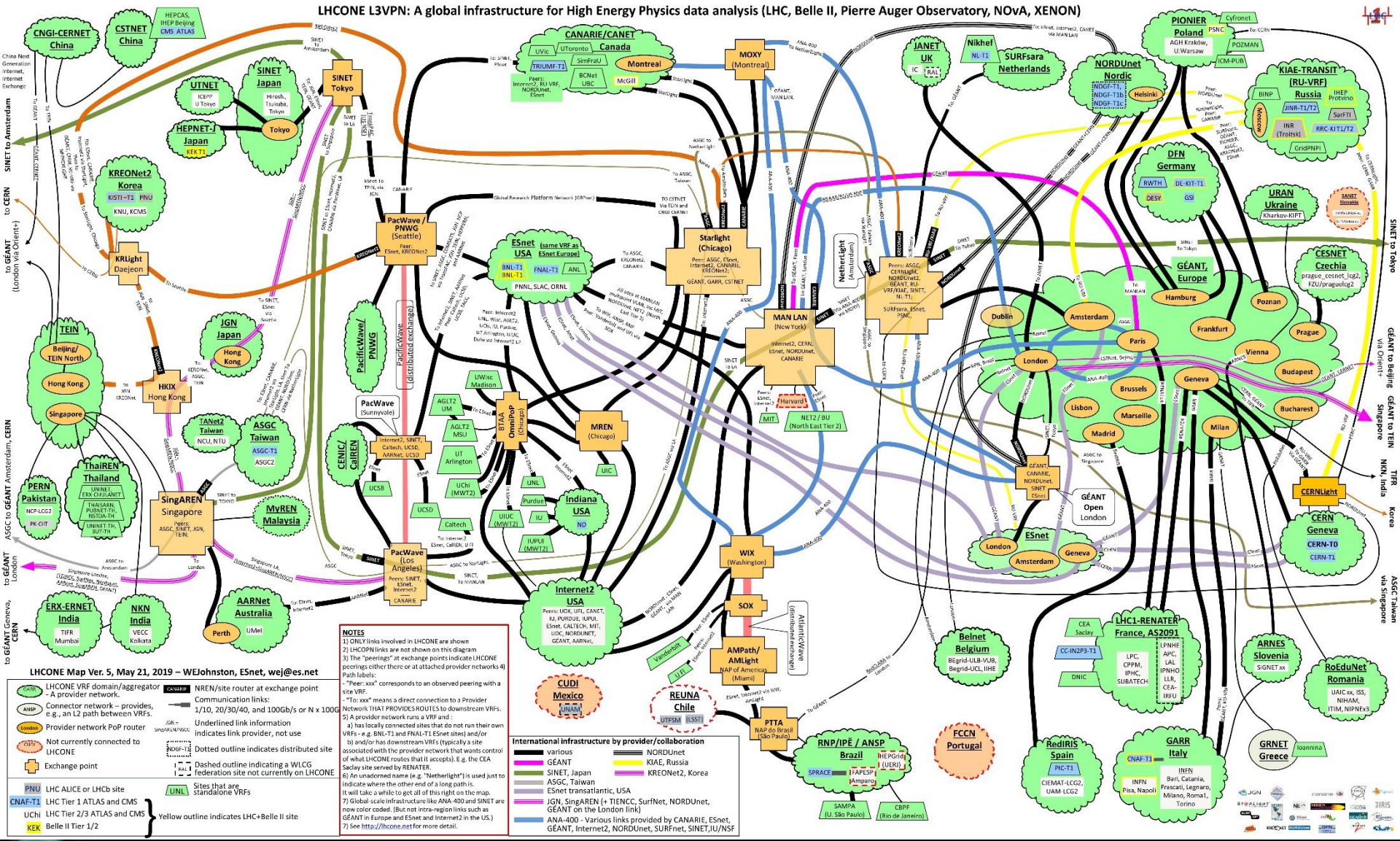
Annual Global Research Platform Workshop – Co-Located With IEEE International Conference On eScience Oct 9-10

Next Global Research Platform Workshop
Osaka University, Osaka, Japan,
co-located with eScience Sept 16-19, 2024

LHCOPN map


ES-PIC
AS43115
CA-TRIUMF
AS36391
US-T1-BNL
AS43
TW-ASGC
AS24167
US-FNAL-CMS
AS3152
KR-KISTI
AS17579
RRC-KI-T1
AS59624
CH-CERN
AS 513
UK-T1-RAL
AS43475
RRC-JINR-T1
AS2875
NDGF
AS39590
FR-CCIN2P3
AS789
NL-T1
AS1162, 1104
DE-KIT
AS58069
IT-INFN-CNAF
AS137
T0-T1 and T1-T1 traffic
T1-T1 traffic only
= Alice = Atlas = CMS = LHCb
edoardo.martelli@cern.ch 20170202
10Gbps
20Gbps
40Gbps
100Gbps

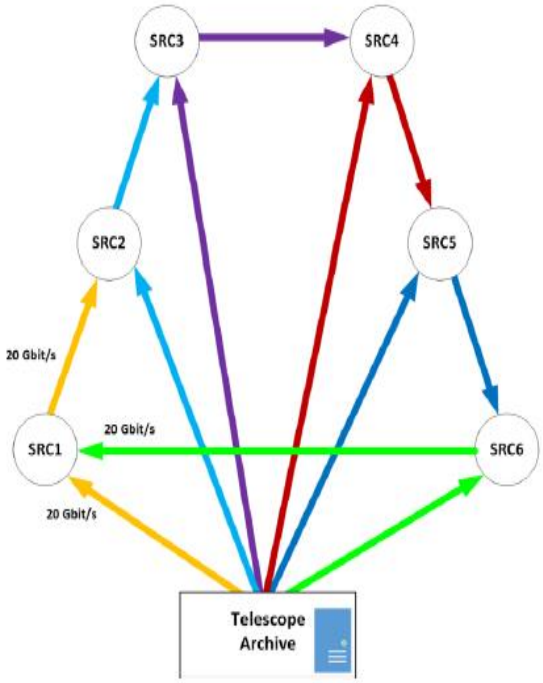


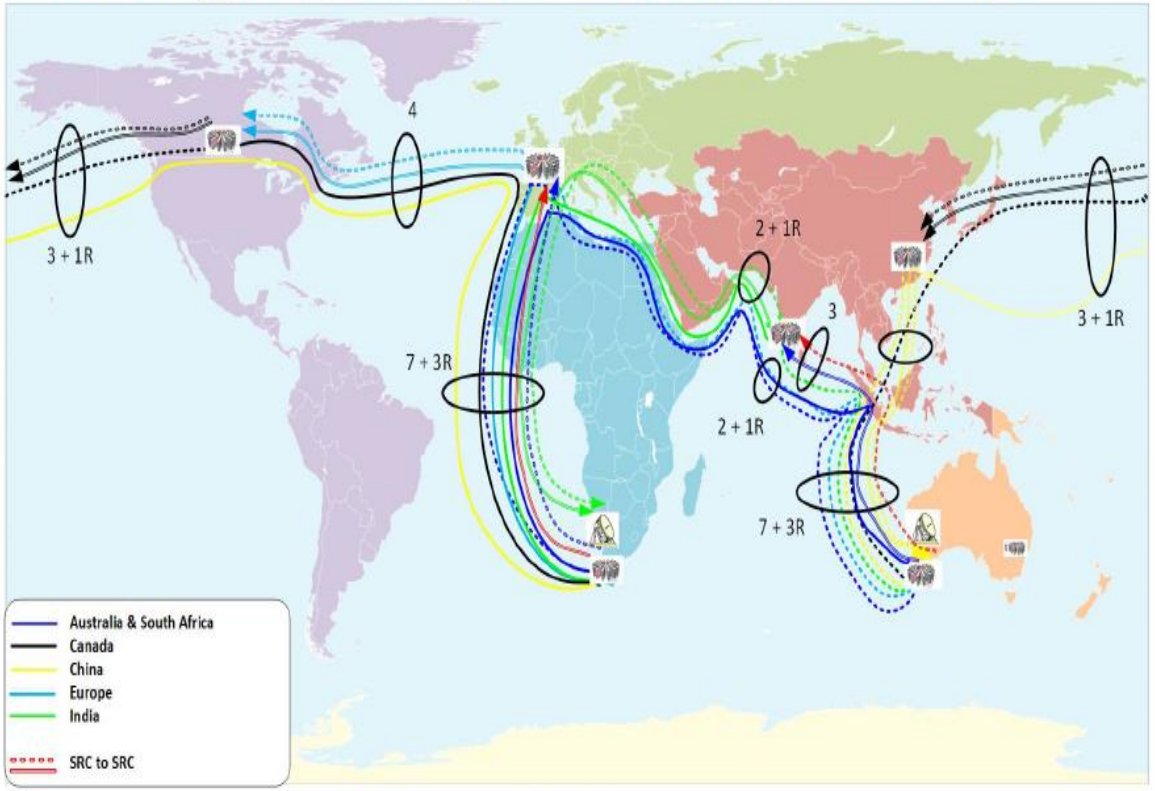
Non-LHC Scientific Communities Using LHCONE

- Belle II Experiment, Particle Physics Experiment Designed To Study Properties od B Mesons (Heavy Particles Containing a Bottom Quark)
- Pierre Auger Observatory, Studying Ultra-High Energy Cosmic Rays, the Most energetic and Rarest Particles in The Universe
- LIGO and Virgo (In August 2027 This Collaboration Measured a Gravatational Wave Originating From a Binary Neutron Star Merger.
- NOvA Experiment: Designed To Answer Fundamental Questions In Neutrino Physics
- XEON Dark Matter Project: Global Collaboration Investigating Fundamental Properties of Dark Matter, Largest Component of the Universe
- DUNE/ProtoDUNE – Deep Underground Nutrino Experiment

Global Data Flows if the SRC Re-distribute data – 2 Replicas

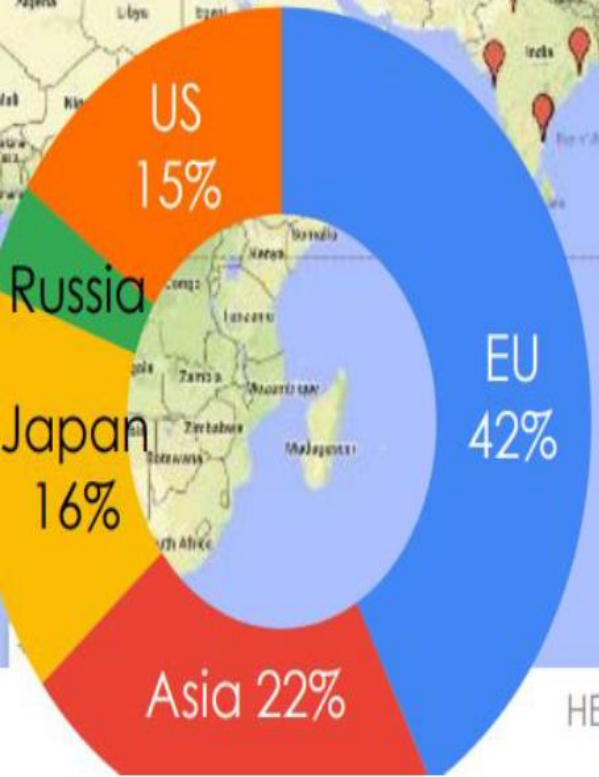
- Each SRC accepts its fraction of the Observatory Data Products and re-distributes to another SRC.
- SRC has 20 Gbit/s flow from the telescope & a second continuous 20 Gbit/s flow from another SRC.
- Each SRC sends out a 20 Gbit/s flow.
- Makes substantial use of the shared academic network which would imply charges to the SKA community.
- **Probable cost to SKA community Very approx. ~ 0.8 M USD/year not allowing for the extra BW from the telescopes**





Belle II Collaboration

A Global Collaboration
as wide as an LHC experiment



26 countries/regions
123 institutes
1,075 researchers

Global Scale Science Highlighted At Prior GRP Workshops

- The Square Kilometer Array: Data Transport, Processing, Archiving and Access, Shaun Amy, Australia Telescope National Facility
- Large Synoptic Survey Telescope Distributed Computing and Networks, Jeff Kantor, LSST
- Korean Fusion Program: KSTAR, ITER and K-DEMO and International Collaborators, Si-Woo Yoon, National Fusion Research Institute
- Square Kilometer Array (SKA), Richard Hughes-Jones, GÉANT
- Vera C. Rubin Observatory, Large Synoptic Survey Telescope (LSST), Nate Lust, LSST/Rubin Observatory
- Belle II, Super B-Factory Experiment, Silvio Pardi, National Institute for Nuclear Physics, (INFN)
- Deep Underground Neutrino Experiment (DUNE) – Kenneth Herner, Fermi National, Accelerator Laboratory
- Distributed Computing Operations For HL-LHC With Operational
- Intelligence, Federica Legger, National Institute of Nuclear Physics (INFN)
- Next-Generation Cyberinfrastructures for LHC, High-Luminosity LHC and Data Intensive Sciences, Harvey Newman, Caltech
- KAUST Genomics Cloud, Alex Moura, KAUST

Selected GRP Themes

- Orchestration Among Multiple Domains
- Large-Scale High Capacity Data WAN Transport

(Highlighted at SC23: 400 Gbps, 800 Gbps, 1.2 Tbps WAN Services For Data Intensive Science)

- High-Fidelity Data Flow Monitoring, Visualization, Analytics, Diagnostic Algorithms, Event Correlation AI/ML/DL
- International Testbeds for Data-Intensive Science

AutoGOLE Open R&E Exchanges

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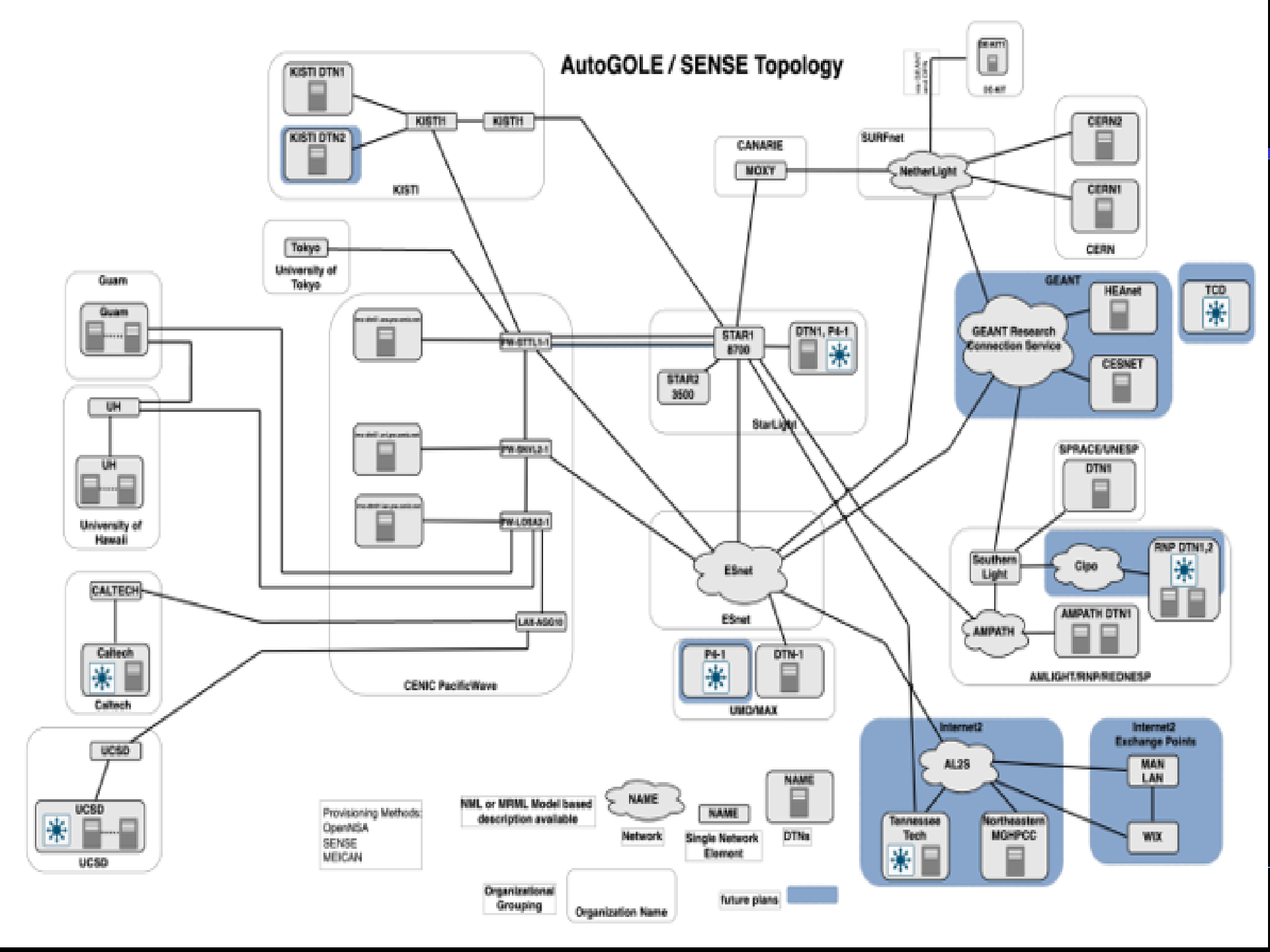
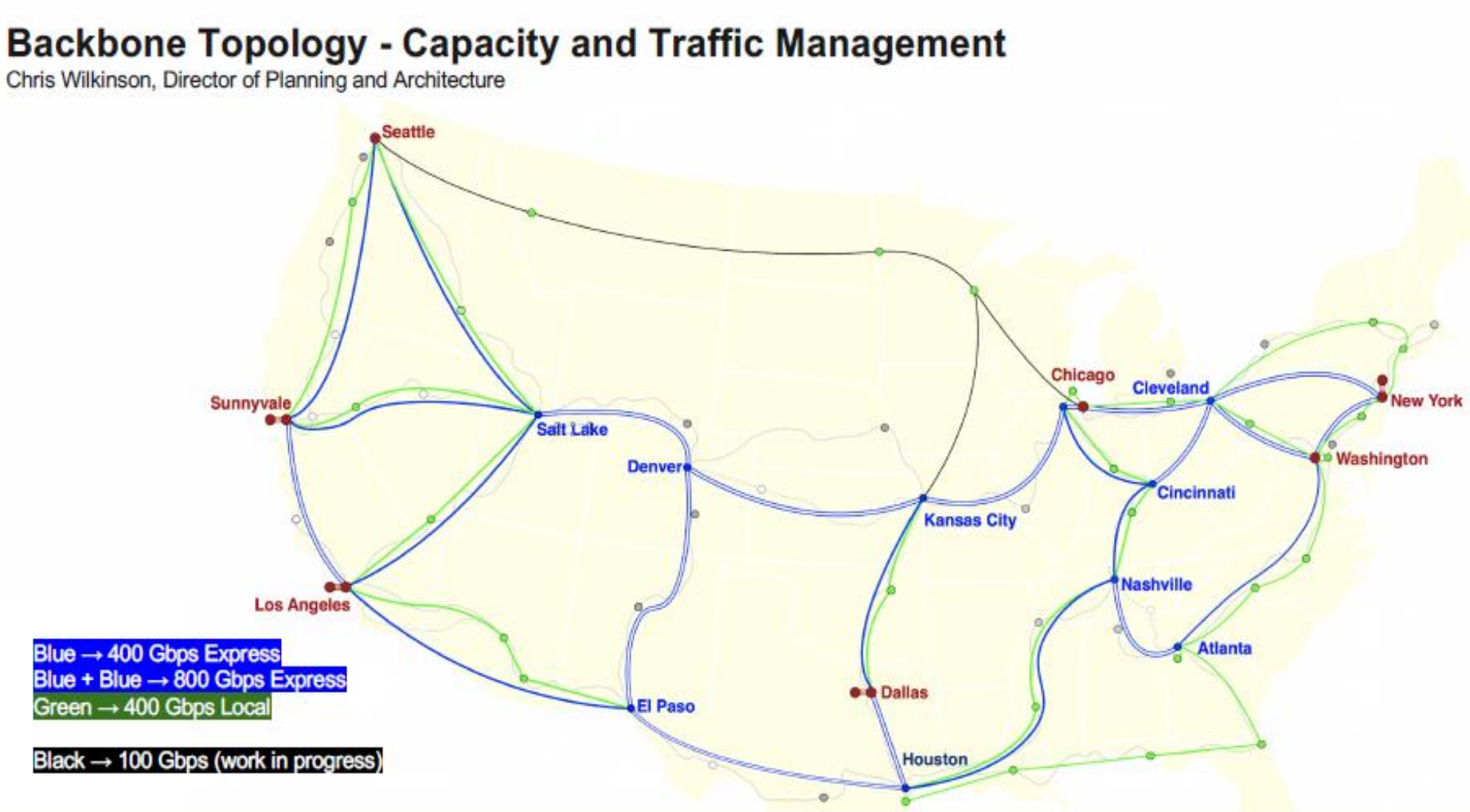
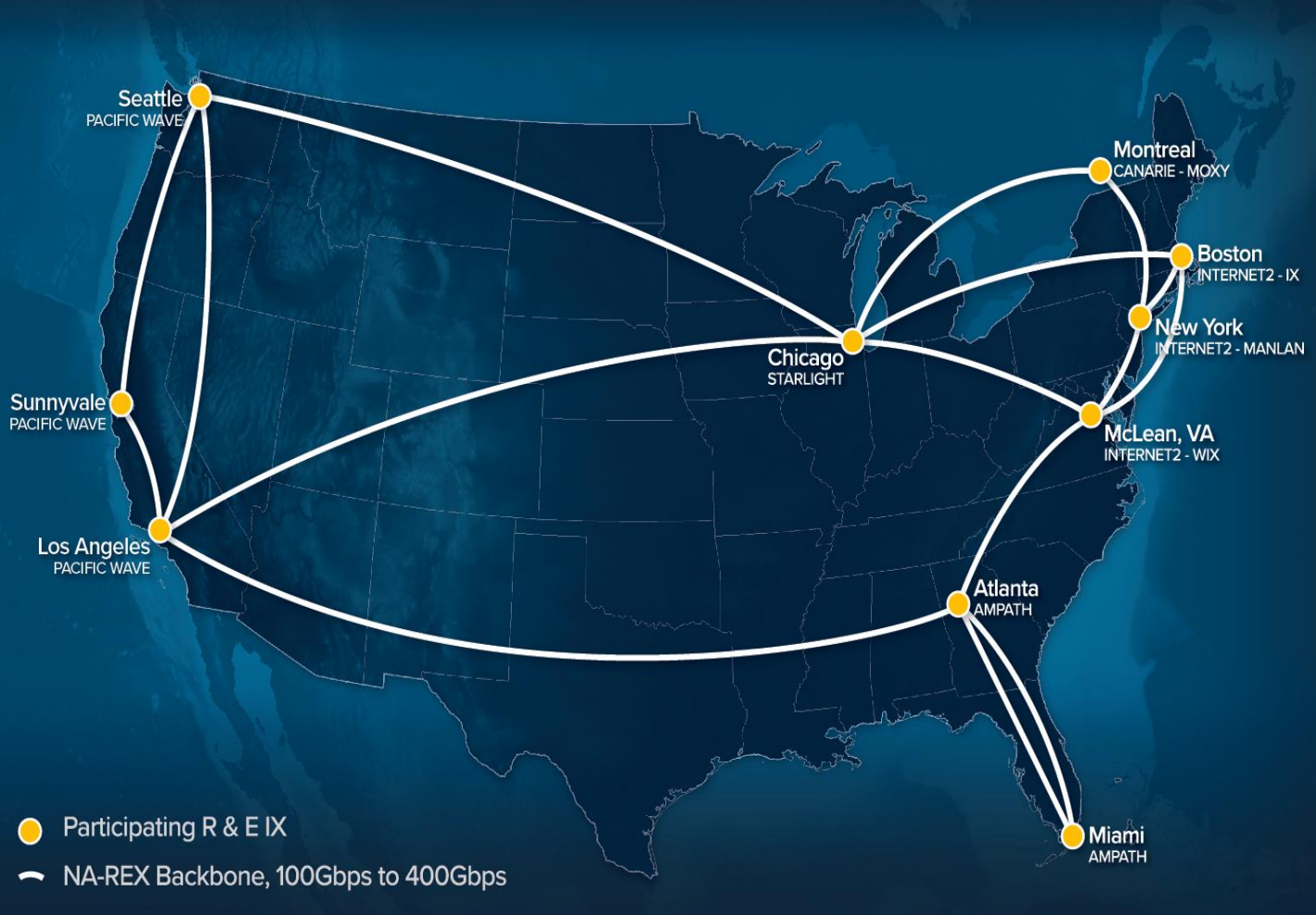

AutoGOLE / SENSE Topology
KISTI DTN1
KISTI DTN2
KISTI
KISTI
KISTI
KISTI
CANARIE
MCKY
SURFnet
NetherLight
CERN2
CERN1
CERN
Tokyo
University of Tokyo
Guam
Guam
UH
UH
University of Hawaii
FW-STTL1-1
FW-SNV1-2-1
FW-LOS1-2-1
STAR1 8700
STAR2 3500
DTN1, P4-1
StarLight
GEANT
GEANT Research Connection Service
HEAnet
CESNET
TCD
SPRACE/UNESP
DTN1
Southern Light
Cipo
RNP DTN1,2
AMPATH
AMPATH DTN1
AMLIGHT/RNP/REDNESP
ESnet
ESnet
LAX-AGG10
CALTECH
Caltech
Caltech
CENIC PacificWave
P4-1
DTN-1
UMD/MAX
UCSD
UCSD
UCSD
Internet2
AL2S
Tennessee Tech
Northeastern MGHPCC
Internet2 Exchange Points
MAN LAN
WIX
Provisioning Methods:
OpenNSA
SENSE
MEICAN
NML or MRML Model based description available
NAME
Network
NAME
Single Network Element
NAME
DTNs
Organizational Grouping
Organization Name
future plans


ESnet6
LSQ
HLAN
NETL-ALB
PNWL
INL
LBNL
NERSC
SLAC
LLNL
SNLCA
NREL
NGA-SW
Salt Lake City
AMES
ANL
FNAL
FRIB
KCNSC
NETL-PGH
NETL-MGN
BNL
LNS
PSFC
CERN
NREL-DC
JLAB
PPPL
ORAU
ORCC
Y-12
ORNL
LANL
LANL-NNSS
KCNSC-NM
SNLA
GA
NNSS
PANTEX
SRS
Hubs
increasing bandwidth
SITES
*Locations generalized for clarity
ESnet
ENERGY
Office of Science
STARLIGHT SM

Internet2 Backbone Topology



NA-REX North America Research & Education Exchange Collaboration

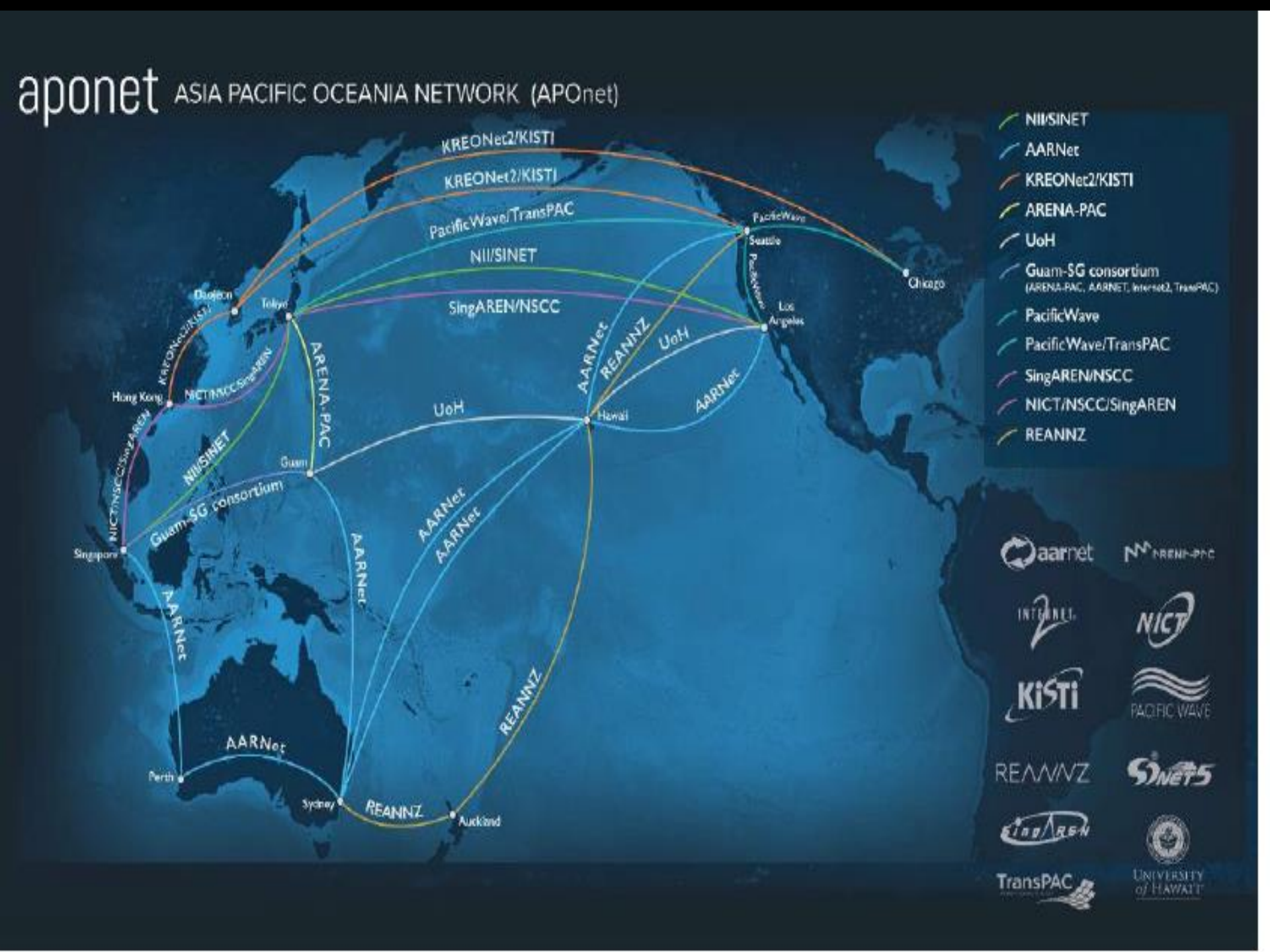


AMPATH PATHWAY TO THE AMERICAS
canarie
ESnet ENERGY SCIENCES NETWORK
INTERNET2
International Networks at Indiana University
STARLIGHT The Optical STAR TAP
CENIC
PACIFIC NORTHWEST GIGAPOP
PACIFIC WAVE

November 2023

STARLIGHT SM

aponet ASIA PACIFIC OCEANIA NETWORK (APOnet)



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

Abbott Hall, Northwestern University's Chicago Campus

Currently: 20+ 400 Gbps Paths Prototyping 800 Gbps Tbps

iCAIR

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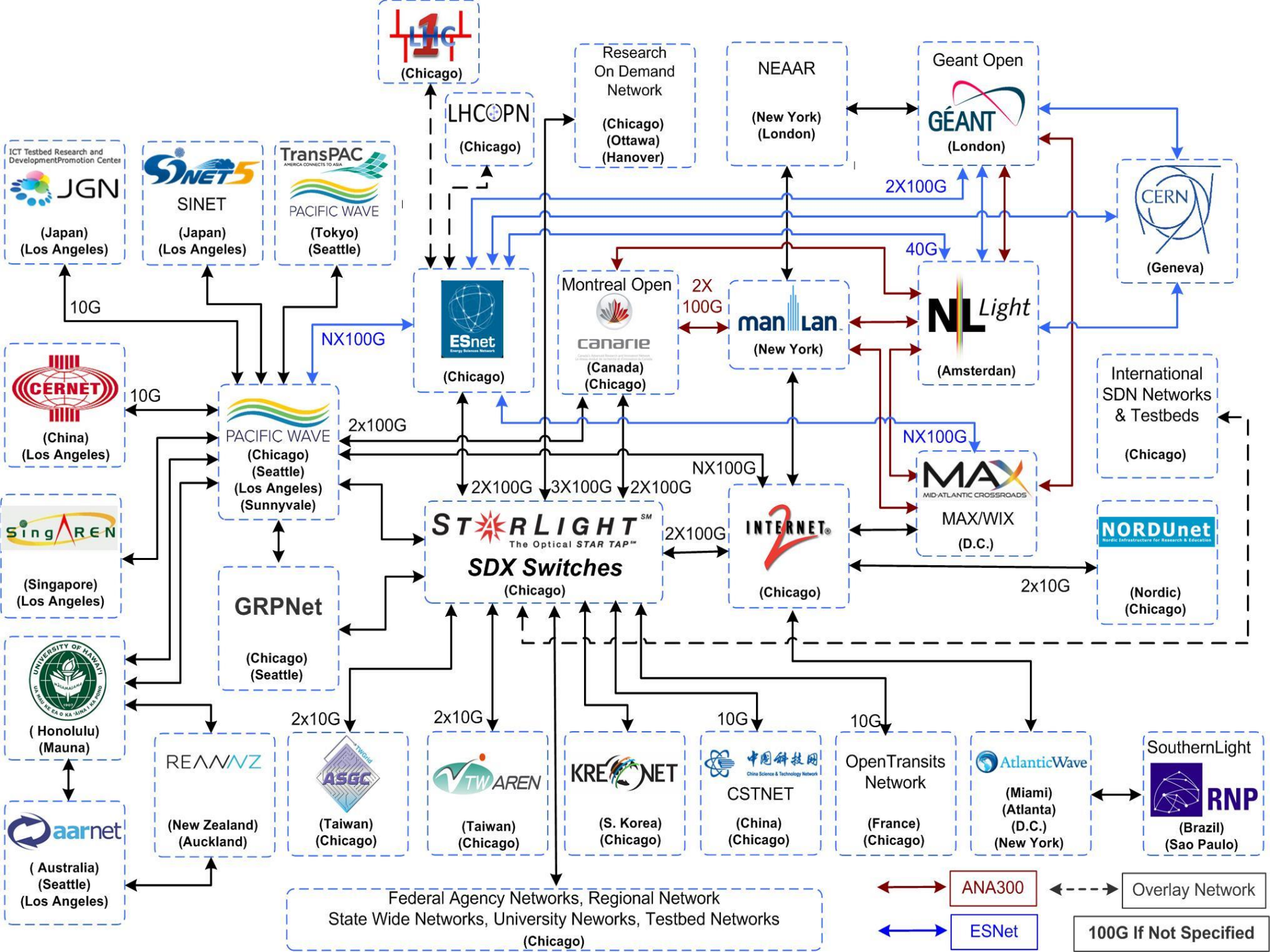
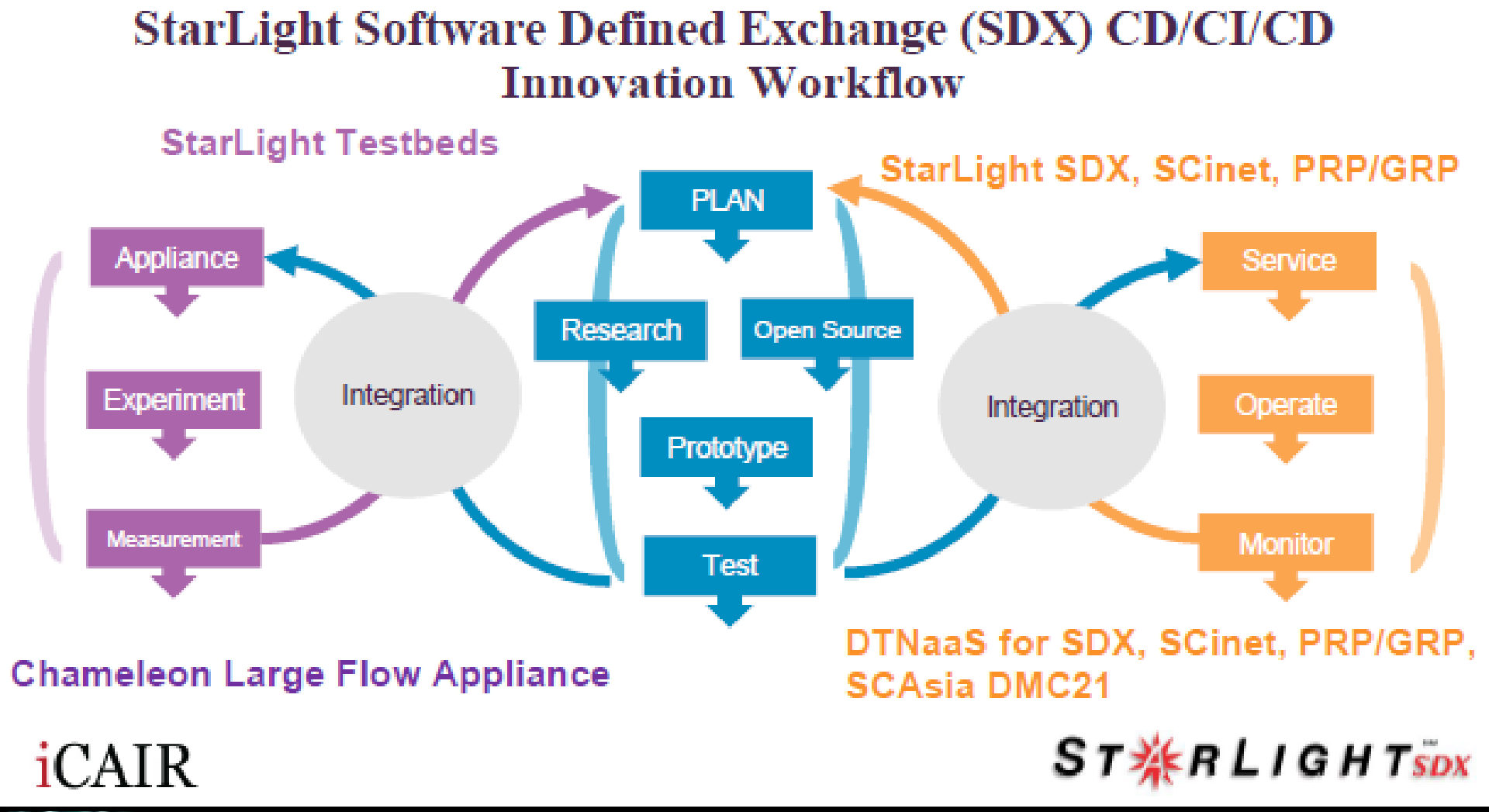

LHC
(Chicago)
LHCOPN
(Chicago)
Research On Demand Network
(Chicago)
(Ottawa)
(Hanover)
NEAAR
(New York)
(London)
Geant Open
GÉANT
(London)
CERN
(Geneva)
2X100G
40G
ICT Testbed Research and DevelopmentPromotion Center
JGN
(Japan)
(Los Angeles)
SINET
(Japan)
(Los Angeles)
TransPAC
PACIFIC WAVE
(Tokyo)
(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
SingAREN
(Singapore)
(Los Angeles)
STARLIGHT
The Optical STAR TAP
SDX Switches
(Chicago)
2X100G
INTERNET2
(Chicago)
2x10G
NORDUnet
(Nordic)
(Chicago)
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 GENI SDX (Global Environment for Network Innovations)
- The GENI SDX Supports National and International Federated Testbeds

StarLight Software Defined Exchange



iCAIR

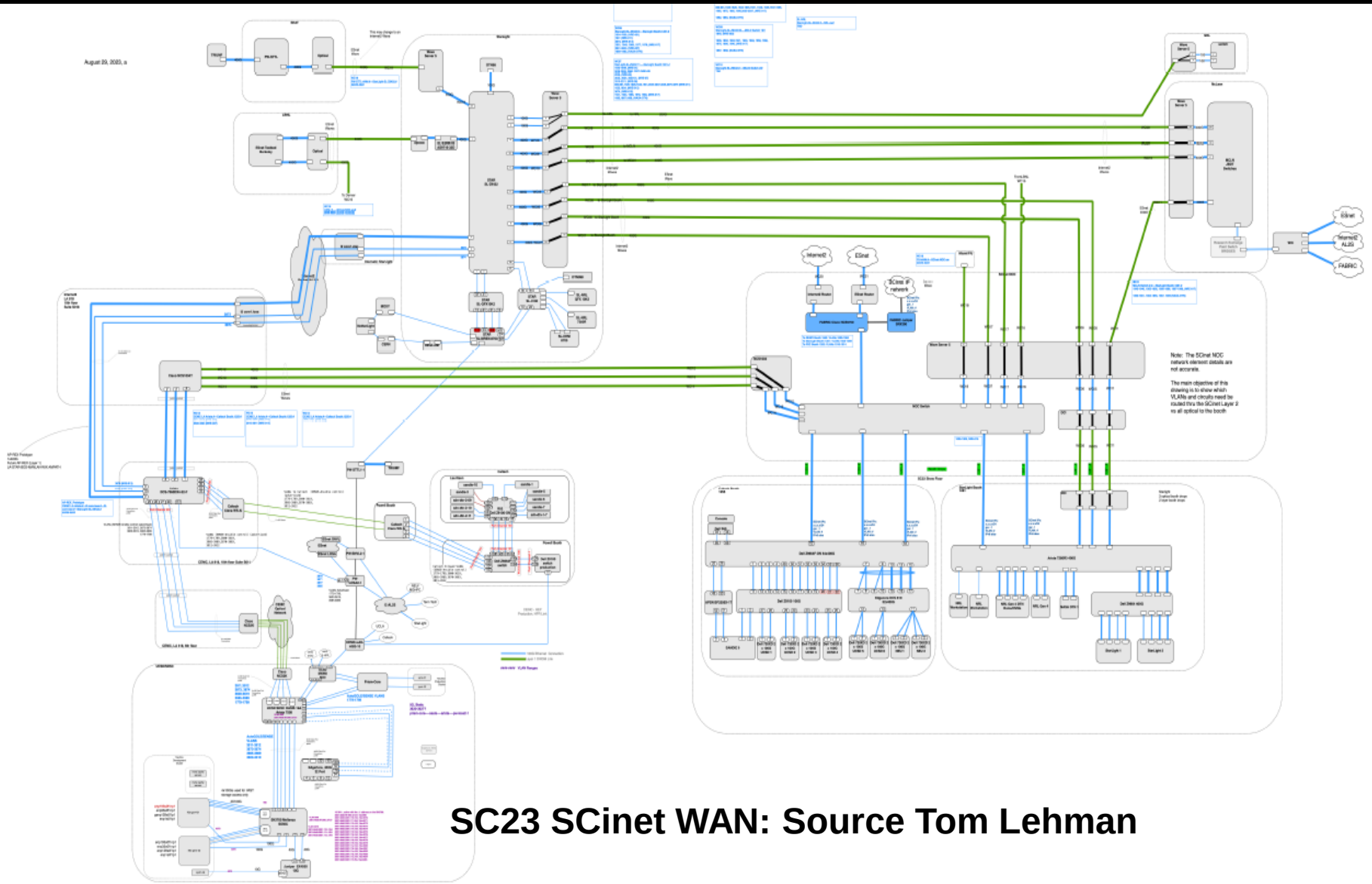
STARLIGHT SDX

Source: Jim Chen

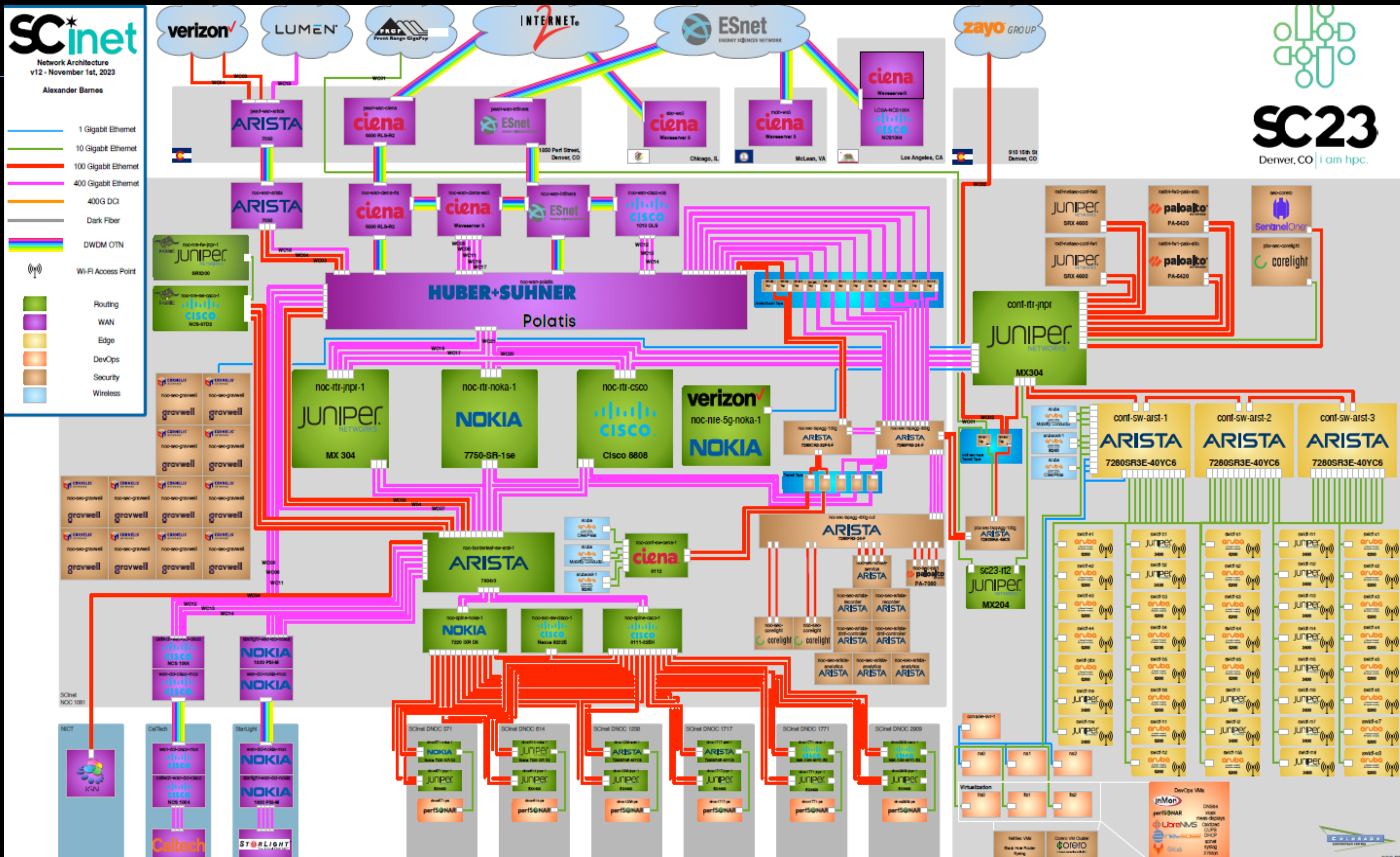
STARLIGHT SM

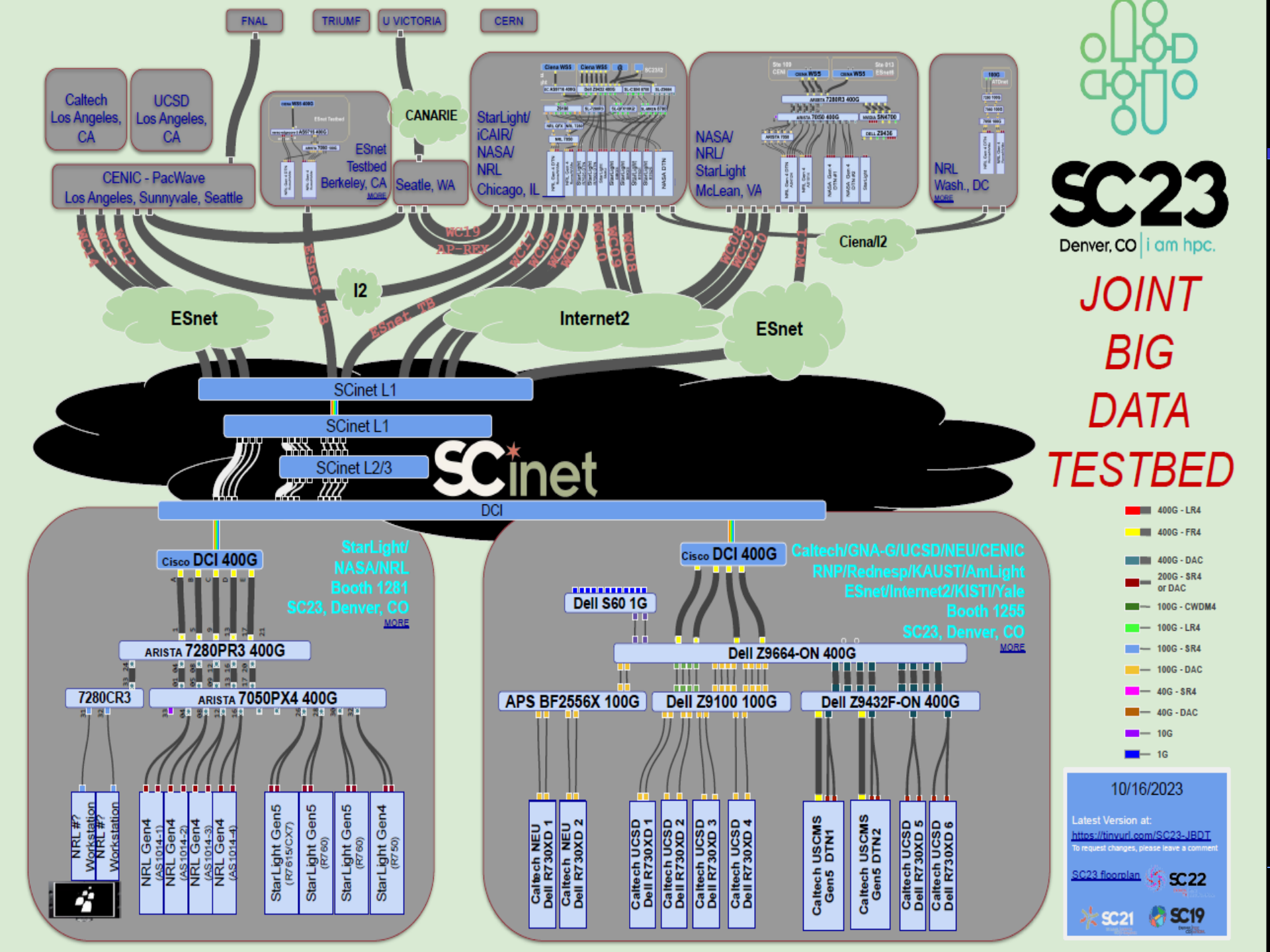
SCinet National WAN Testbed

- As In Previous Years, iCAIR Supports SCinet In Designing and Implementing a National WAN Testbed
- A Key Focus Is 400, 800, and 1.2 Tbps Path Services and Interconnections, Including Direct Connections To Edge Nodes, Primarily High Performance DTNs
- The SC23 National WAN Testbed Is Being Designed and Implemented To Support Demonstrations and Experiments Of Innovations Related To Data Intensive Science



SC23 SCinet WAN: Source Tom Lehman


SCinet
Network Architecture
v12 - November 1st, 2023
Alexander Barnes
1 Gigabit Ethernet
10 Gigabit Ethernet
100 Gigabit Ethernet
400 Gigabit Ethernet
400G DCI
Dark Fiber
DWDM OTN
Wi-Fi Access Point
Routing
WAN
Edge
DevOps
Security
Wireless
verizon
LUMEN
INTERNET2
ESnet
zayo GROUP
SC23
Denver, CO | i am hpc.
1850 Pearl Street, Denver, CO
Chicago, IL
McLean, VA
Los Angeles, CA
910 15th St Denver, CO
HUBER+SUHNER
Polatis
noc-rtr-jnpr-1
JUNIPER
MX 304
noc-rtr-noka-1
NOKIA
7750-SR-1se
noc-rtr-csco
CISCO
Cisco 8808
verizon
noc-nre-5g-noka-1
NOKIA
conf-rtr-jnpr
JUNIPER
MX304
conf-sw-arst-1
ARISTA
7280SR3E-40YC6
conf-sw-arst-2
ARISTA
7280SR3E-40YC6
conf-sw-arst-3
ARISTA
7280SR3E-40YC6
sc23-rtr2
JUNIPER
MX204
ARISTA
ciena
paloalto
corelight
SentinelOne
gravwell
NOKIA
CISCO
perfSONAR
Caltech
STARLIGHT



SC23
Denver, CO | i am hpc.

JOINT BIG DATA TESTBED

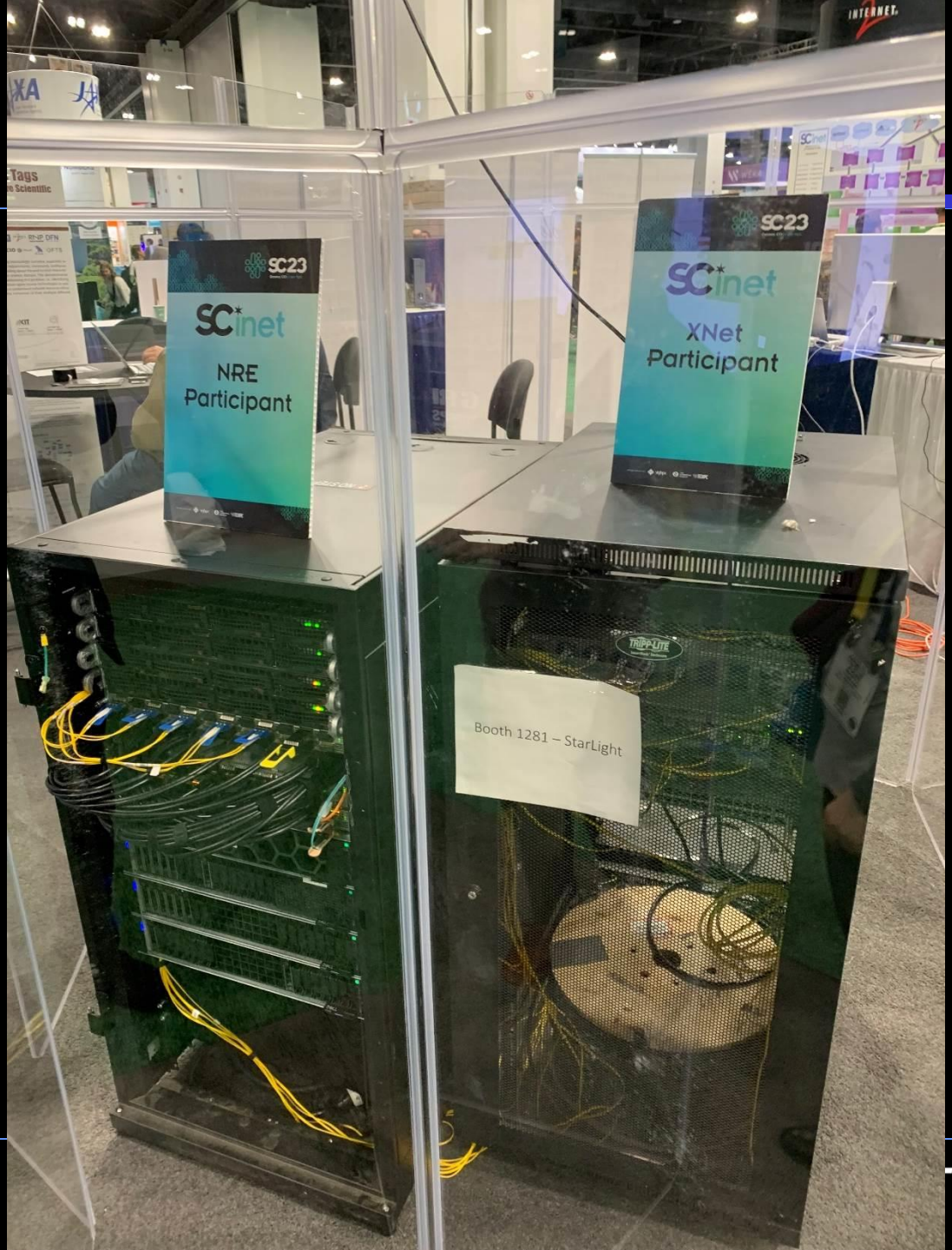
- 400G - LR4
- 400G - FR4
- 400G - DAC
- 200G - SR4 or DAC
- 100G - CWDM4
- 100G - LR4
- 100G - SR4
- 100G - DAC
- 40G - SR4
- 40G - DAC
- 10G
- 1G

10/16/2023

Latest Version at:
https://tinyurl.com/SC23-JBDT
To request changes, please leave a comment

SC23 floorplan
SC22
SC21
SC19

StarLight
SC23
Booth 1281



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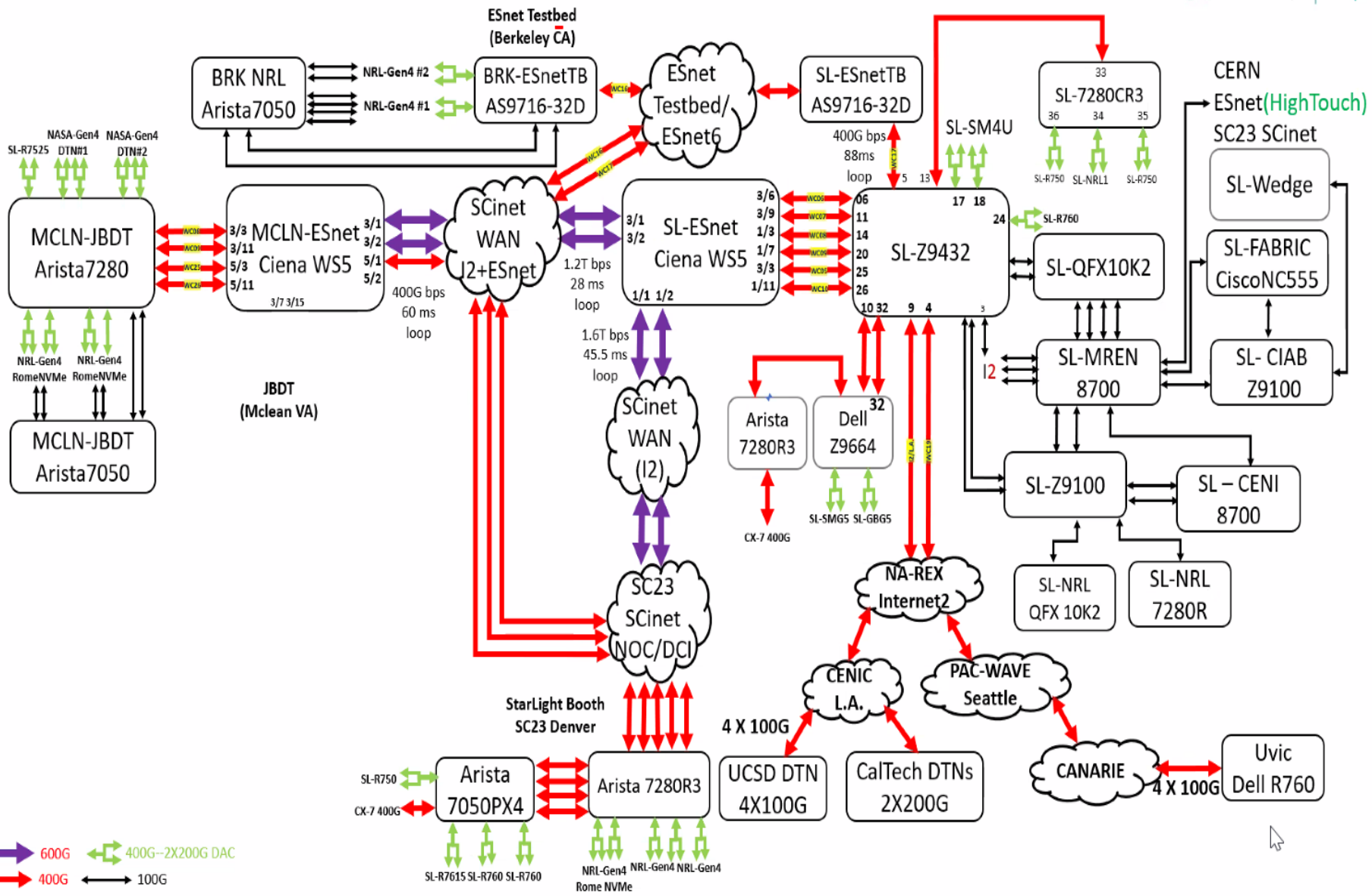
9 X 400G WAN Testbed by ESnet(ESnet Testbed)-I2(NA-REX)-CENIC-PAC-WAVE-CANARIE-SCinet-StarLight-JBDT 10/21/2023



Example SC23 SCinet Network Research Exhibitions

- Global Research Platform (GRP)
- SDX 1.2 Tbps WAN Services
- SDX E2E 400 Gbps 800 Gbps WAN Services
- 400 Gbps DTNs & Smart NICs
- Network Optimized Transport for Experimental Data (NOTED) – With AI/ML Driven WAN Network Orchestration
- Orchestration With Packet Marking (SciTags)
- ESnet High Touch 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
- P4 Integration With Kubernetes, P4 Global Lab
- High Perf Network Entropy Platform Using P4
- NASA Goddard Space Flight Center HP WAN Transport Services (400 G Dsk-Dsk)
- **Resilient Distributed Processing & Rapid Data Transfer**
- AutoGOLE/SENSE E2E Orchestration Net Services And Workflow Integration
- Open Science Grid Demonstrations
- N-DISE Named Data Networking for Data Intensive Science
- Chameleon FABRIC/FAB Integration
- SciStream Multi Site Data Streaming Orchestration
- Distributed Pipelines Over WANs For For On-Line Data Analysis
- DTNs for Research Enhanced Environments (ONION-RED ONION)

STARLIGHT℠