

SC21 Advanced Networking For Data Intensive Science Experiments and Demonstrations

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International/National Communications Exchange Facility

(www.startap.net/starlight),

PI IRNC: RXP: StarLight SDX, Co-PI Chameleon, PI-iGENI, PI-OMNINet

**IEEE/ACM International Conference
On High Performance Computing
Networking, Storage and Analytics
November 14-19, 2021
St. Louis, Mo**



Next Generation Distributed Environment For Global Science



Selected Applications



GENI
www.geni.net



Open Storage Network
www.openstorage.network.org



OSIRIS
www.osris.org



XSEDE
www.xsede.org



Blue Waters
bluewaters.ncsa.illinois.edu



PRAGMA
www.pragma-grid.net



CENTRA
www.globalcentra.org



OSG
www.openscience.grid.org



GRP
theglobalresearchplatform.net/



PRP
pacificresearchplatform.org



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



SAGE2
sage2.sagecommons.org



Polar Geospatial Center
www.pgc.umn.edu



IceCube
icecube.wisc.edu



Chameleon
www.chameleoncloud.org



Jetstream
www.jetstream-cloud.org



Genomic Science Program
genomicscience.energy.gov



LSST
www.lsst.org



Pierre Auger Observatory
www.auger.org



Belle II
www.belle2.org



LBNF/DUNE/ProtoDUNE
lbnf.fnal.gov



ISS
www.nasa.gov/station



SKA
www.skatelescope.org



XENON
xenon.astro.columbia.edu



NOVA
novaexperiment.fnal.gov



Virgo
www.virgo-gw.eu



LIGO
www.ligo.caltech.edu



SDSS
www.sdss.org



ALMA
www.almaobservatory.org



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



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



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



IVOA
www.ivoa.net

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

STARLIGHTSM

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 (60+ Paths)
StarWave
100 G Exchange
World's Most Advanced Exchange
Multiple First of a Kind
Services and Capabilities

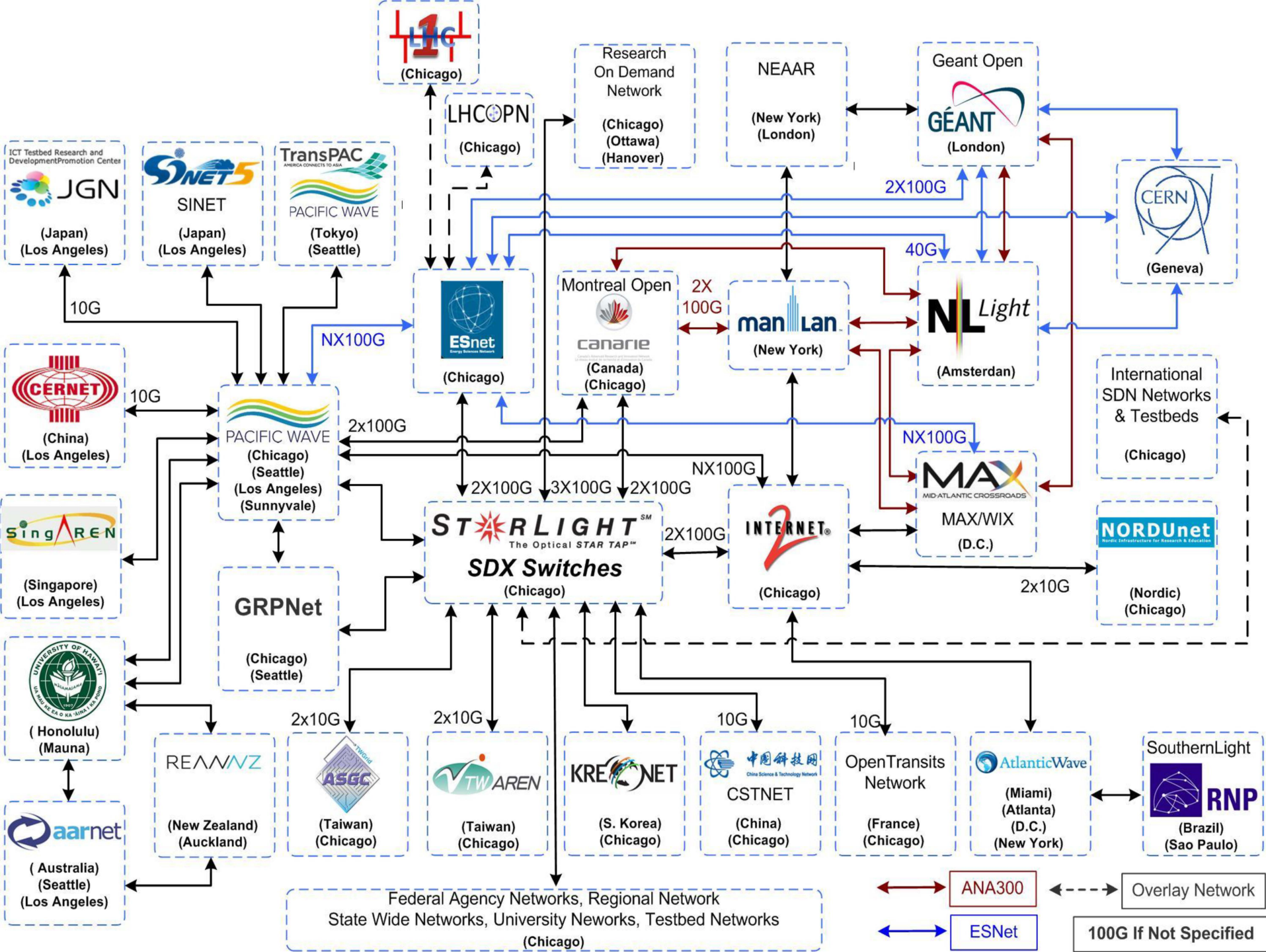


View from StarLight



Abbott Hall, Northwestern University's Chicago Campus



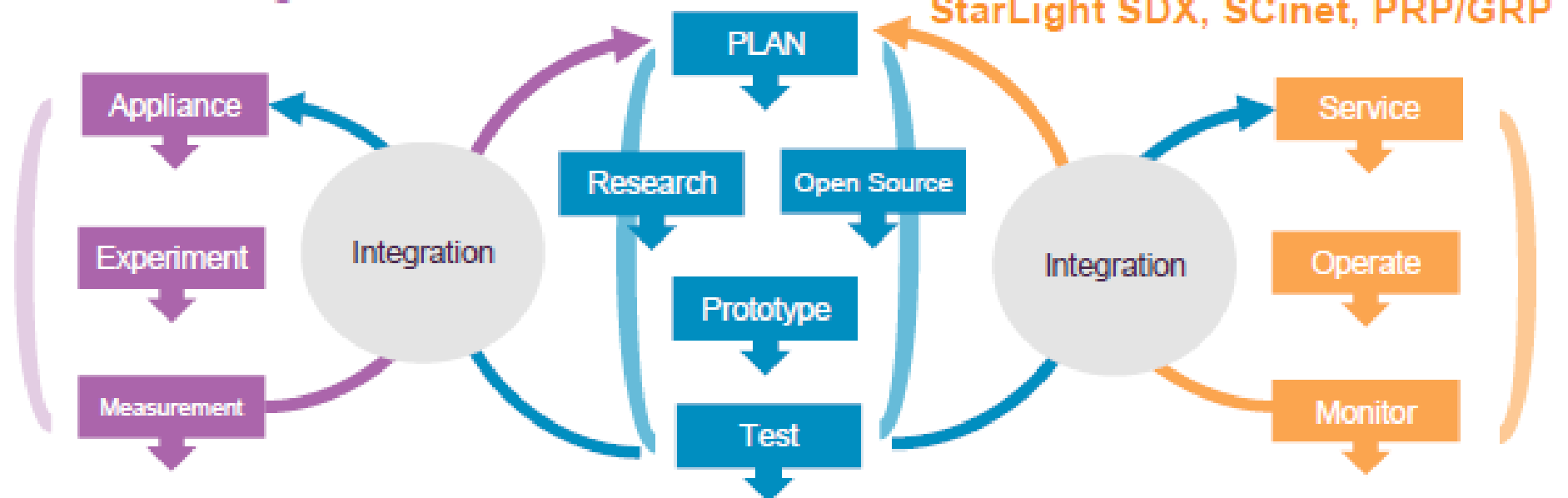


StarLight Software Defined Exchange

StarLight Software Defined Exchange (SDX) CD/CI/CD Innovation Workflow

StarLight Testbeds

StarLight SDX, SCinet, PRP/GRP



Chameleon Large Flow Appliance

DTNaaS for SDX, SCinet, PRP/GRP,
SCAsia DMC21

iCAIR

STARLIGHTSMSDX

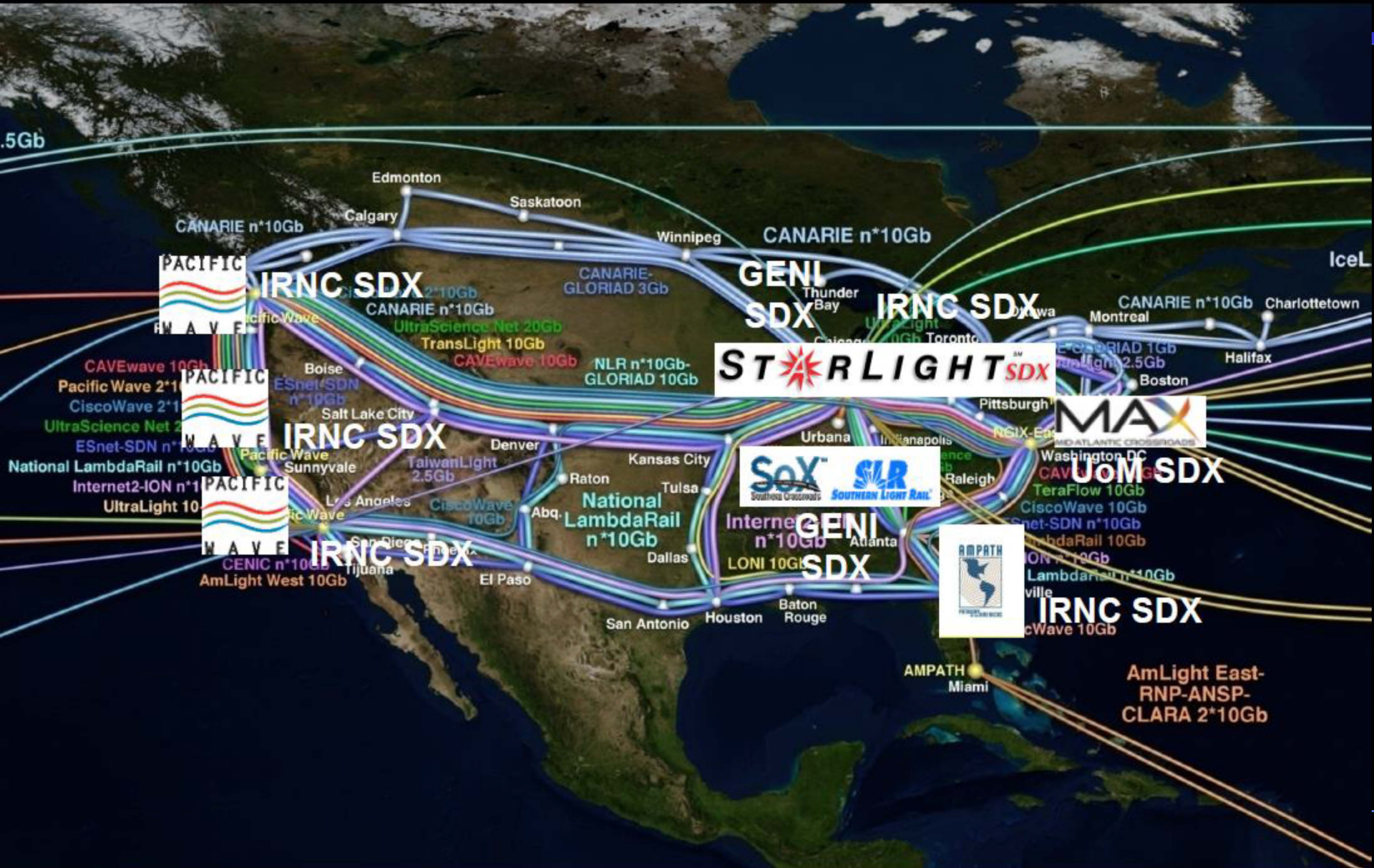
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International Federated Testbeds As Instruments for Computer Science/Network Science

- **The StarLight Communications Exchange Facility Supports ~ 25-30 Network Research Testbeds (Instruments For Computer Science/Networking Research)**
- **Software Defined Networking Techniques Are Used To Segment (“Slice”) Distributed Virtual Environments**
- **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**



Emerging US SDX Interoperable Fabric



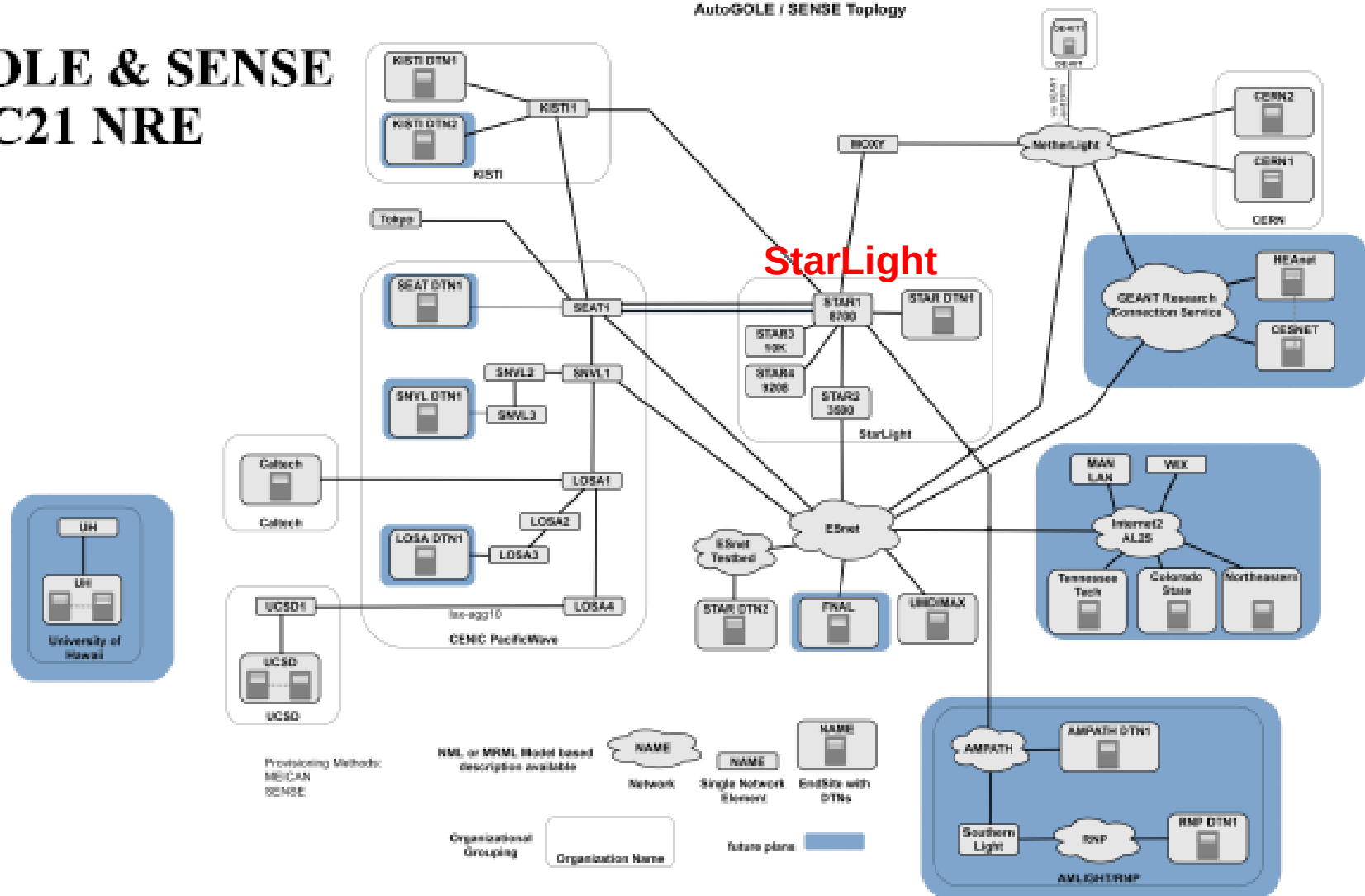
"The global advancement of science by realizing a multiresource infrastructure through international collaboration."



AutoGOLE Open R&E Exchanges

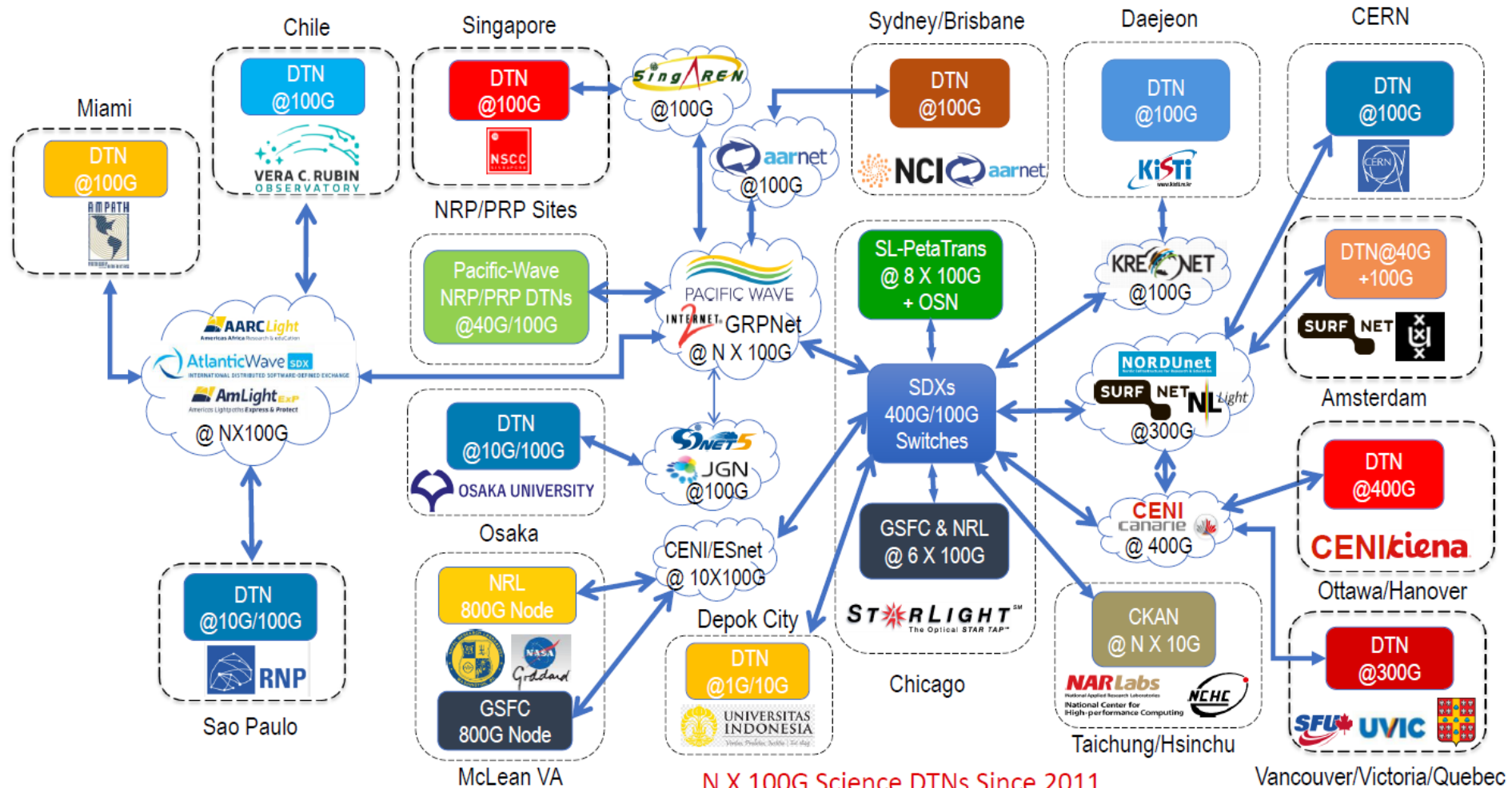
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AutoGOLE / SENSE Toplogy

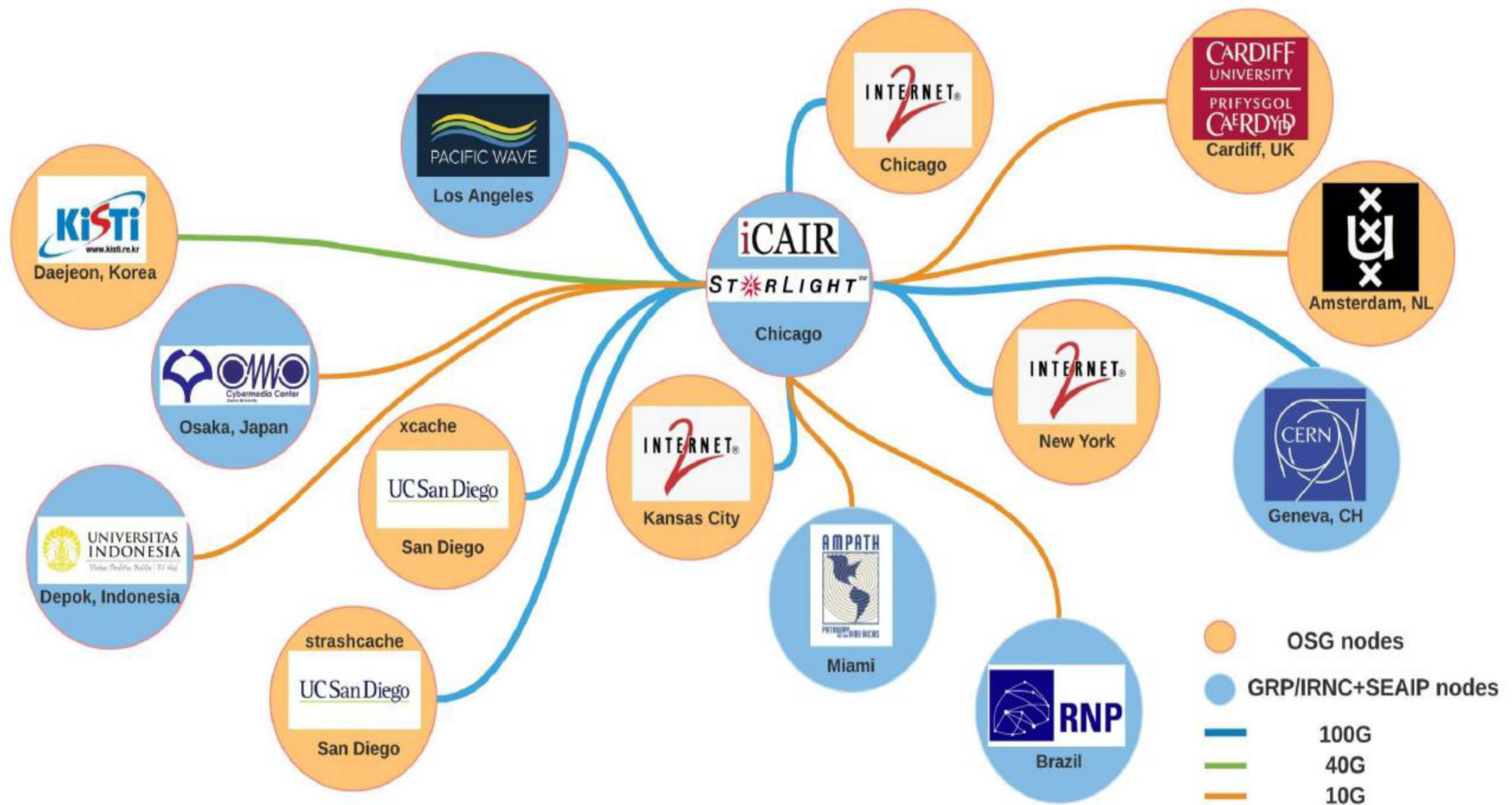


Persistent Communication Services For Petascale Sciences: Demonstration At SC21, St Louis, Mo

GRP Service: DTNaaS for Petascale Sciences Data Movement (Nov 2021)



OSG XCache Federation with IRNC/GRP DTNaaS Prototype



PRP/TNRP,MREN and AutoGOLE Research Platform

Nautilus Mesh Dashboard

Nautilus Mesh - Latency - Loss



No problems found in grid

My perfSONAR Dashboard

Dashboards Reports Settings

MREN Mesh Dashboard

MREN Mesh - Latency_v555 - Loss



Found a total of 2 problems involving 2 hosts in the grid



MREN Mesh - throughput_v555 - Throughput



Found a total of 4 problems involving 3 hosts in the grid



My perfSONAR Dashboard

Dashboards Reports Settings

Opennsa Mesh Dashboard

Opennsa Mesh - Latency_opennsa - Loss



Found a total of 9 problems involving 8 hosts in the grid

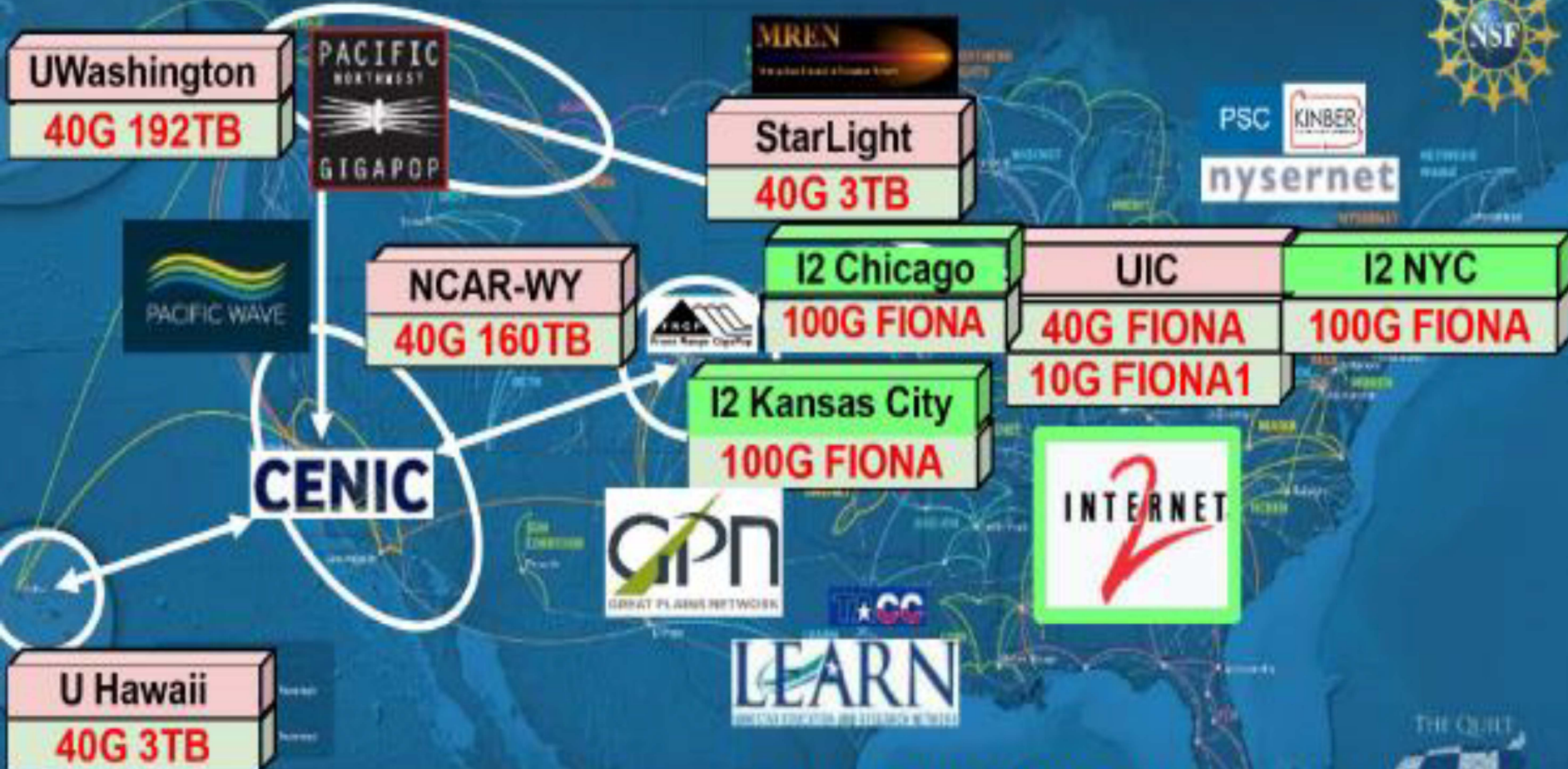


iCAIR

STARLIGHT_{SDX}

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REGIONAL RESEARCH AND EDUCATION NETWORKS IN THE UNITED STATES



QUIET MEMBERS AND AFFILIATES

↔ CENIC/PW Link

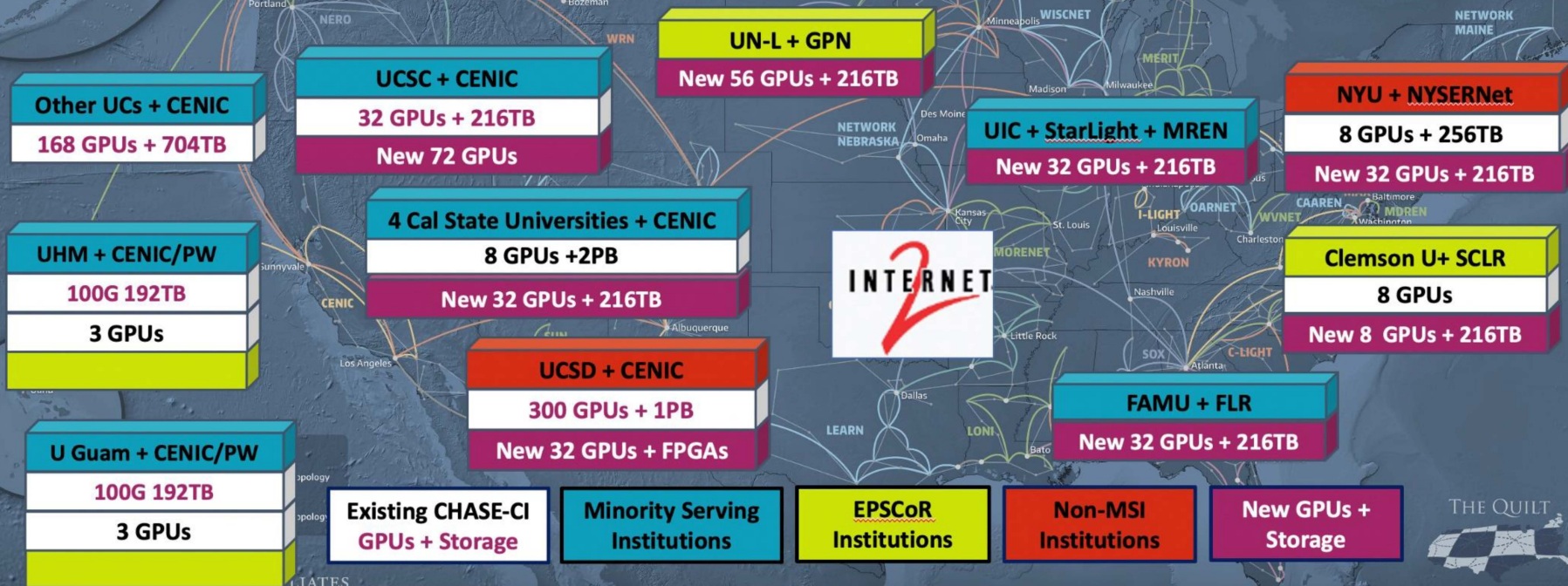
PRP/TNRP's **United States** Nautilus Hypercluster FIONAs



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REGIONAL RESEARCH AND EDUCATION NETWORKS IN THE UNITED STATES

Proposed Extension of Nautilus 2021-2024



SC21 SCinet National WAN Testbed

- As In Previous Years, iCAIR Supported SC21 SCinet To Create a National WAN Testbed
- A Key Focus Was 400, 800, and 1.2 Tbps Path Services and Interconnections, Including Direct Connections To Edge Nodes, Primarily High Performance DTNs
- The National WAN Testbed Was Designed and Implemented To Support Demonstrations and Experiments Of Innovations Related To Data Intensive Science



Example iCAIR Led/Supported SC21 SCinet Network Research Exhibitions

- **SC21-NRE-002- Network Optimized Transport for Experimental Data (NOTED) – AI/ML Driven WAN Network Orchestration**
- **SC21-NRE-004-Global Research Platform (GRP)**
- **SC21-NRE-005-IRNC SDX 1.2 Tbps WAN Services**
- **SC21-NRE-006-IRNC SDX E2E 400 Gbps WAN Services**
- **SC21-NRE-007-IRNC SDX International Testbed Integration**
- **SC21-NRE-008-StarLight SDX for Petascale Science**
- **SC21-NRE-009- DTN-as-a-Service**
- **SC21-NRE-010- P4 Integration With Kubernetes**
- **SC21-NRE-011-PetaTrans Services Based on NVMe-Over-Fabric**
- **SC21-NASA Goddard Space Flight Center Demonstrations**
- **SC21-NRL Demonstrations**
- **SC21-PRP/NRP Demosntrations**
- **SC21-Open Science Grid Demonstrations**
- **SC21-N-DISE Demonstrations**



Thanks To The SCinet WAN Group

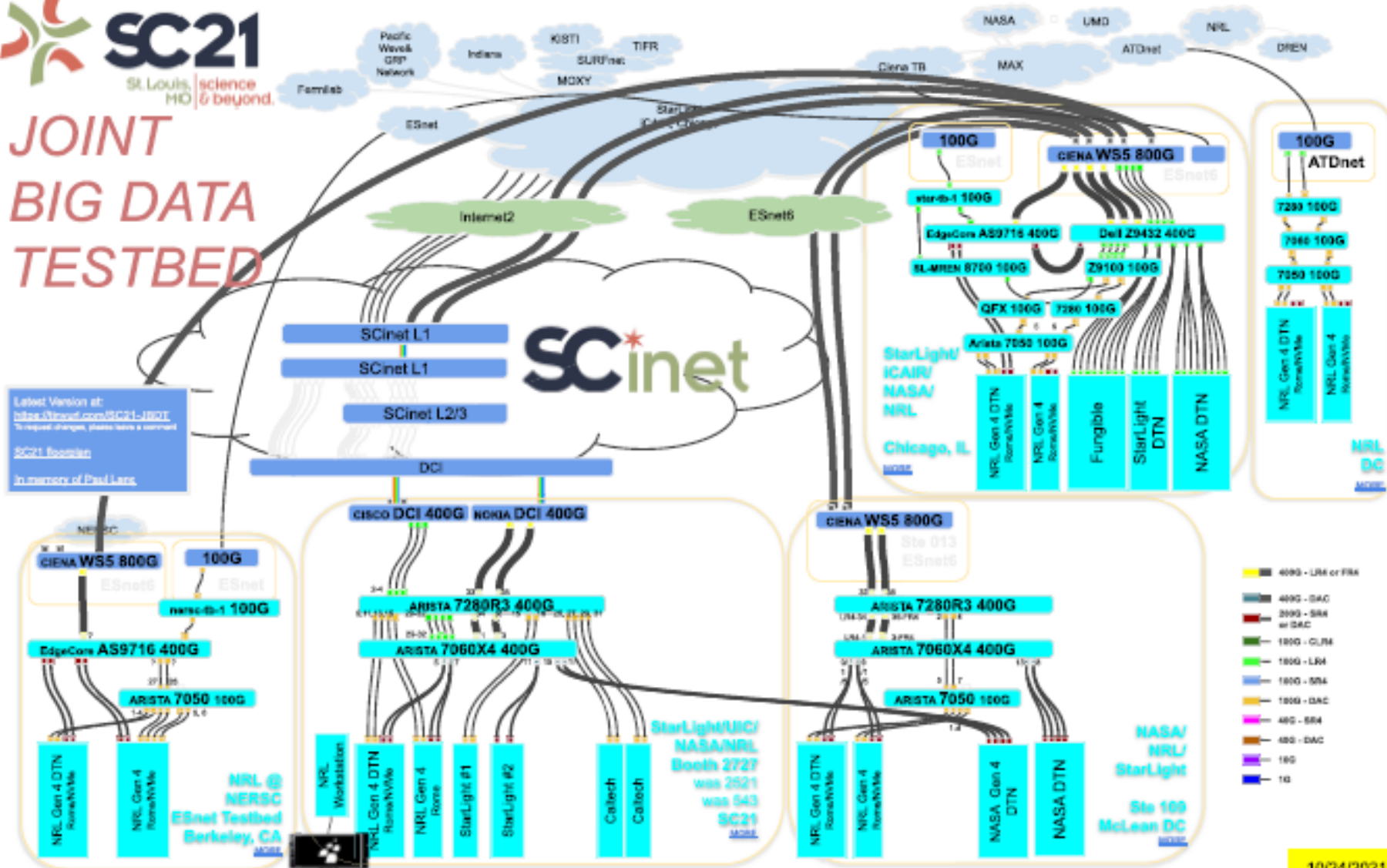
- Brenna Meade
- Kate Robinson
- Scott Kohlert
- Paul Love
- Hans Addleman
- Matt Zekauskas
- Et Al





JOINT BIG DATA TESTBED

Latest Version at:
<https://www.sc21-testbed.com/SC21-TESTBED>
To request changes, please leave a comment
SC21 Foundation
In memory of David Lane

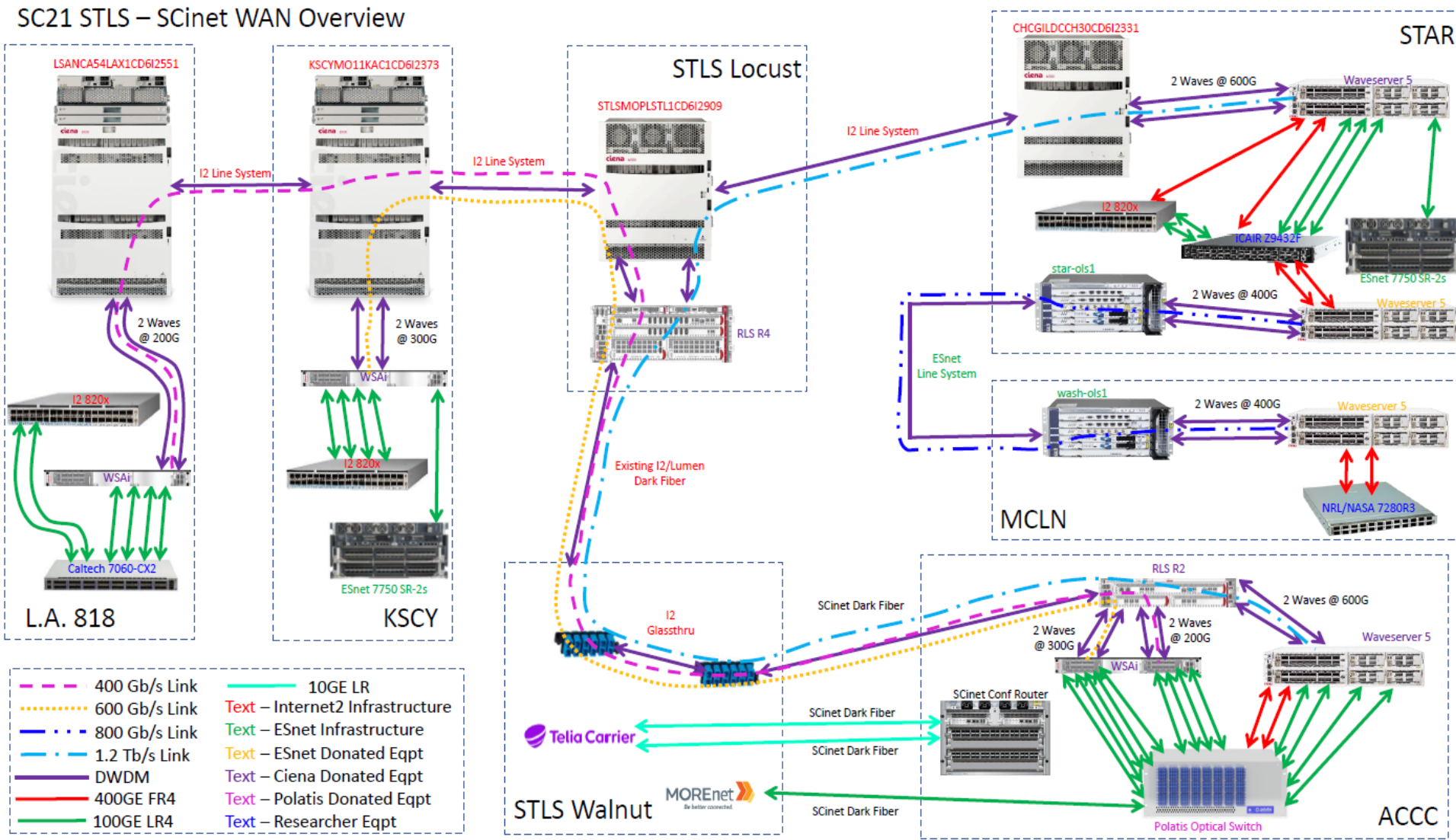


10/24/2021

Source: Linden Mercer

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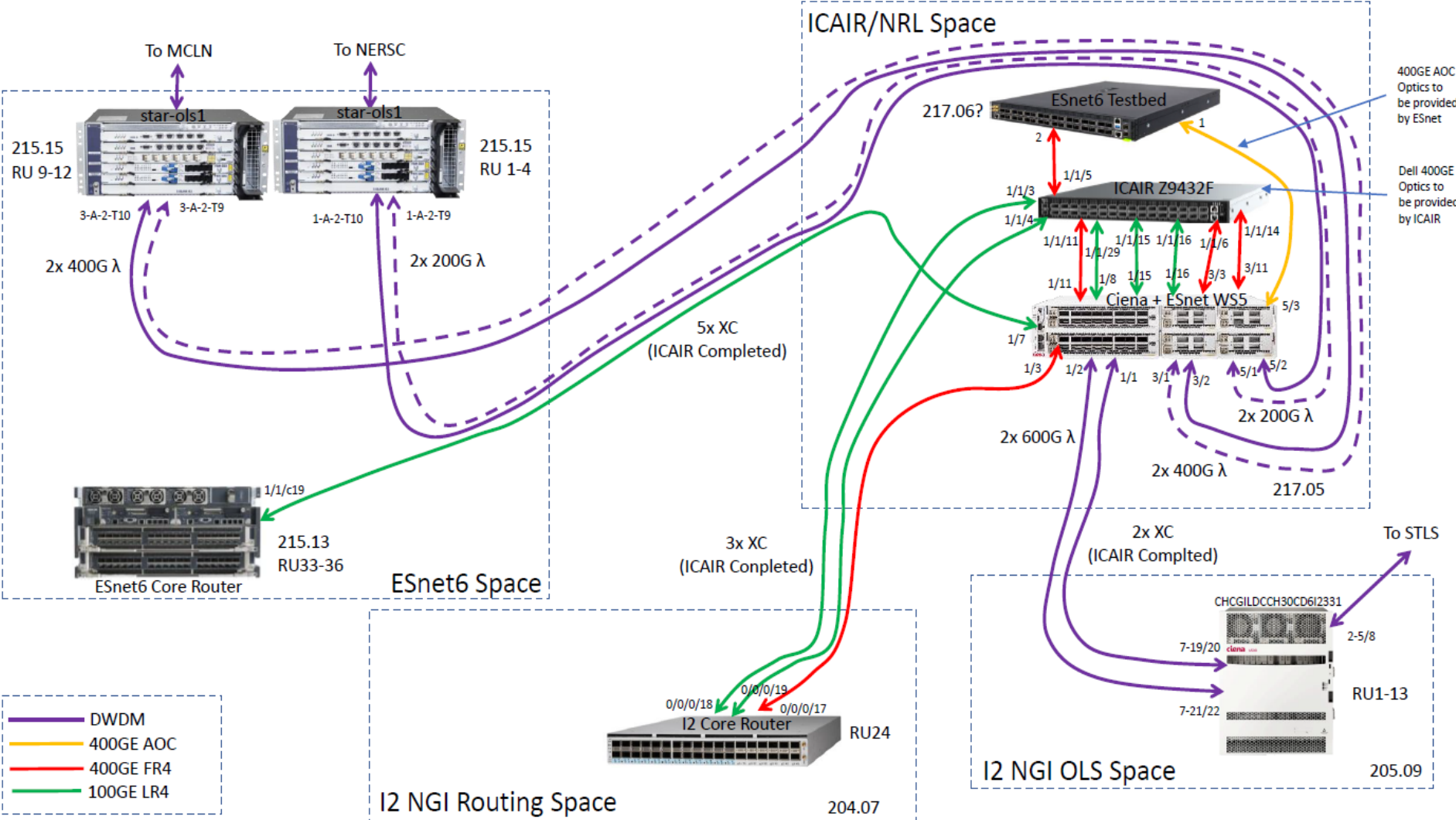
SC21 STLS – SCinet WAN Overview



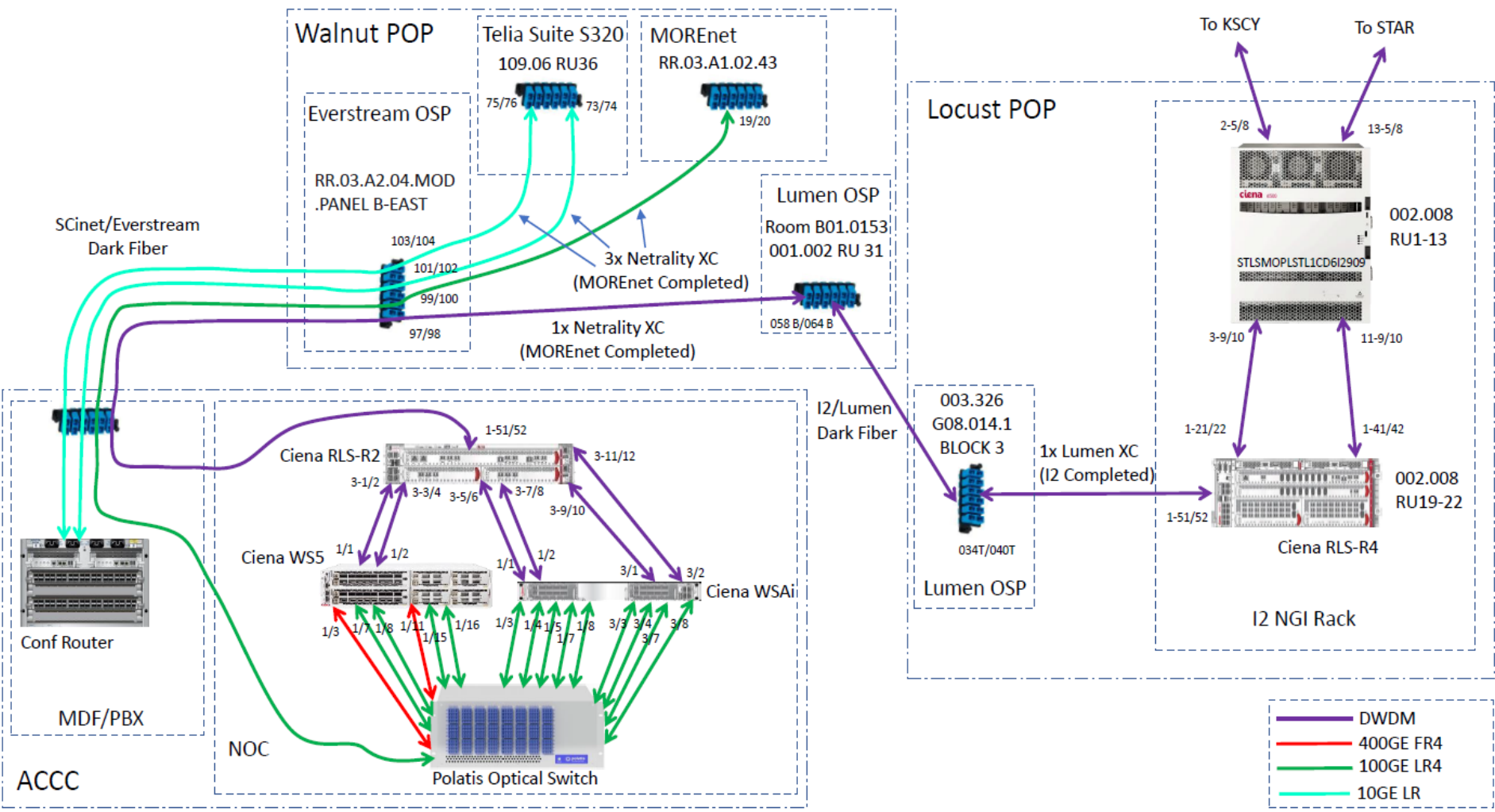
Source: Scott Kohlert

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STAR Cross-Connect Plan

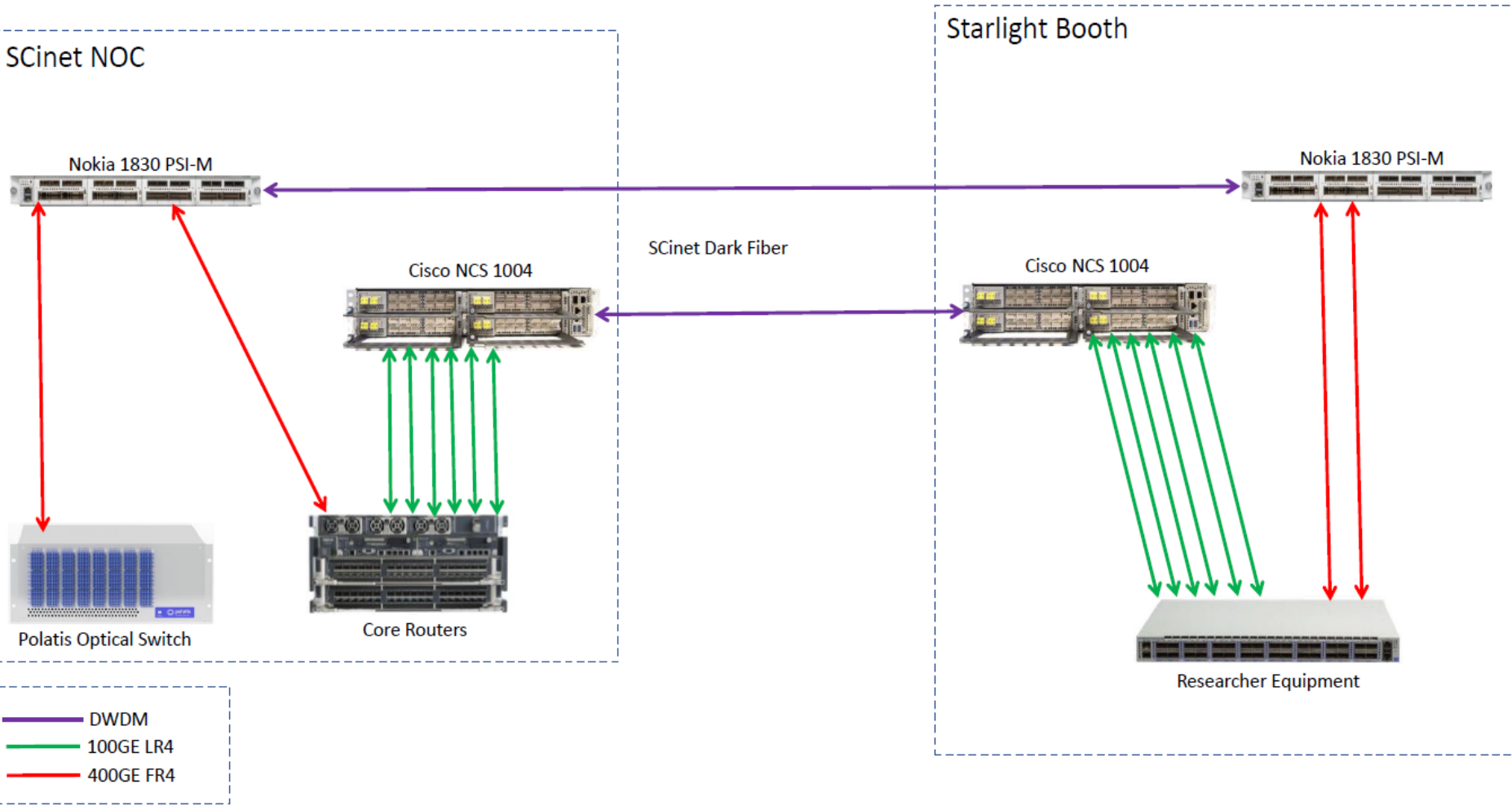


St. Louis Cross-Connect Plan

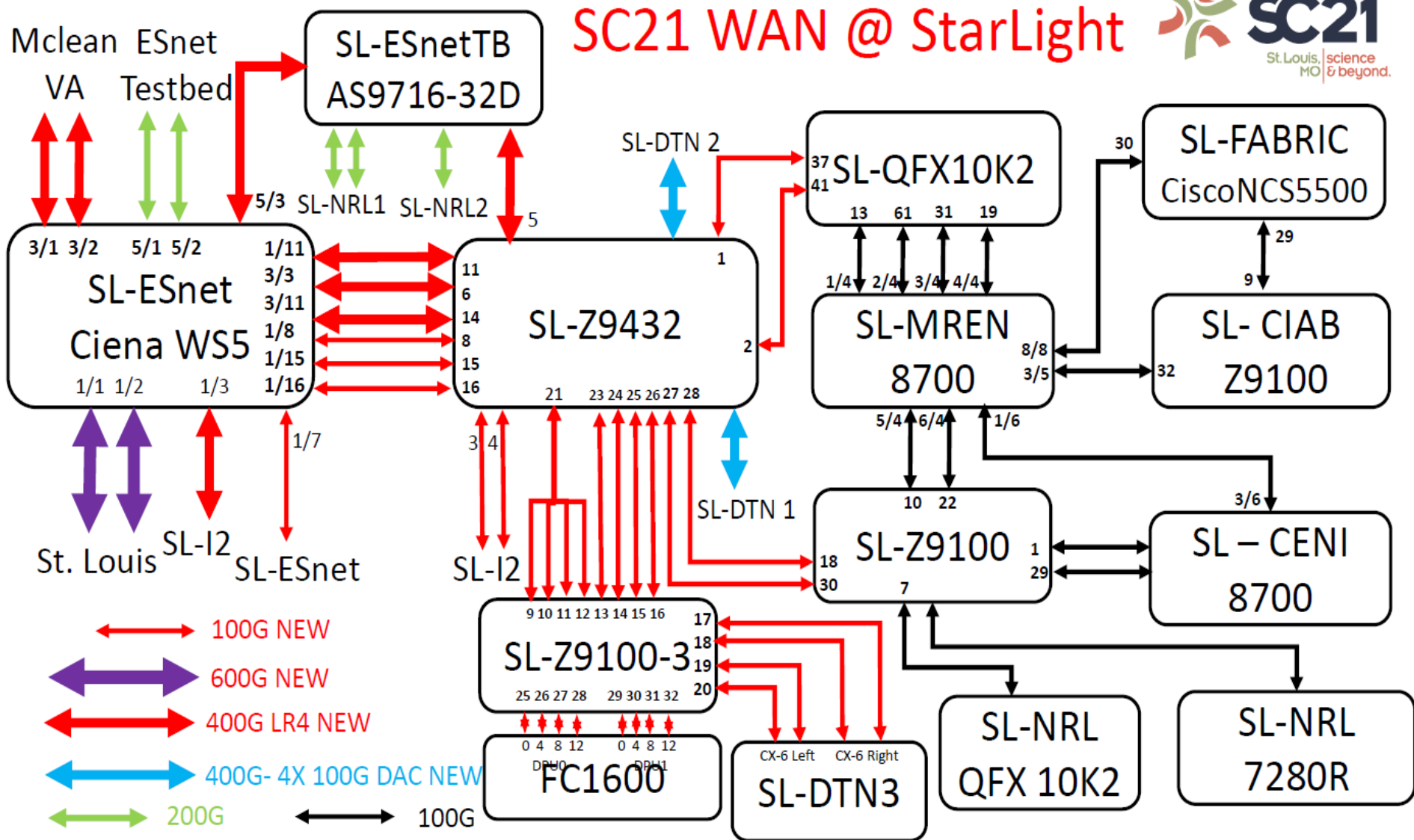


Source: Scott Kohlert

St. Louis Convention Center DCI Overview (Number of booth circuits approximated)

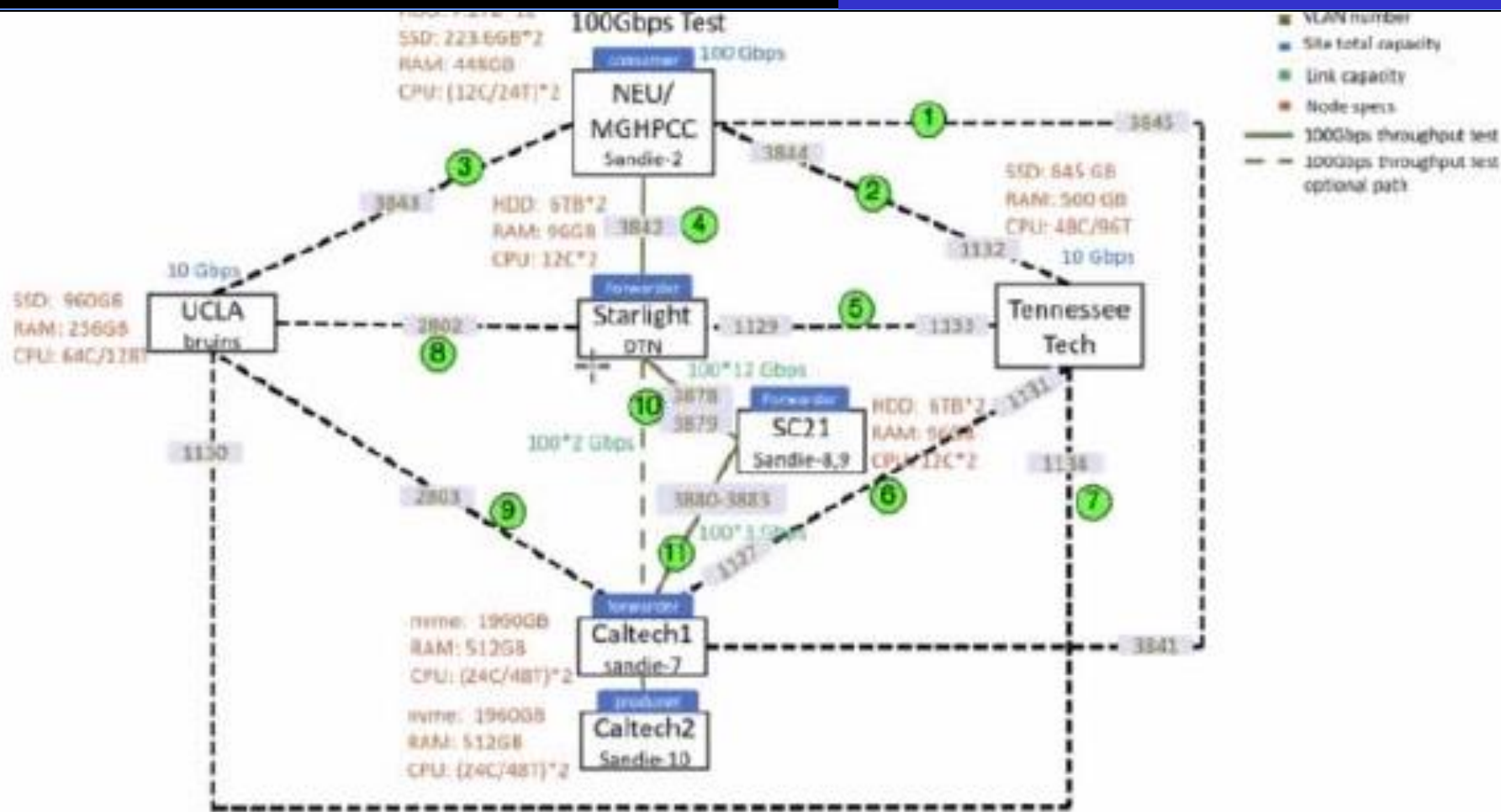


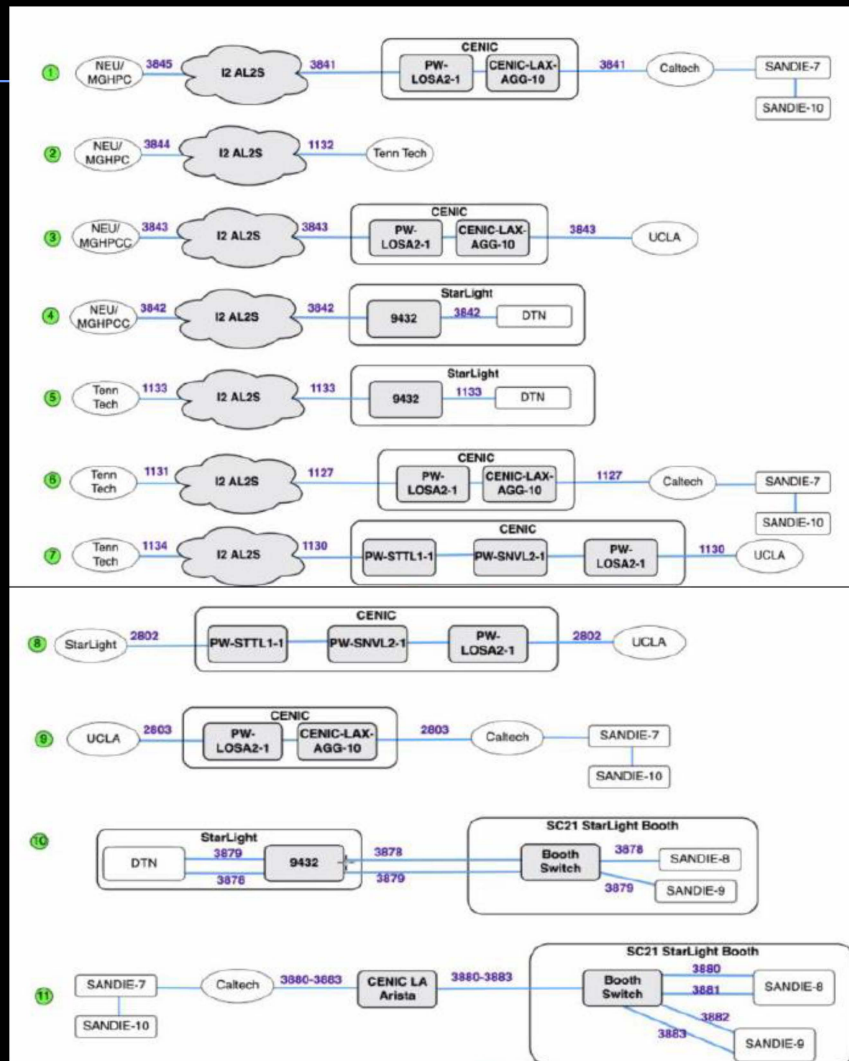
SC21 WAN @ StarLight



Source: Jim Chen

STARLIGHTSM





SC20

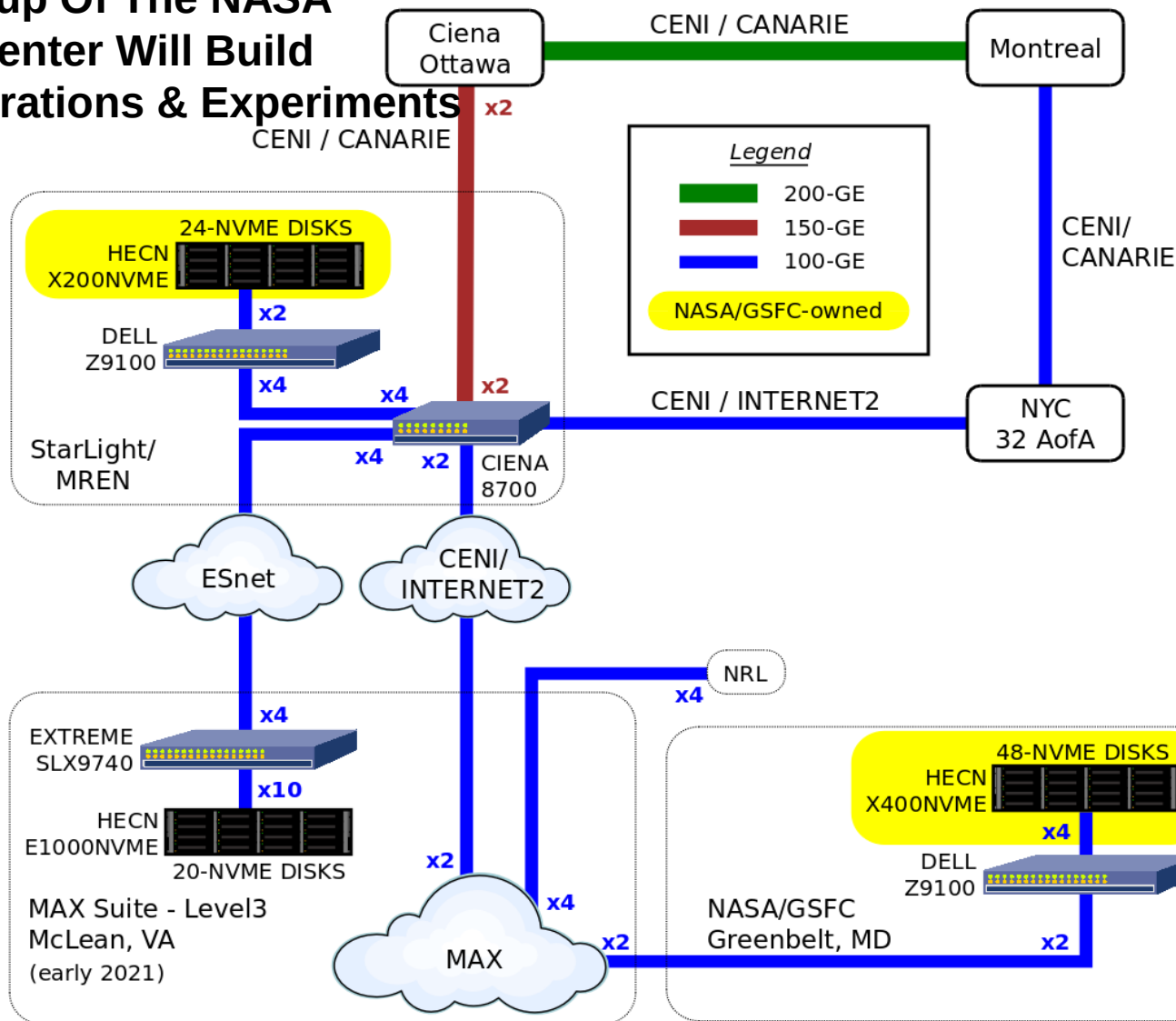
Virtual Conference
(originally planned
for Atlanta, GA)

Demonstrations of 400 Gbps Disk-to-Disk WAN File Transfers using NVMe-OF/TCP

An SC20 Collaborative Initiative Among NASA and Several Partners

At SC21, The HECN Group Of The NASA
Goddard Space Flight Center Will Build
On Their SC20 Demonstrations & Experiments

R&D Partners



NRL aims to demonstrate:

- Dynamic arrangement and re-arrangement of widely distributed processing of large volumes of data across a set of compute and network resources organized in response to resource availability and changing application demands
- Real-time video processing pipeline will be demonstrated from SC21 to compute and storage assets in Washington, DC; McLean, VA; Chicago, IL; and Berkeley, CA

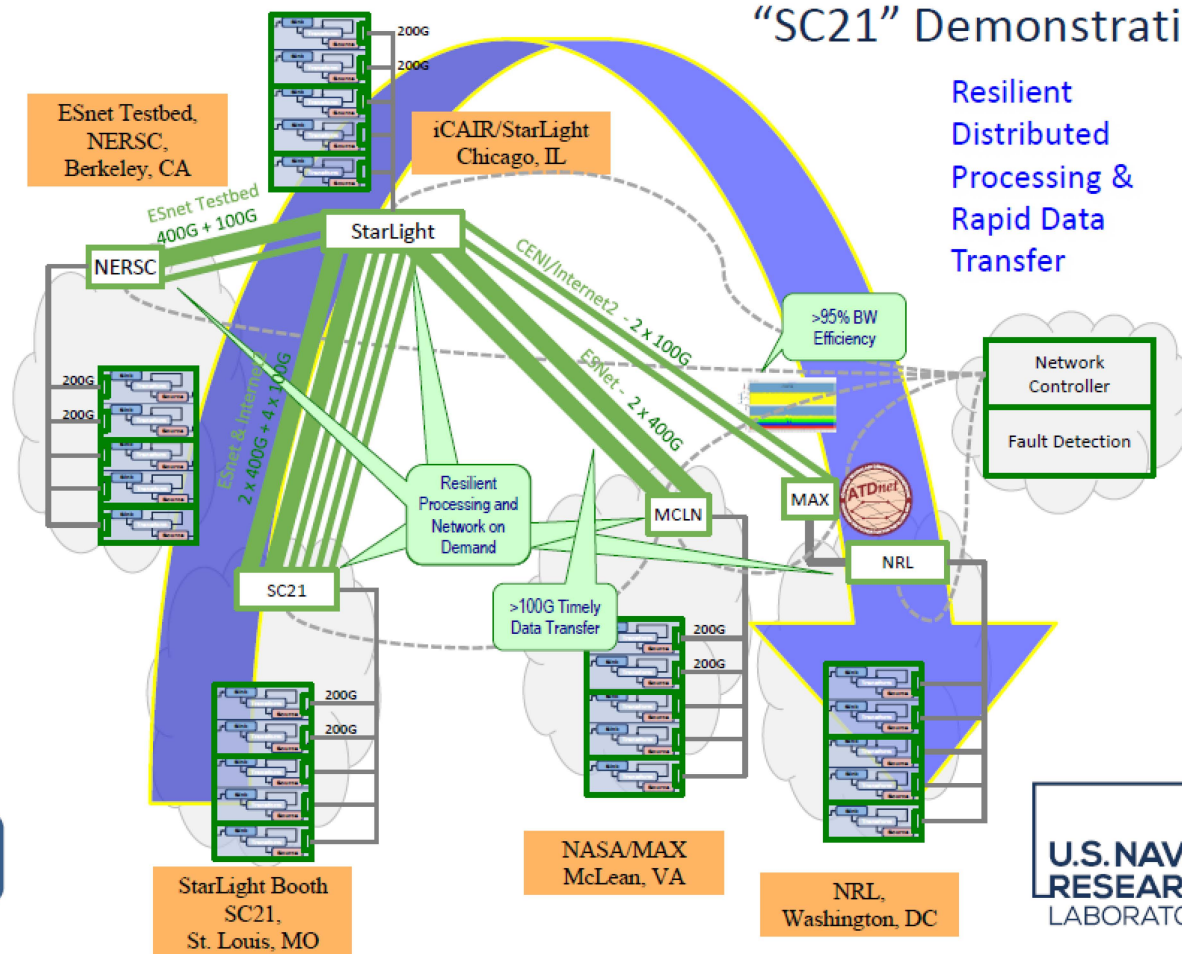
Specific goals:

1. Fast fault detection and location using an active probe.
2. Dynamic shifting of processing and network resources from one location/path/system to another (in response to demand and availability).
3. Leverage RDMA/distance performance for timely Terabyte bulk data transfers (goal < 1 min Tbyte transfer on 400G network).

"Interconnected and interlocking problems"
demand a high performance dynamic distributed data centric infrastructure

Naval Research Laboratory Center for Computational Science "SC21" Demonstration

Resilient
Distributed
Processing &
Rapid Data
Transfer



DTN-as-a-Service – Demonstrated At SC21

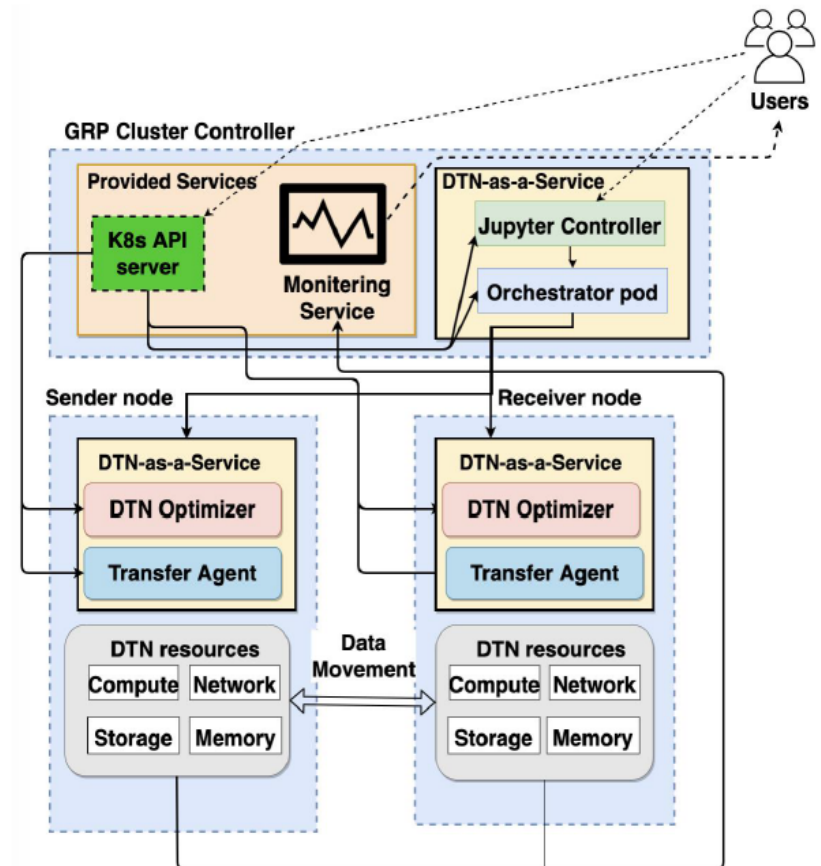
GRP Cluster with DTN-as-a-Service

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

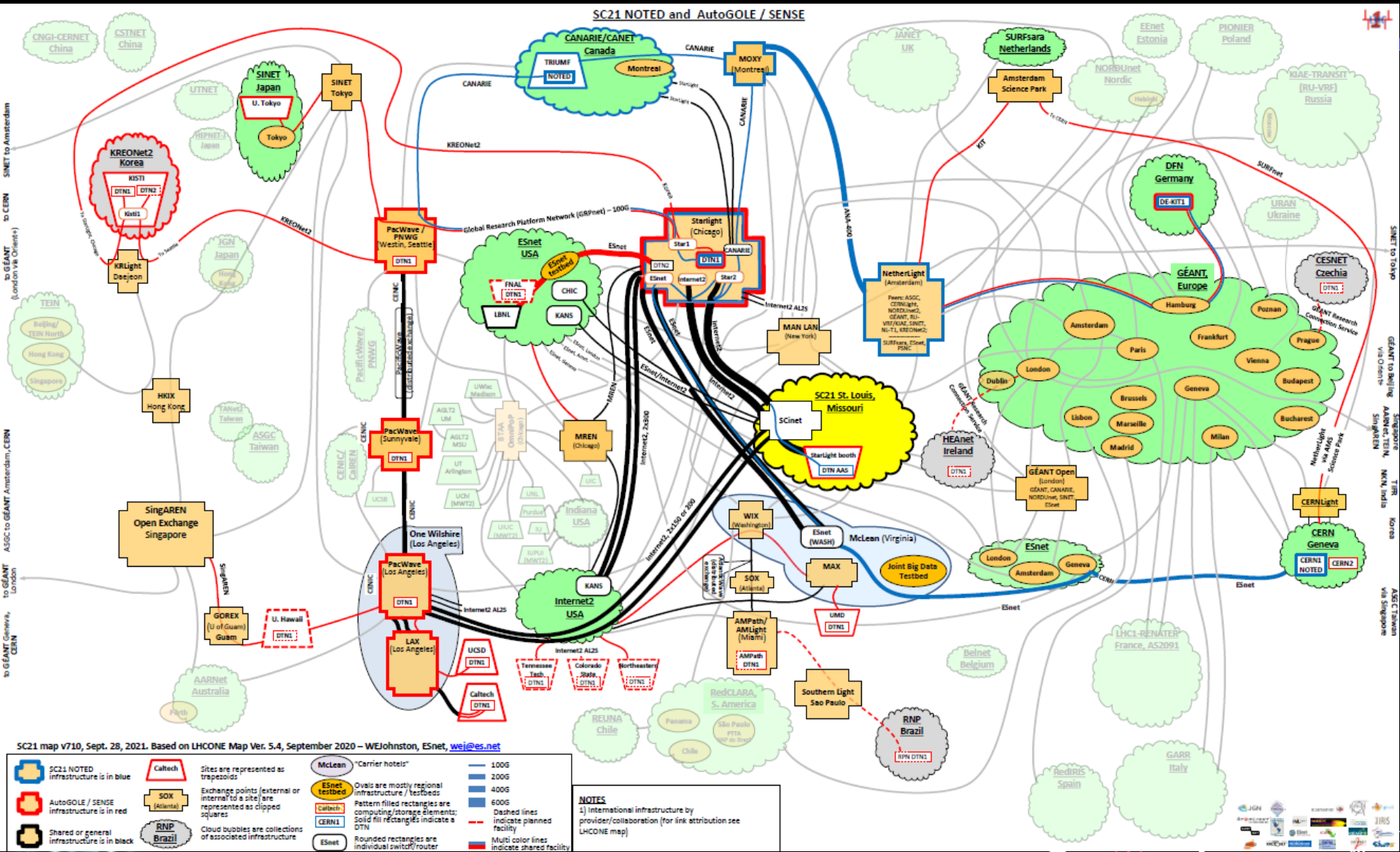
1. Deploy DTNaaS workloads via k8s API server
2. Use Jupyter to optimize and run transfers
3. Observe performance from monitoring service

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



Network Optimized For Transport Of Experimental Data (NOTED)



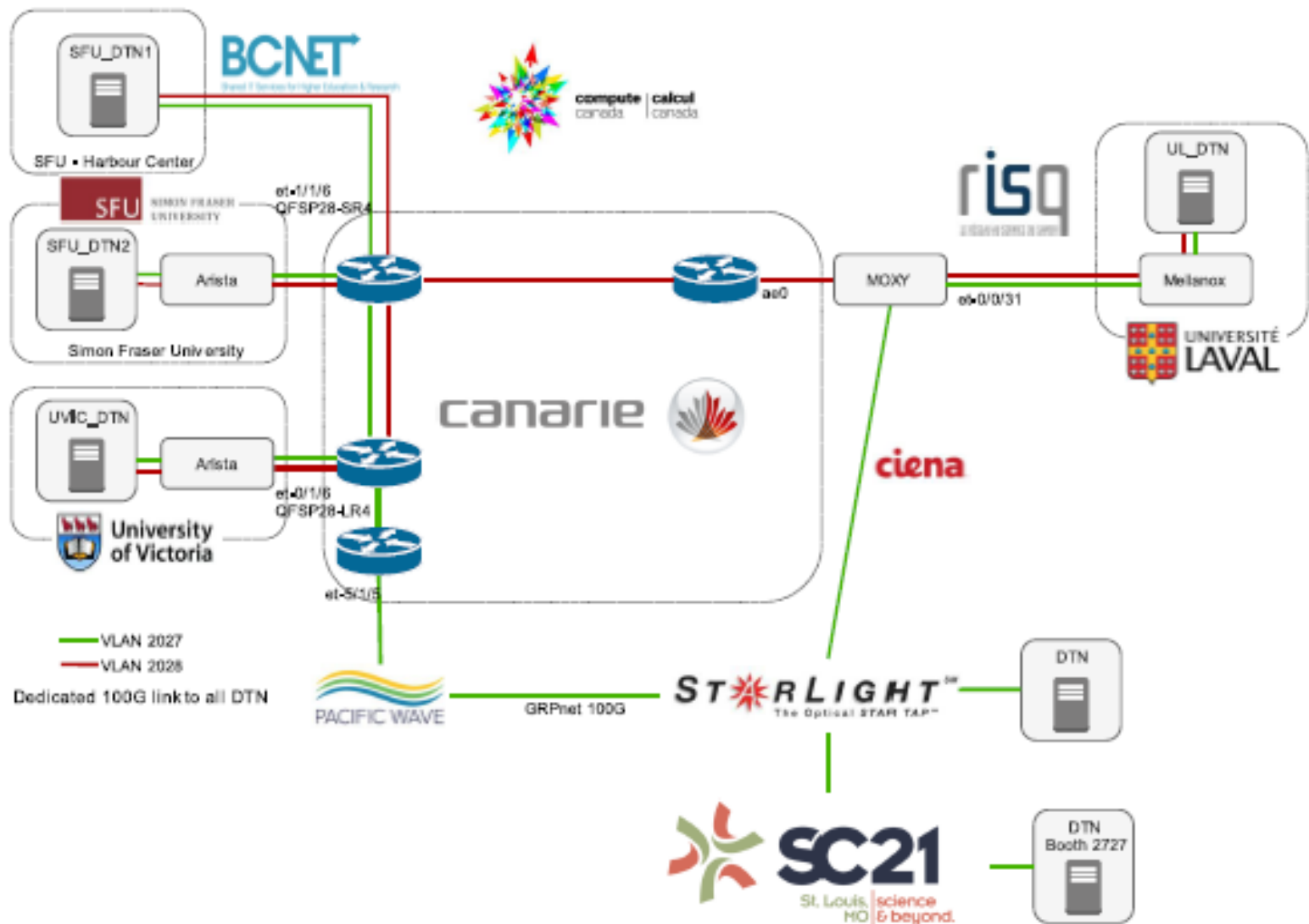
AI/ML Based Steering of LHC Data Flows

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Compute Canada Demonstrations Of Data Intensive Science WAN Transport

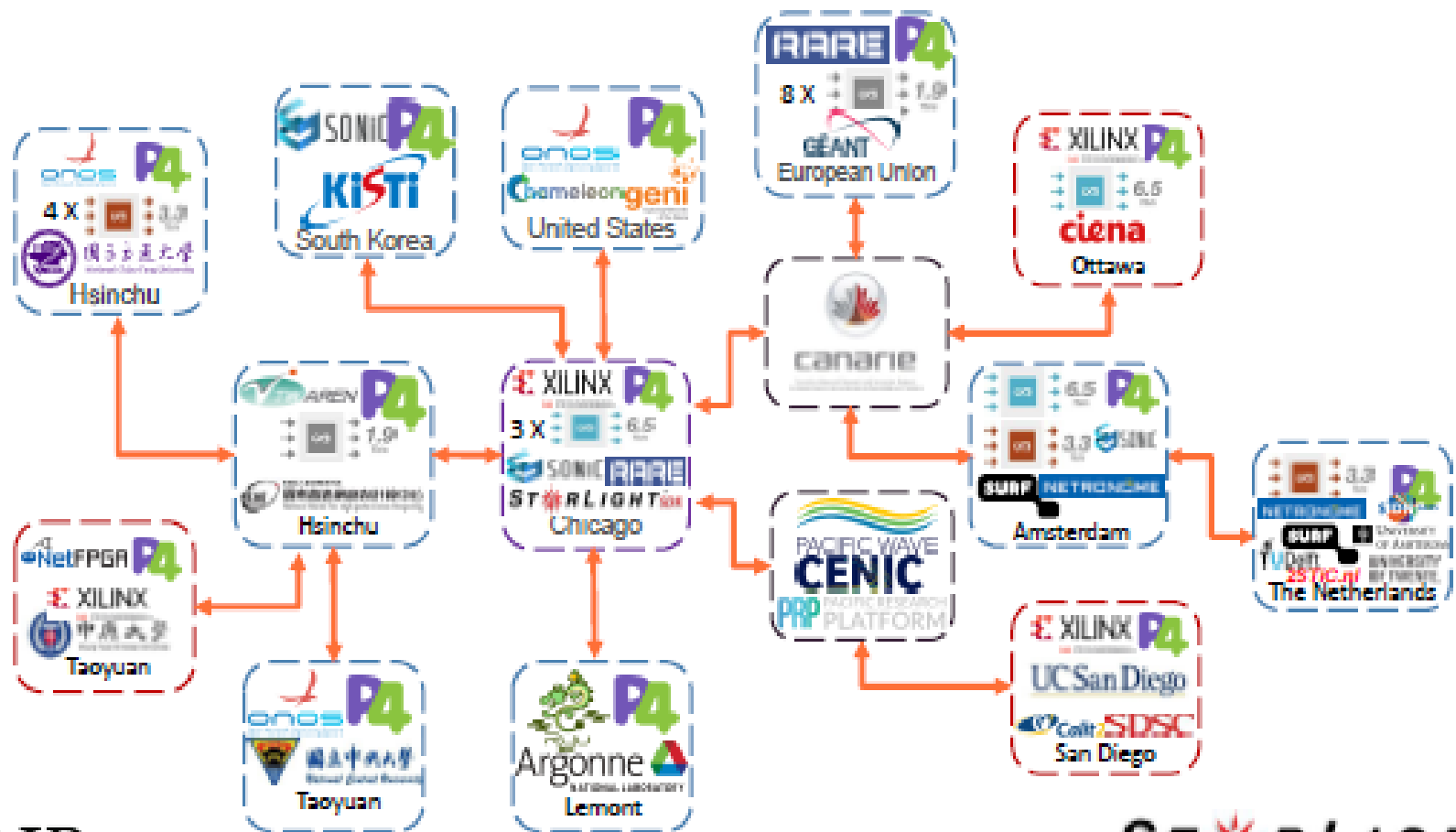


Compute Canada Demonstrations Of Data Intensive Science WAN Transport

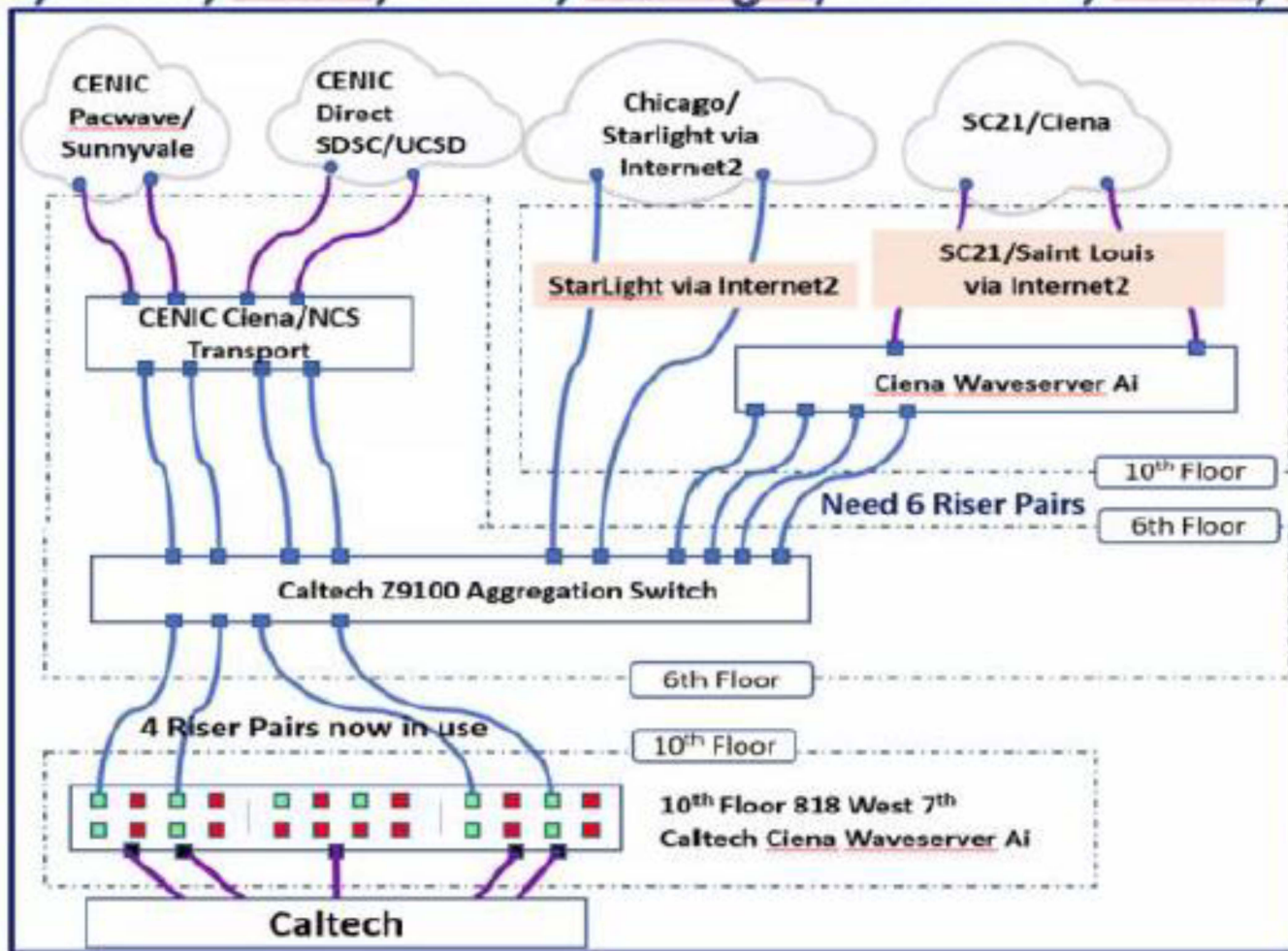


International P4 Testbed Showcase at SC21

GRP Service: International P4 Experimental Networks (iP4EN)

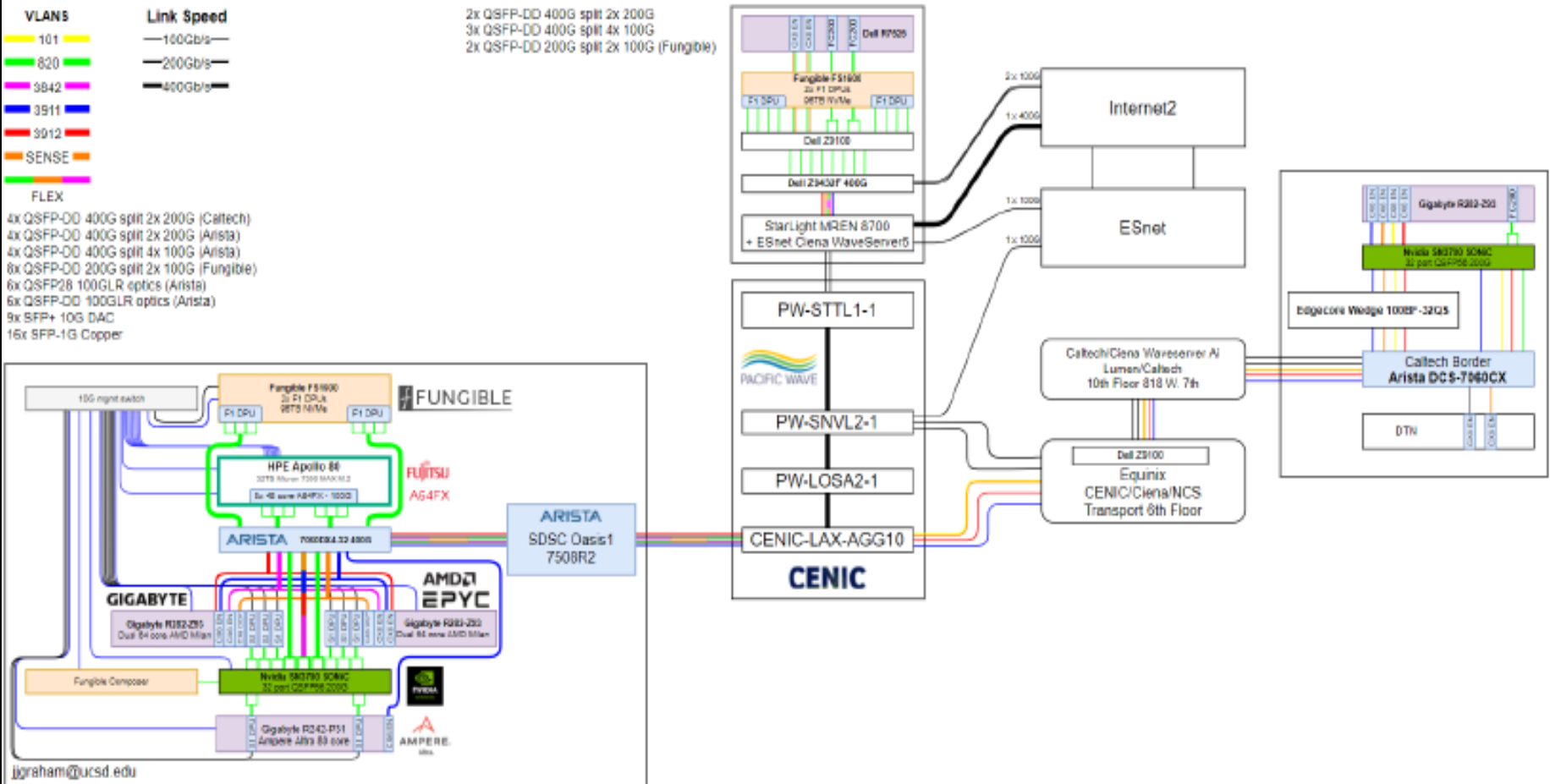


SC21: Next Step Advanced Network Infrastructures: Caltech, UCSD, Ciena, CENIC, StarLight, Internet2, ESnet, SCInet



Open Science Grid SD Distributed Storage

OSG Distributed Software Defined Storage Over 1.2 Tbps WAN With NVMe/TCP Storage Cluster and DPUs



Source: John Graham

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SAGE3

SAGE3: Smart Amplified Group Environment A Framework for Data-Intensive Visual Analytics and Collaboration



SAGE3 provides scientists with an intuitive framework that integrates Artificial Intelligence (AI) technologies with applications, workflows, smart visualizations and collaboration services to help scientists access, share, explore and analyze data – on a variety of displays, from laptop screens to large tiled display walls – and come to conclusions and make decisions with greater speed, accuracy, comprehensiveness and confidence.

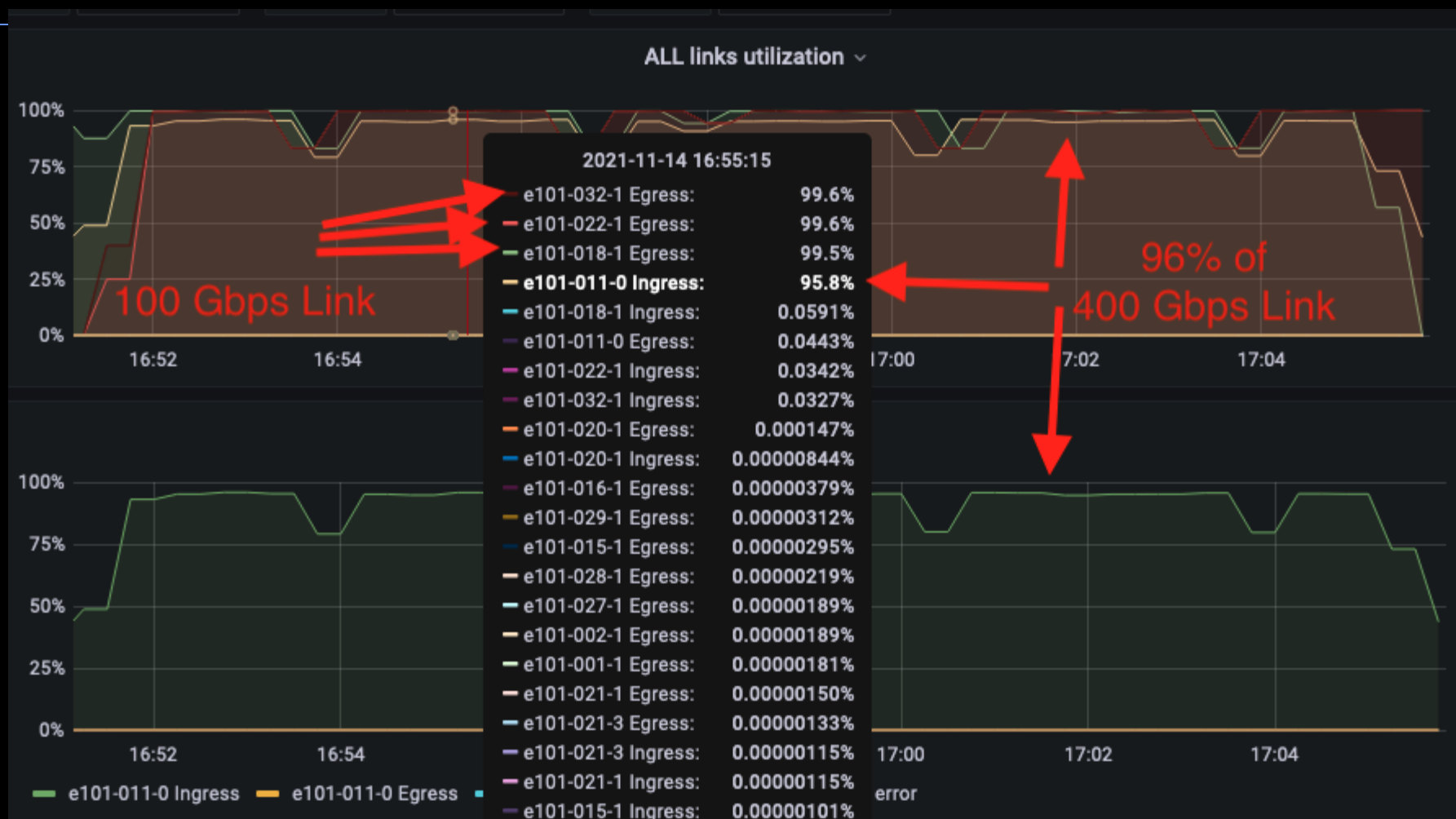
University of Hawai'i at Mānoa (UHM), Lab for Advanced Visualization & Applications
University of Illinois at Chicago (UIC), Electronic Visualization Laboratory
Virginia Tech (VT), Sanghani Center for AI and Data Analytics



NSF awards ACI-2004014 (UHM),
ACI-2003800 (UIC),
ACI-2003387 (VT)



Initial Data Flows SC21



Chameleon & FABRIC @ SC21

- Currently, Two NSF Testbeds Are Investigating Methods For Optimizing Cross Platform Research: Chameleon, A Large-Scale, Deeply Reconfigurable Experimental Platform for Computer Sciences Systems Research, and FABRIC, Which Enables Edge And Exploratory Research At-Scale in Networking, Cybersecurity, Distributed Computing And Storage Systems, Machine Learning, and Science Applications.
- As A first step, These Projects Are Designing Demonstrations That Will Be Staged At the IEEE/ACM International Conference For High Performance Computing, Networking, Storage, and Analytics, November 14-19, 2021, in St Louis, Mo, An annually Showcase Of Breakthrough Discoveries and Innovations.
- Demonstrations Being Considered Are Experiments Using Jupyter Notebooks (Which Can Be Shared By Publishing via Trovi) to Integrate Chameleon and FABRIC Resources. Also Being Considered Is Implementing An L2 Stitched Network Between Chameleon and FABRIC That Can Be Used With Slices Deployed With a Jupyter Notebook, Which May Involve Scinet.
- Ref SC21 StarLight Booth 2727





www.chameleoncloud.org

CHAMELEON: A LARGE SCALE, RECONFIGURABLE EXPERIMENTAL INSTRUMENT FOR COMPUTER SCIENCE

Kate Keahey

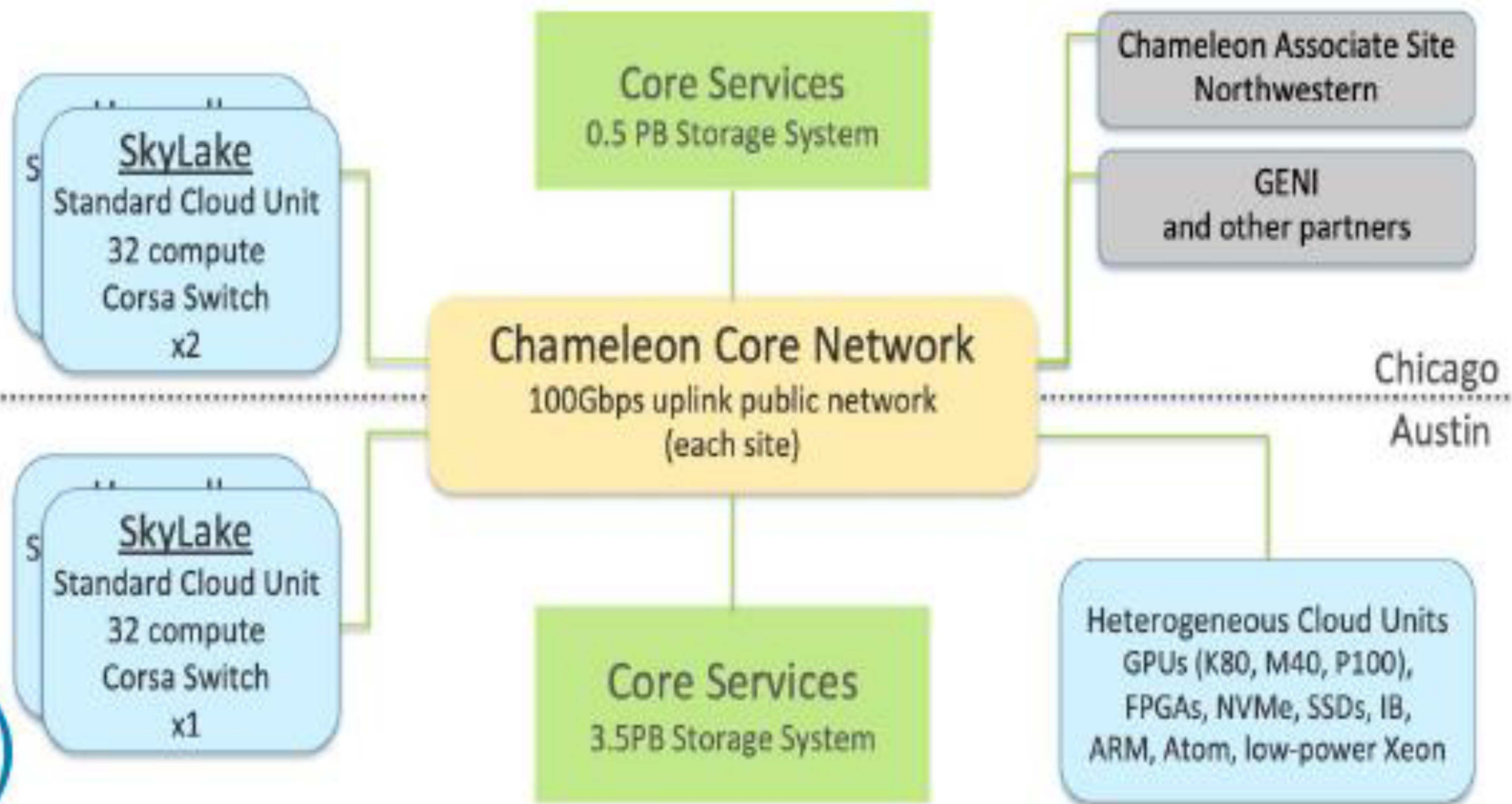
Joe Mambretti, Pierre Riteau, Paul Ruth, Dan Stanzione

SEPTEMBER 28, 2017

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Chameleon CHI In A Box(CIAB) at StarLight



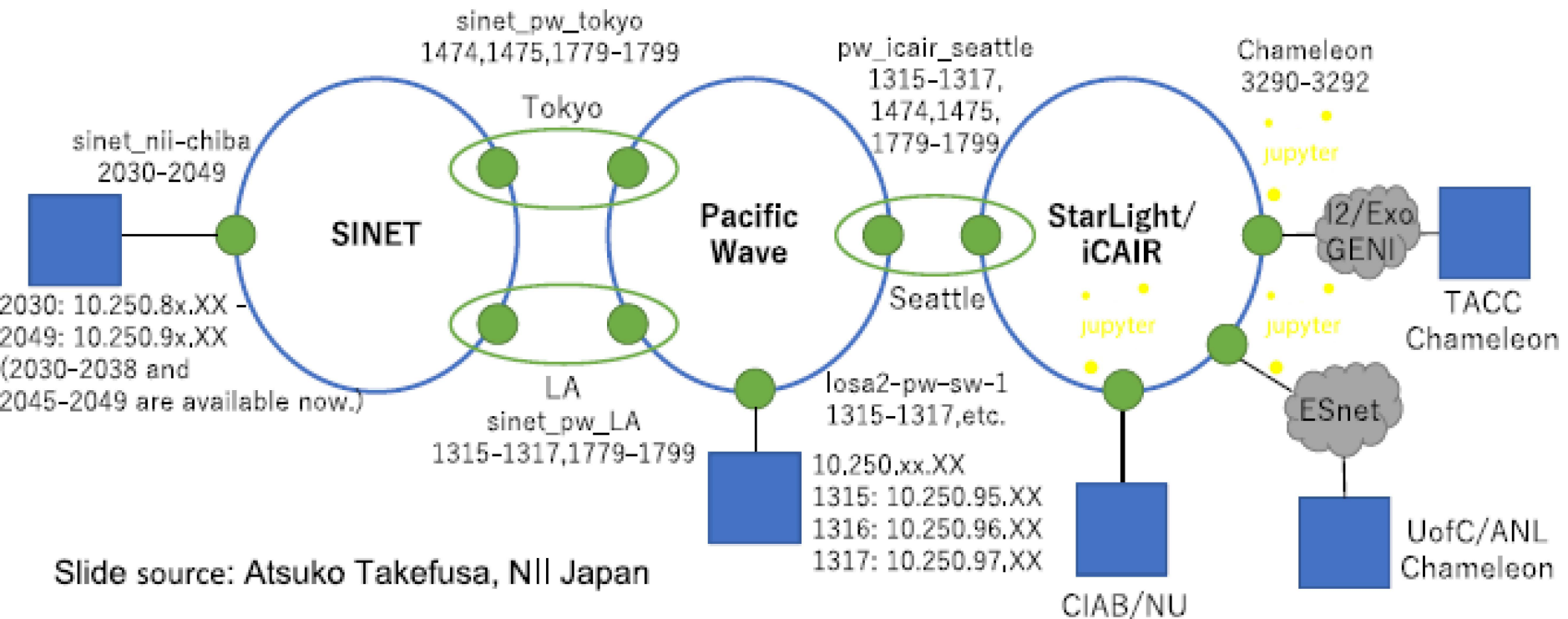
Ilya Baldine PI, RENCI: FABRIC



Figure 1 FABRIC Topology

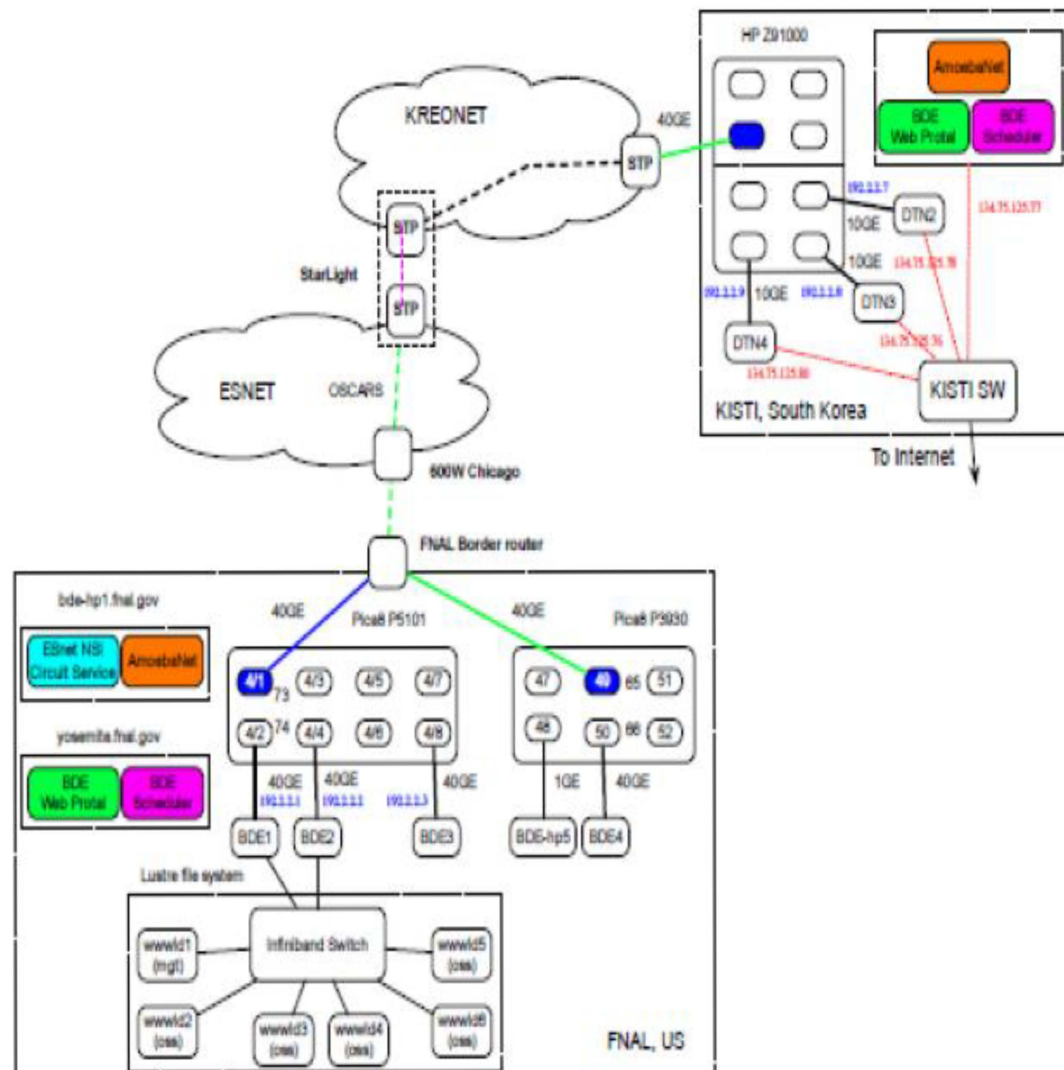
NSI Enabled Dynamic International Multi-Domain Networks for Cloud Research

Virtual Cloud Provider (VCP) : Application-Centric Overlay Cloud
Prototyped over NII Cloud-Chiba, Japan and NSF Chameleon Cloud, U.S.

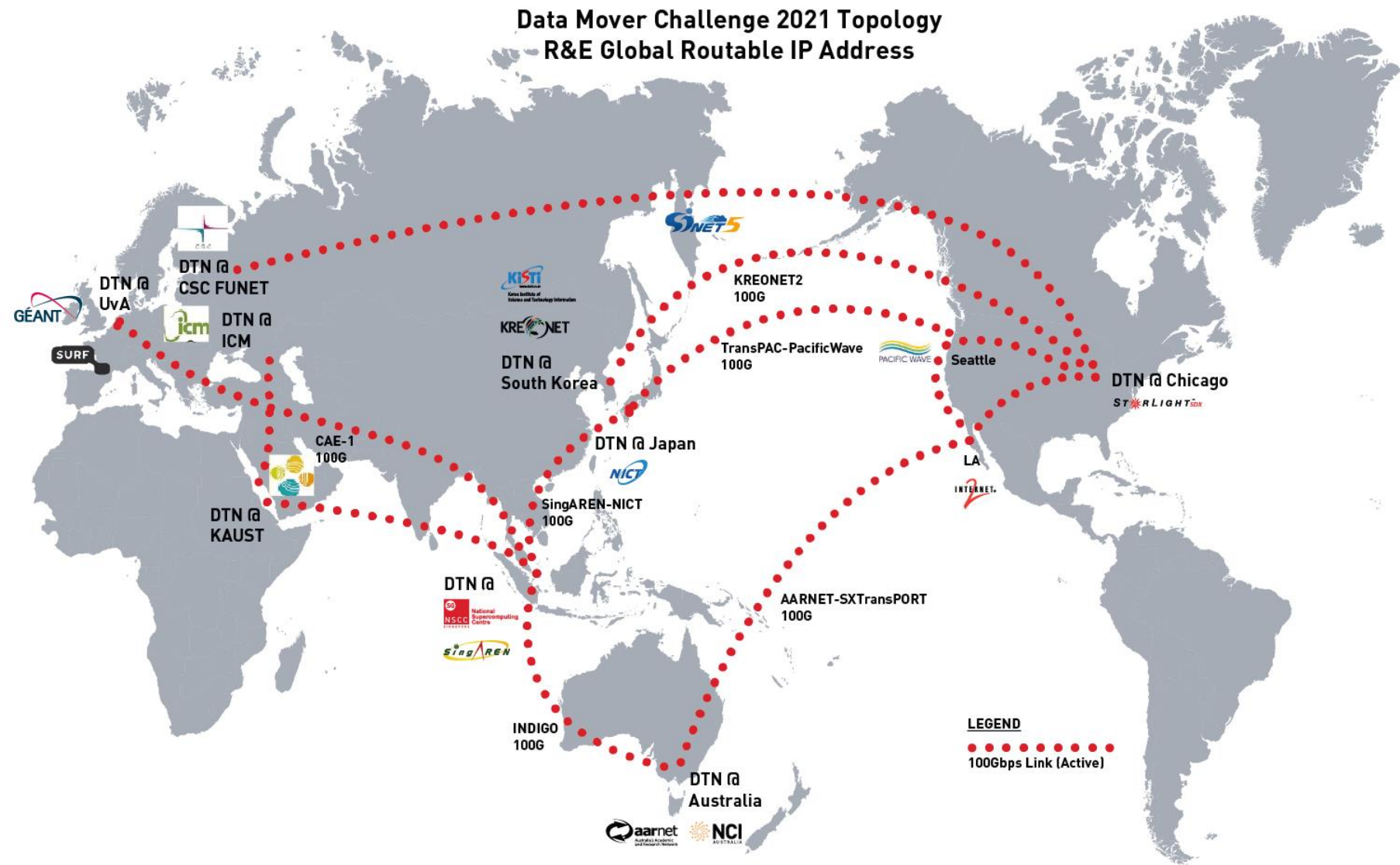




A Cross-Pacific SDN Testbed



StarLight: Founding Partner Of Supercomputing Asia DMC International Testbed

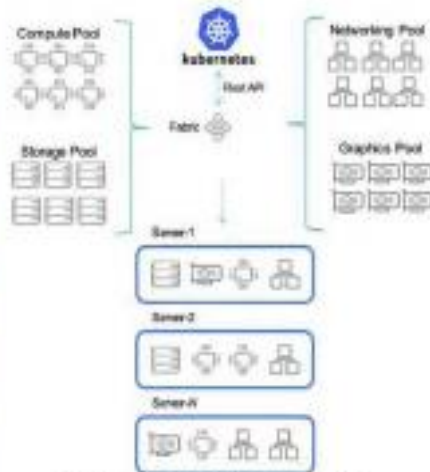


Composable Platform As a Service

Composable Platform as a Service Instrument for Deep Learning & Visualization (COMPaaS DLV) Using the *Liquid* Composable Infrastructure System for...



...on-demand post-processing,
AI, deep-learning, CFD, and
visualization.



...developing an API supporting
Kubernetes for user applications
on composable resources.



...providing network connected
GPUoF resources for virtual reality
and visualization at the edge.



...programmable composable
infrastructure using Jupyter
notebooks.

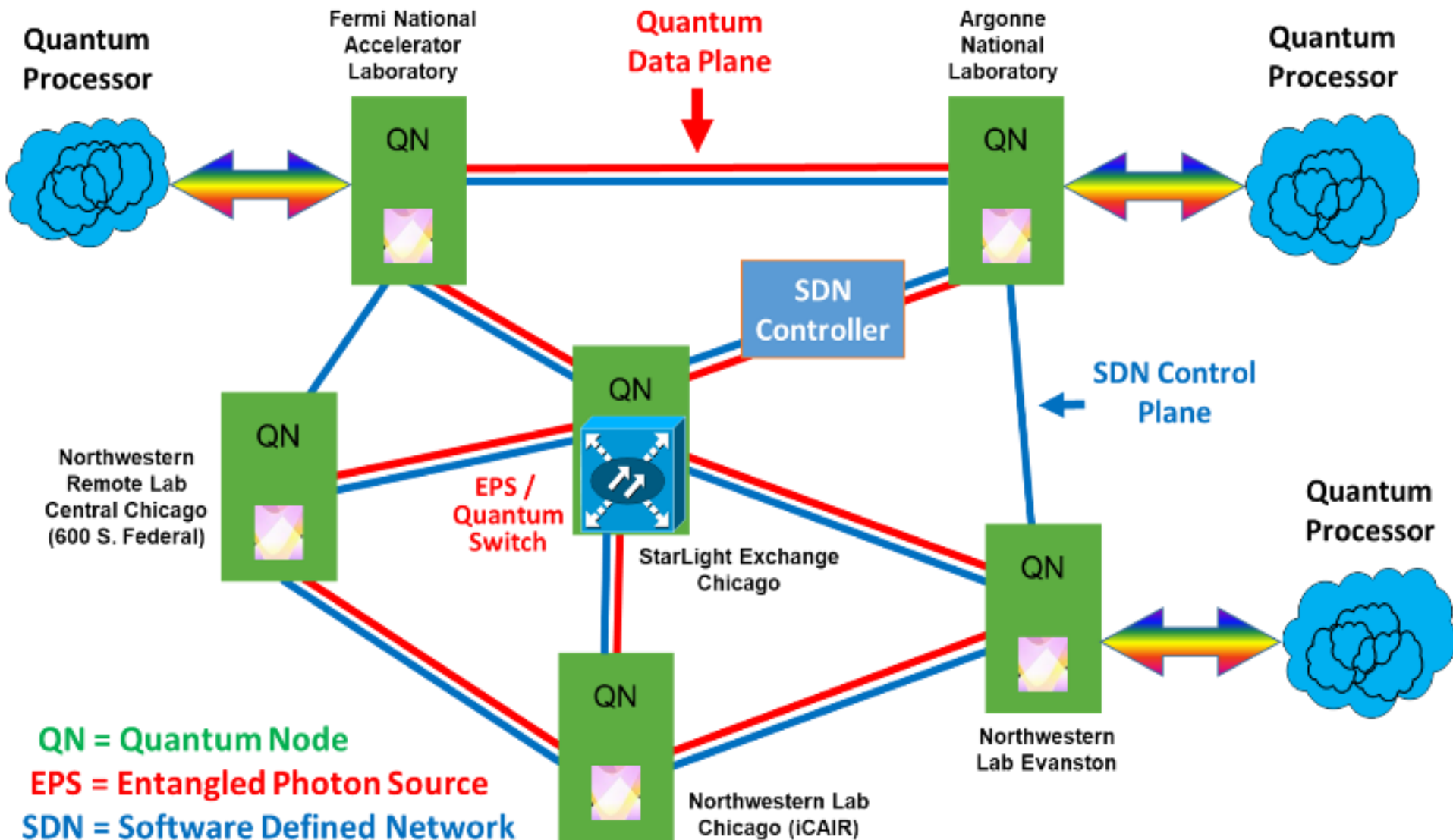

Electronic Visualization Laboratory
University of Illinois at Chicago
<https://www.evl.uic.edu>



NSF award CNS-1828265 to UIC/EVL for COMPaaS DLV
<https://www.evl.uic.edu/compaas-dlv>

Liquid: <https://www.liquid.com/>

Planned Chicago Quantum Exchange Testbed



www.startap.net/starlight

Thanks to the NSF, DOE, NASA,
NIH, DARPA
Universities, National Labs,
International & Industrial
Partners,
and Other Supporters



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"Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Networking and Information Technology Research and Development Program."

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