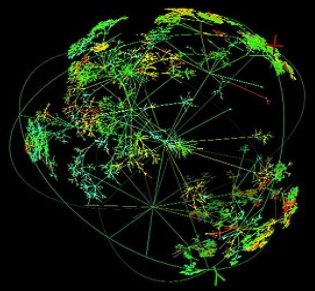
StarLight International/National Communications Exchange Facility 2018

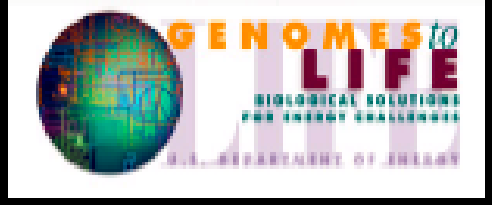
Joe Mambretti, Director, (j-mambretti@northwestern.edu)
International Center for Advanced Internet Research (www.icair.org)
Northwestern University
Director, Metropolitan Research and Education Network (www.mren.org)
Director, StarLight, PI StarLight IRNC SDX,Co-PI Chameleon, PI-iGENI, PI-OMNINet (www.startap.net/starlight)

Global LamdaGrid Workshop 2018
Co-Located With NORDUNET Conference 22018
Helsingør, Denmark
September 20-21, 2018



iCAIR

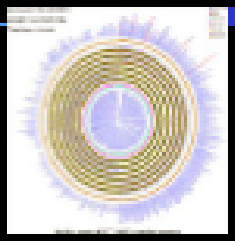
STARLIGHT℠



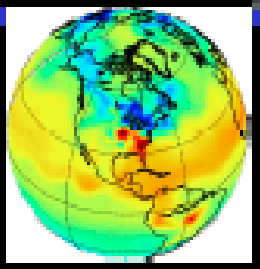
ALMA: Atacama Large Millimeter Array

ANDRILL: Antarctic Geological Drilling
www.andrill.org

BIRN: Biomedical Informatics Research Network
www.nbirn.net



CAMERA metagenomics
camera.calit2.net



Carbon Tracker
www.esrl.noaa.gov/gmd/ccgg/carbontracker

CineGrid
www.cinegrid.org

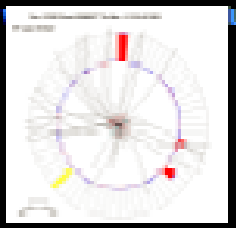
LHCONE
www.lhcone.net

GLEON: Global Lake Ecological Observatory Network

OOI-CI
ci.oceanobservatories.org

ISS: International Space Station
www.nasa.gov/station

Comprehensive Large-Array Stewardship System
www.class.noaa.gov



DØ (DZero)
www-d0.fnal.gov

LIGO
www.ligo.org

WLCG
lcg.web.cern.ch/LCG/public/

Pacific Rim Applications and Grid Middleware Assembly
www.pragma-grid.net

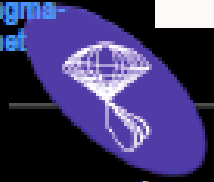
TeraGrid
www.teragrid.org

IVOA: International Virtual Observatory
www.ivoa.net

OSG
www.opensciencegrid.org

Globus Alliance
www.globus.org

SKA
www.skatelescope.org



Sloan Digital Sky Survey
www.sdss.org

XSEDE
www.xsede.org

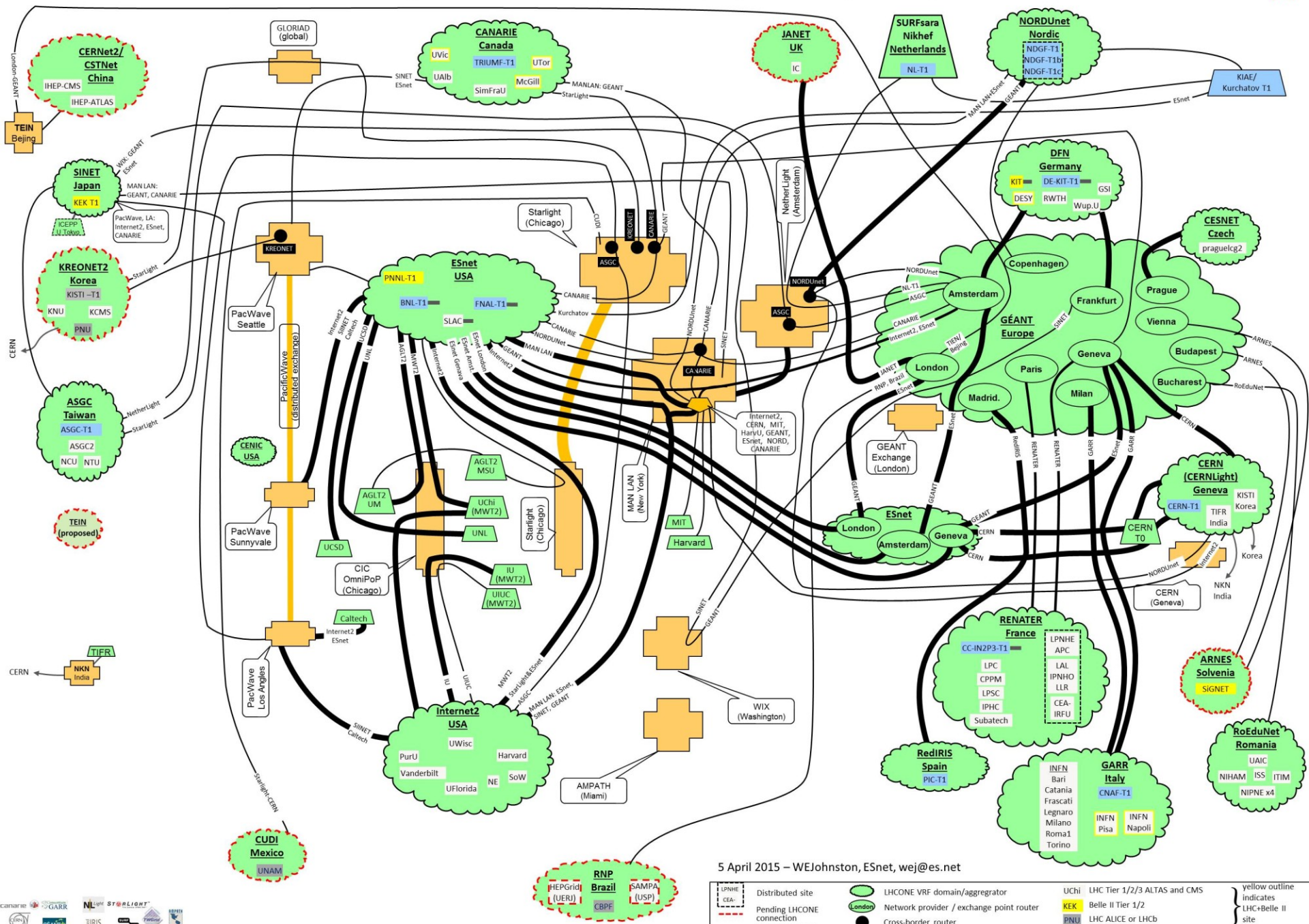
Compilation By Maxine Brown

STARLIGHT SM

Emerging Topics In Advanced Networking

- Transition From Legacy Networks To Networks That Take Full Advantage of IT Architecture and Technology
- Extremely Large Capacity (Multi-Tbps Streams)
- Specialized Network Services, Architecture and Technologies for Data Intensive Science
- High Degrees of Communication Services Customization
- Highly Programmable Networks
- Network Facilities As Enabling Platforms for Any Type of Service
- Network Virtualization
- Tenet Networks
- Network Virtualization
- Network Programming Languages (e.g., P4) API (e.g., Jupyter)
- Disaggregation
- Orchestrators
- Highly Distributed Signaling Processes
- Network Operations Automation (Including Through AI/Machine Learning)
- SDN/SDX/SDI/OCX/SDC/SDE

LHCONE: A global infrastructure for the High Energy Physics (LHC and Belle II) data management



5 April 2015 – WEJohnston, ESnet, wej@es.net

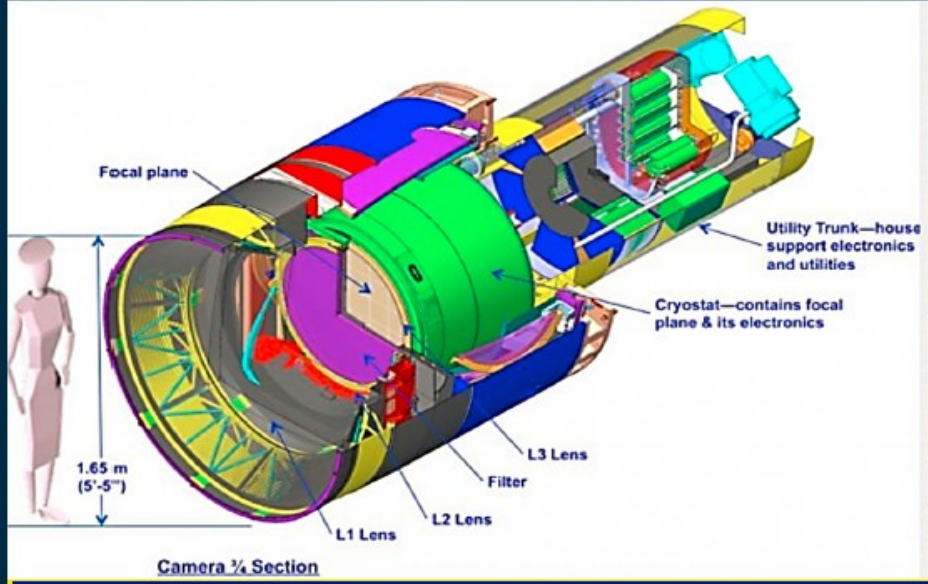
Also see http://lhcone.net for details.

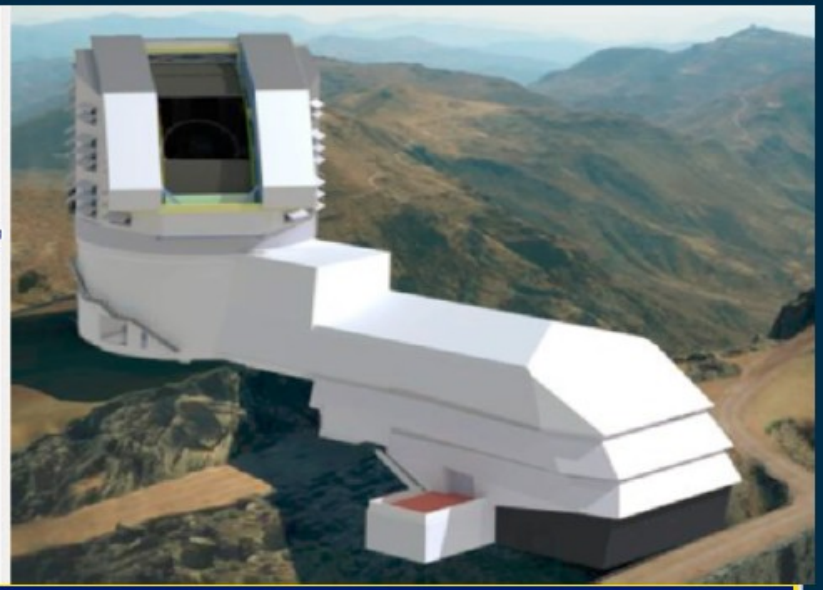
Distributed site
Pending LHCONE connection
Sites connected at 40G-100G
Broadcast VLAN
LHCONE VRF domain/aggregator
Network provider / exchange point router
Cross-border router
Regional R&E communication nexus w/ switch providing VLAN connections
UChi LHC Tier 1/2/3 ALTAS and CMS
KEK Belle II Tier 1/2
PNU LHC ALICE or LHCb
UNL Sites that are standalone VRFs,
yellow outline indicates LHC+Belle II site
Communication links: 1/10, 20/30/40, and 100Gb/s

New Science Communities Using LHCONE

- Belle II Experiment, Particle Physics Experiment Designed To Study Properties of B Mesons (Heavy Particles Containing a Bottom Quark).
- Pierre Auger Observatory, Studying Ultra-High Energy Cosmic Rays, the Most Energetic and Rarest of Particles In the Universe.
- In August 2017 the PAO, LIGO and Virgo Collaboration Measured a Gravitational Wave Originating From a Binary Neutron Star Merger.
- The NOvA Experiment Is Designed To Answer Fundamental Questions In Neutrino Physics.
- The XENON Dark Matter Project Is a Global Collaboration Investing Fundamental Properties of Dark Matter, Largest Component Of The Universe.
- ProtoNUMA/NUMA Nutrino Research

LSST Data Movement
Upcoming challenges for Astronomy





- 3.2 Gigapixel Camera with calibrated exposures at (10 Bytes / pixel)
- Planned Networks: Dedicated 100G for image data, Second 100G for other traffic, and 40G for diverse path
- Lossless compressed Image size = 2.7GB
  (~5 images transferred in parallel over a 100 Gbps link)
- UDP based custom image transfer protocols

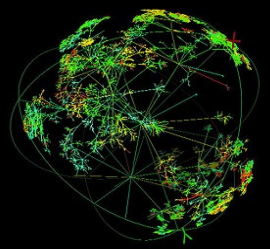
Global Research Platform (GRP)

- A Emerging International Fabric
- A Specialized Globally Distributed Environment/Platform For Science Discovery and Innovation
- Based On State-Of-the-Art-Clouds, Networks, Storage Systems, Data Repositories, etc
- Interconnected With Computational Grids, Supercomputing Centers, Specialized Instruments, et al
- Also, Based On World-Wide 100 Gbps (Soon 100 G+) Networks
- Leveraging Advanced Architectural Concepts, e.g., SDN/SDX/SDI – Science DMZs
- ***Core Building Blocks Exist Today!***
- Ref: 1st Demonstrations @ SC15, Austin Texas November 2015
- Subsequent Demonstrations @ SC16 Salt Lake City Utah, November 2016, Global LambdaGrid Workshop 2016 and 2017,
- Major Demonstrations at SC17 in Denver, Colorado, Planned Demonstrations for SC18 in Dallas Texas in November

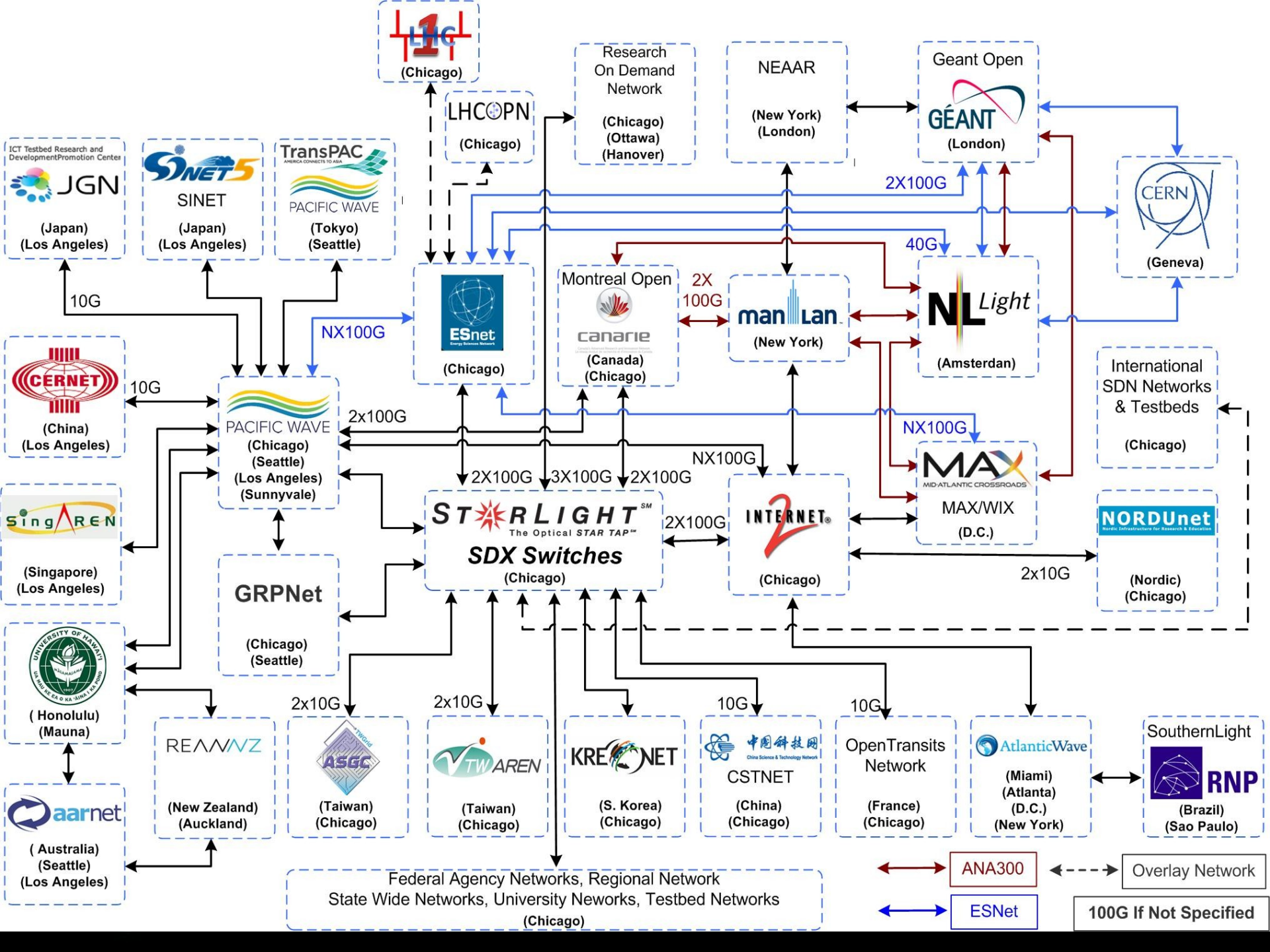
AutoGOLE Sites

IRNC: RXP: StarLight SDX A Software Defined Networking Exchange for Global Science Research and Education

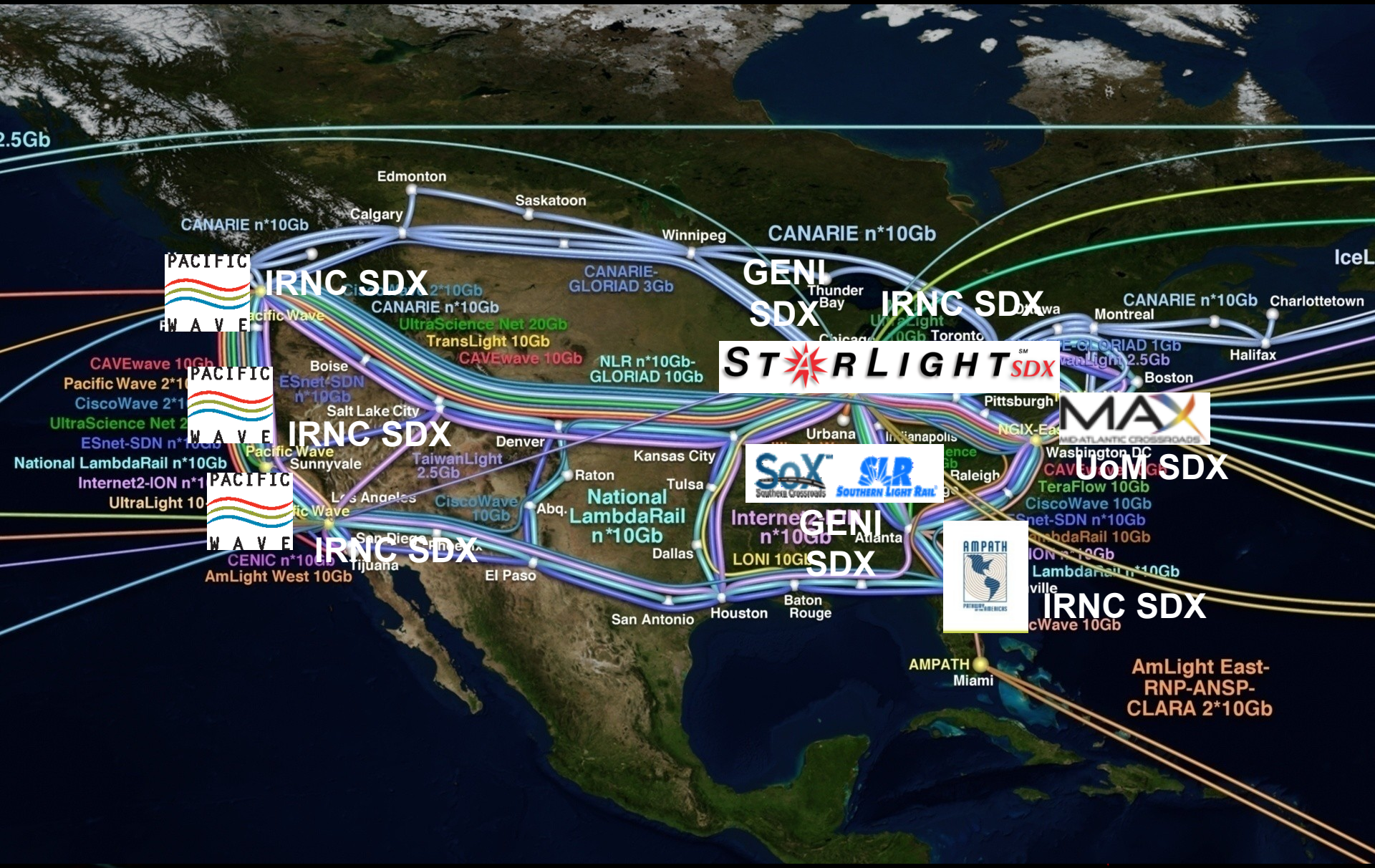
Joe Mambretti, Director, (j-mambretti@northwestern.edu)
International Center for Advanced Internet Research (www.icair.org)
Northwestern University
Director, Metropolitan Research and Education Network (www.mren.org)
Co-Director, StarLight (www.startap.net/starlight)
PI IRNC: RXP: StarLight SDX
Co-PI Tom DeFanti, Research Scientist, (tdefanti@soe.ucsd.edu)
California Institute for Telecommunications and Information Technology (Calit2),
University of California, San Diego
Co-Director, StarLight
Co-PI Maxine Brown, Director, (maxine@uic.edu)
Electronic Visualization Laboratory, University of Illinois at Chicago
Co-Director, StarLight
Jim Chen, Associate Director, International Center for Advanced Internet Research, Northwestern University



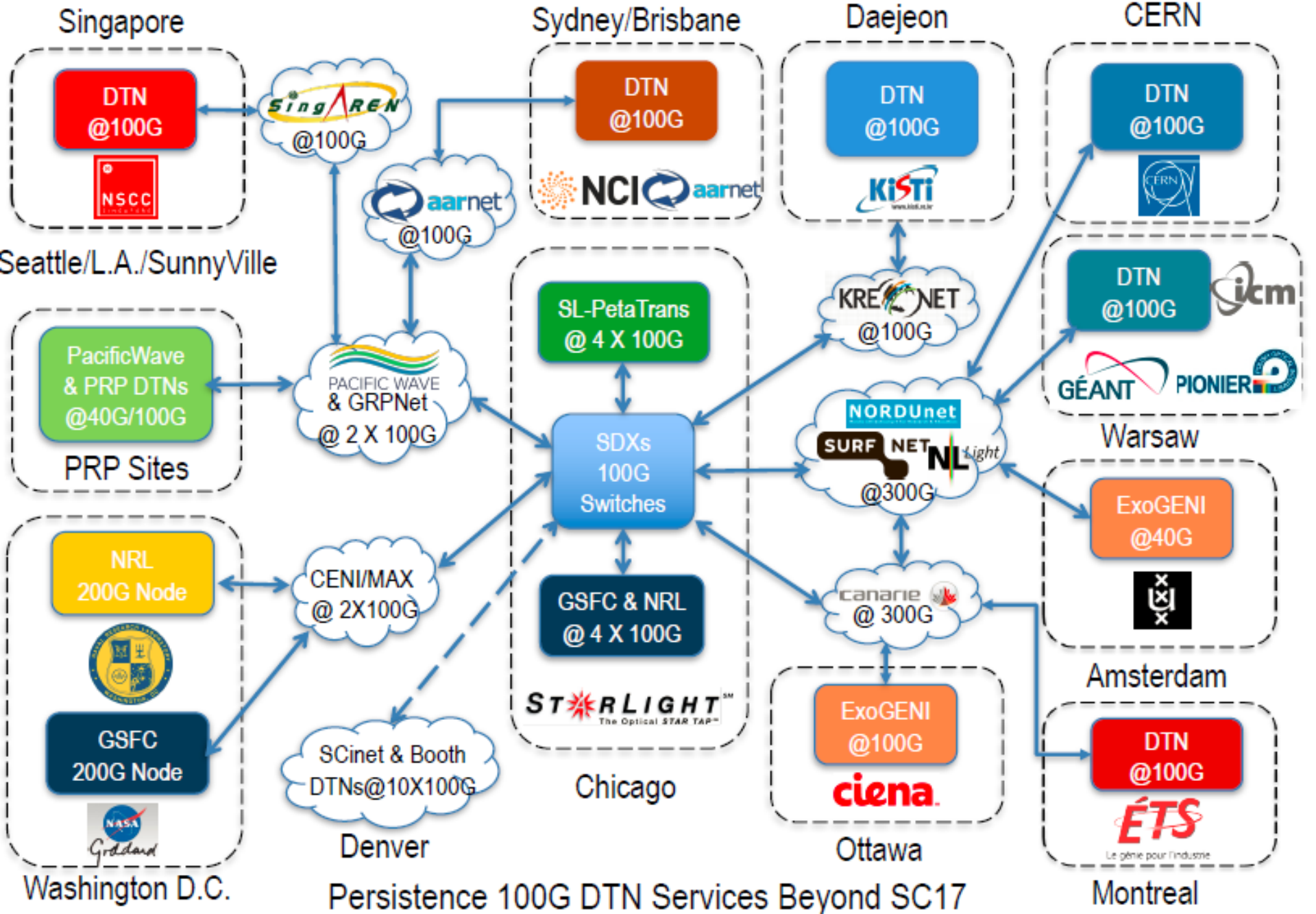
National Science Foundation
International Research Network Connections Program
Workshop
Chicago, Illinois
May 15, 2015


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)
NORDUnet
(Nordic)
(Chicago)
2x10G
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

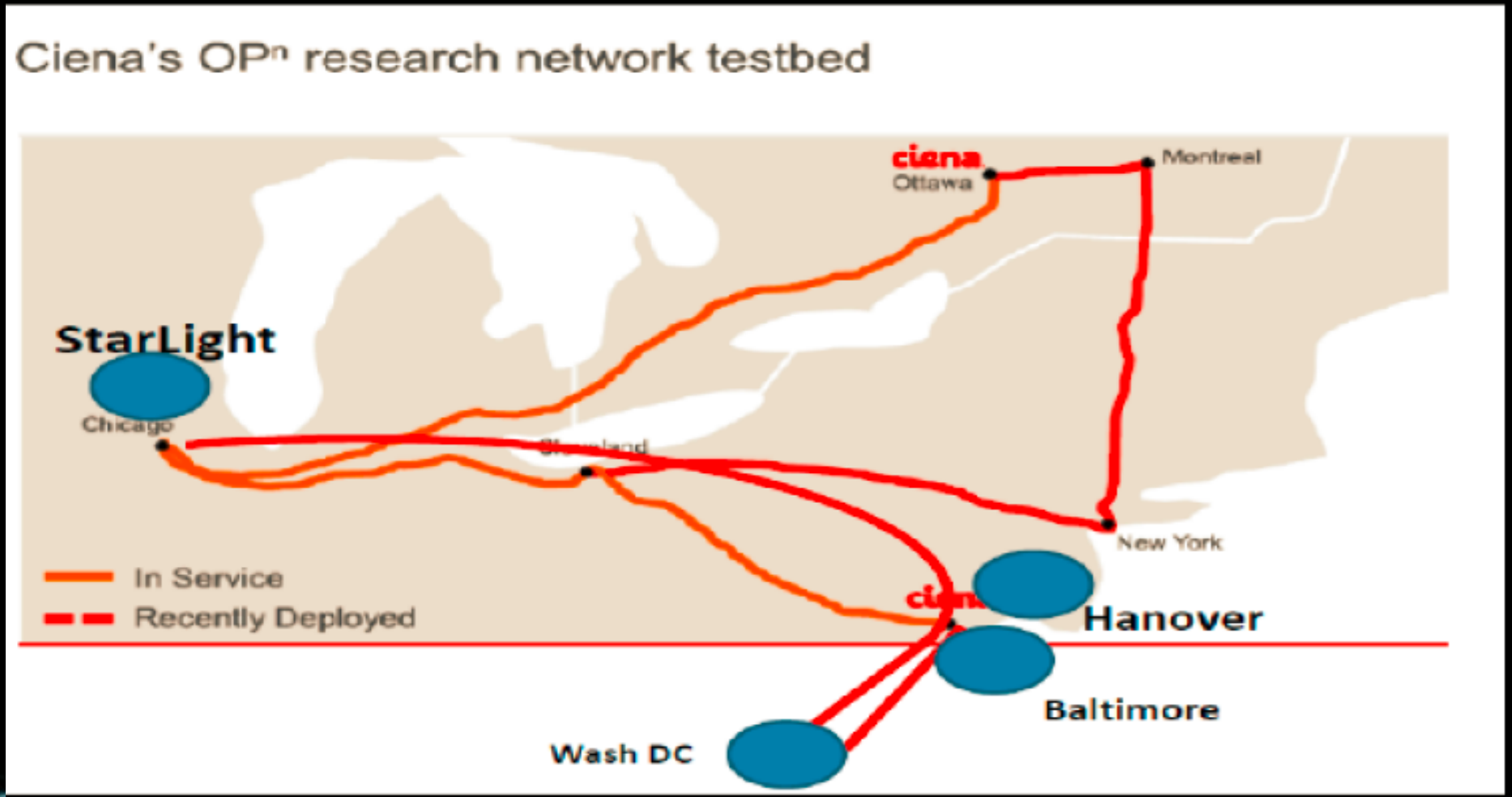
Emerging US SDX Interoperable Fabric



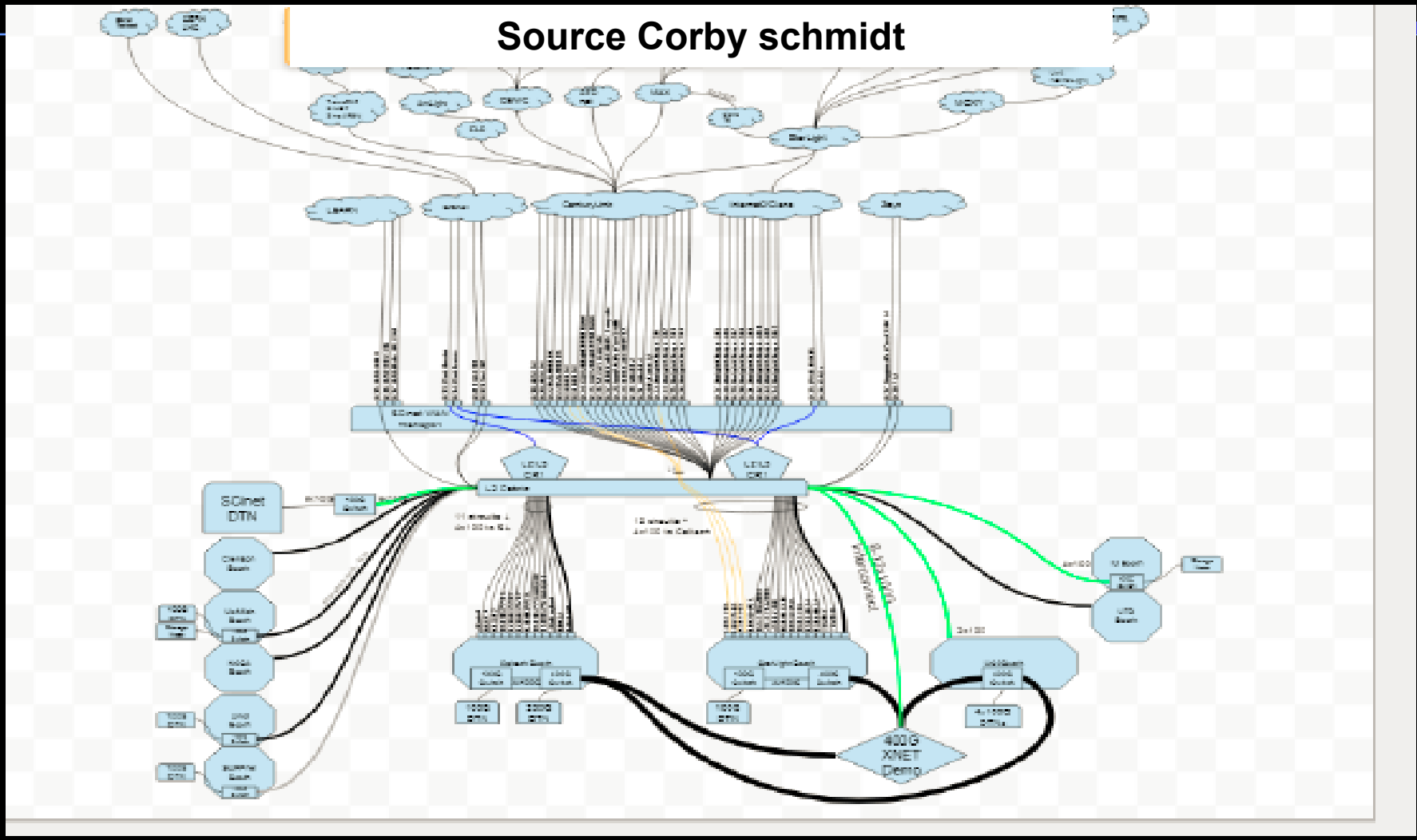
PetaTrans: Petascale Sciences Data Transfer

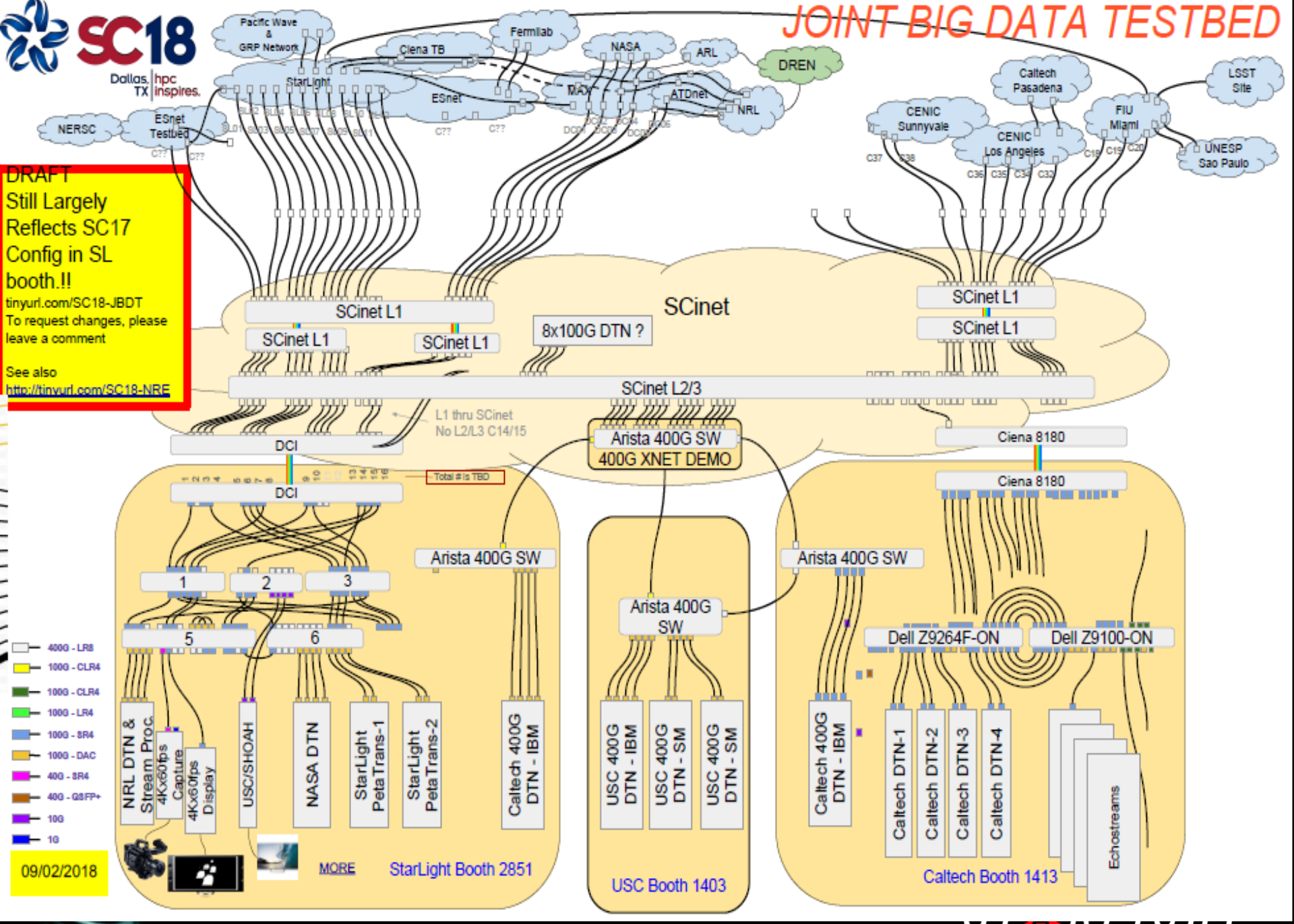


100 Gbps DTN Optical Testbed



Source Corby schmidt

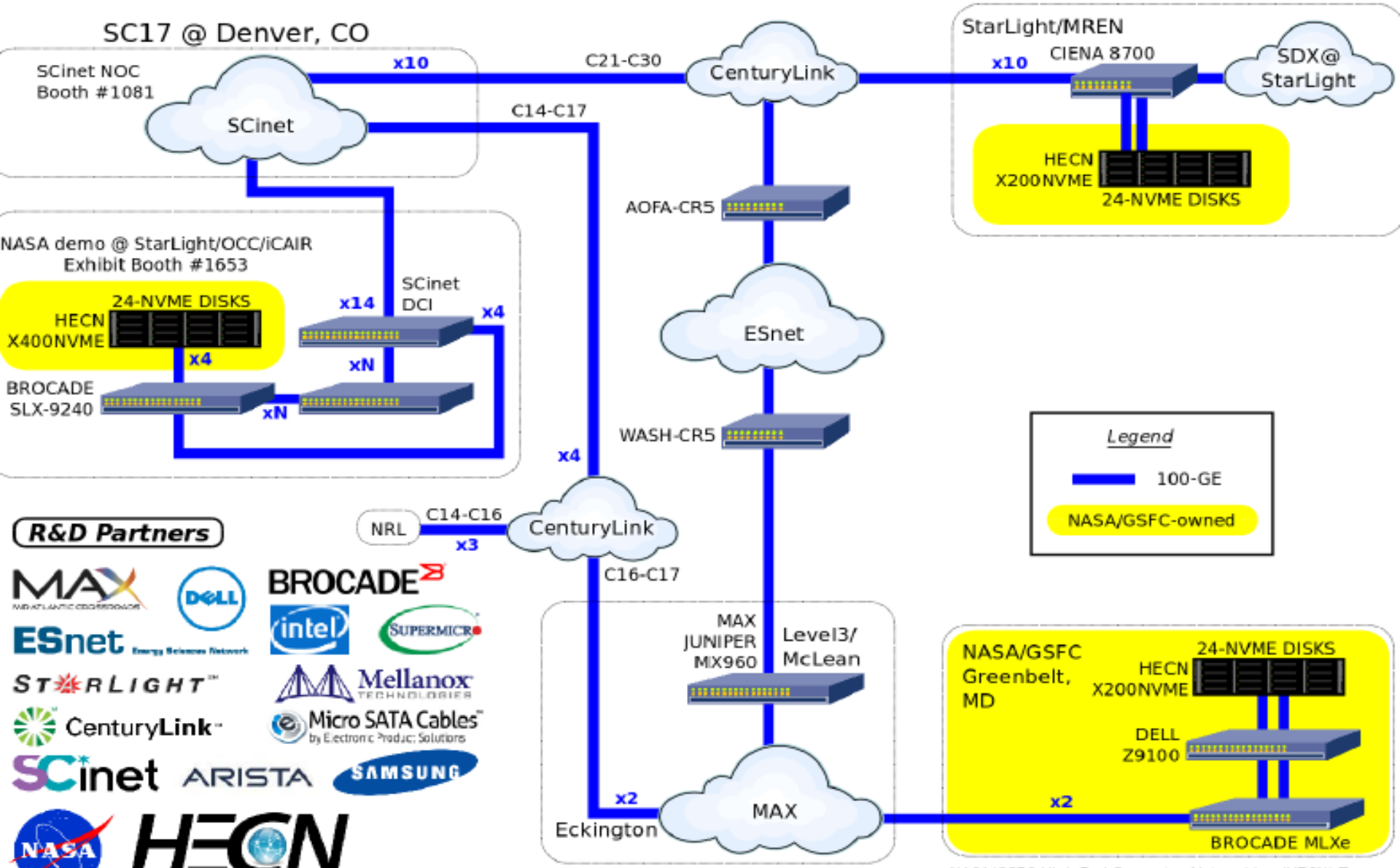



SC18
Dallas, TX | hpc inspires.
JOINT BIG DATA TESTBED
DRAFT
Still Largely Reflects SC17 Config in SL booth.!!
tinyurl.com/SC18-JBDT
To request changes, please leave a comment
See also http://tinyurl.com/SC18-NRE
Pacific Wave & GRP Network
Ciena TB
Fermilab
NASA
ARL
DREN
StarLight
ESnet
MAX
ATDnet
NRL
NERSC
ESnet Testbed
Caltech Pasadena
LSST Site
CENIC Sunnyvale
CENIC Los Angeles
FIU Miami
UNESP Sao Paulo
SCinet
SCinet L1
SCinet L2/3
8x100G DTN ?
L1 thru SCinet
No L2/L3 C14/15
DCI
Total #'s TBD
Arista 400G SW
400G XNET DEMO
Ciena 8180
Arista 400G SW
Dell Z9264F-ON
Dell Z9100-ON
NRL DTN & Stream Proc.
4Kx60fps Capture
4Kx60fps Display
USC/SHOAH
NASA DTN
StarLight Peta Trans-1
StarLight Peta Trans-2
Caltech 400G DTN - IBM
USC 400G DTN - IBM
USC 400G DTN - SM
Caltech DTN-1
Caltech DTN-2
Caltech DTN-3
Caltech DTN-4
Echostreams
MORE
StarLight Booth 2851
USC Booth 1403
Caltech Booth 1413
400G - LR8
100G - CLR4
100G - CLR4
100G - LR4
100G - SR4
100G - DAC
40G - SR4
40G - QSFP+
10G
1G
09/02/2018

SC17

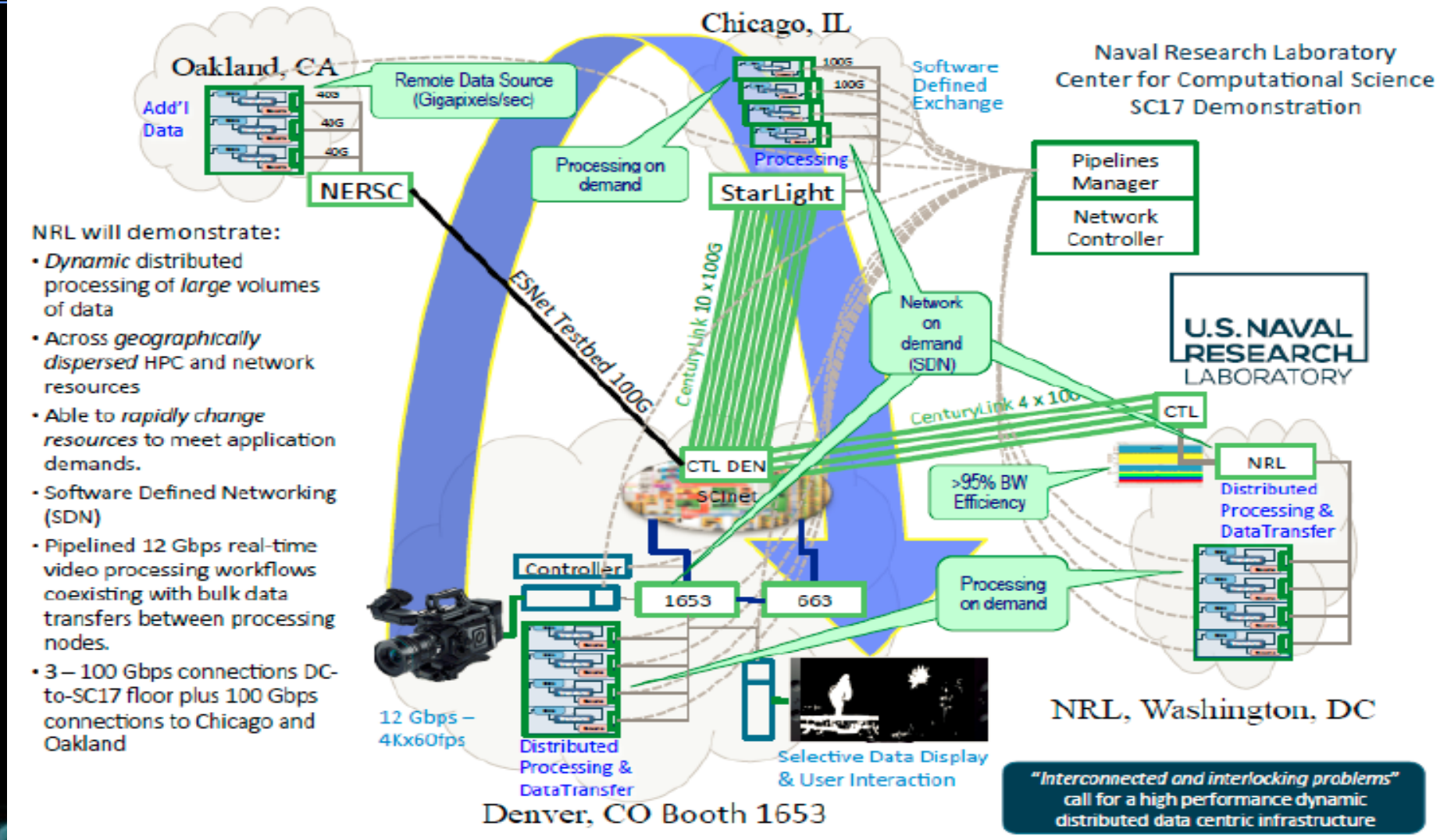
Demonstrations of 400 Gbps Disk-to-Disk WAN File Transfers using iWARP and NVMe Drives

An SC17 Collaborative Initiative Among NASA and Several Partners



NASA/GSFC High End Computer Networking (HECN) Team
Diagram by Bill Fink / Paul Lang - 8/14/2017

Dynamic Distributed Data Processing

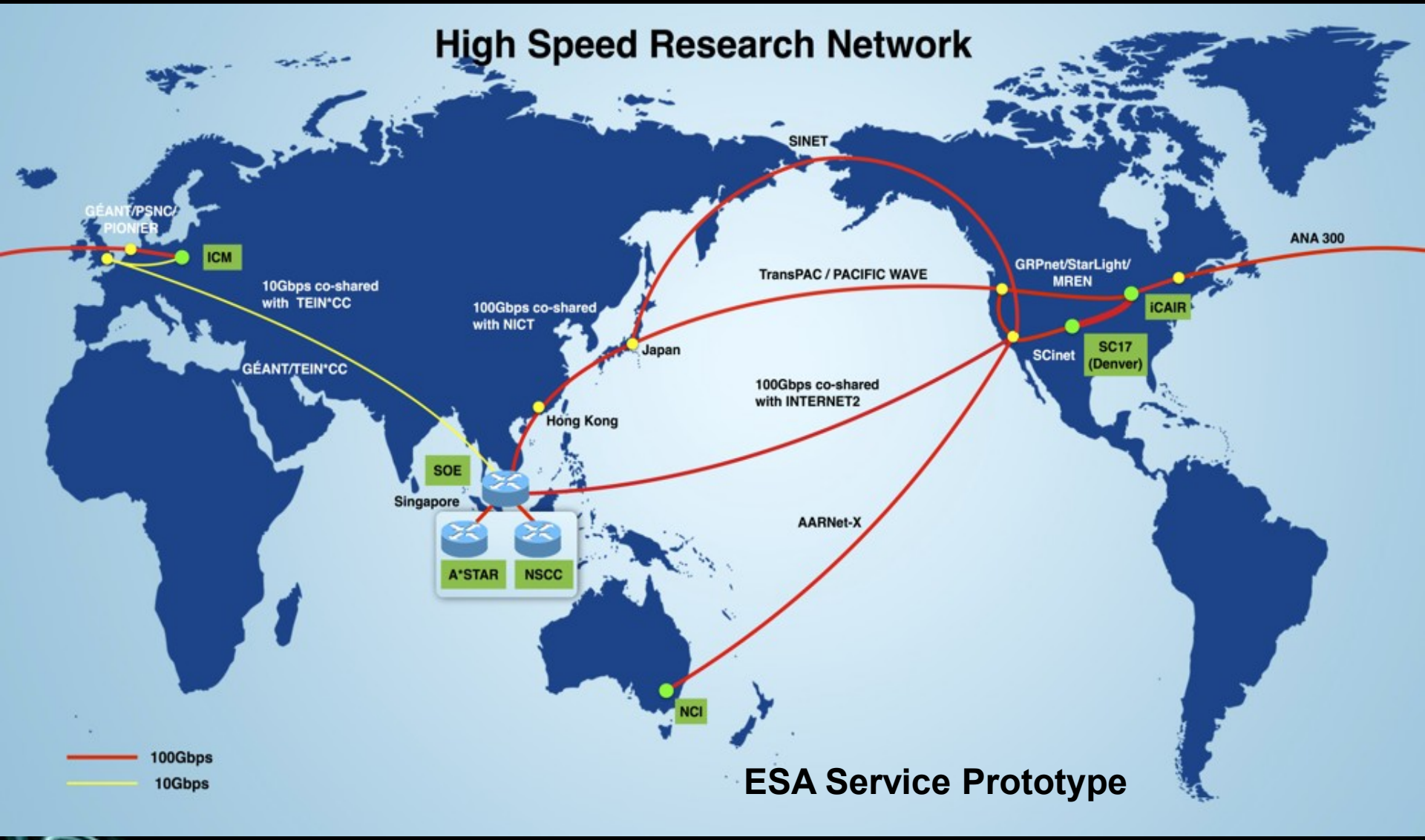


NRL will demonstrate:

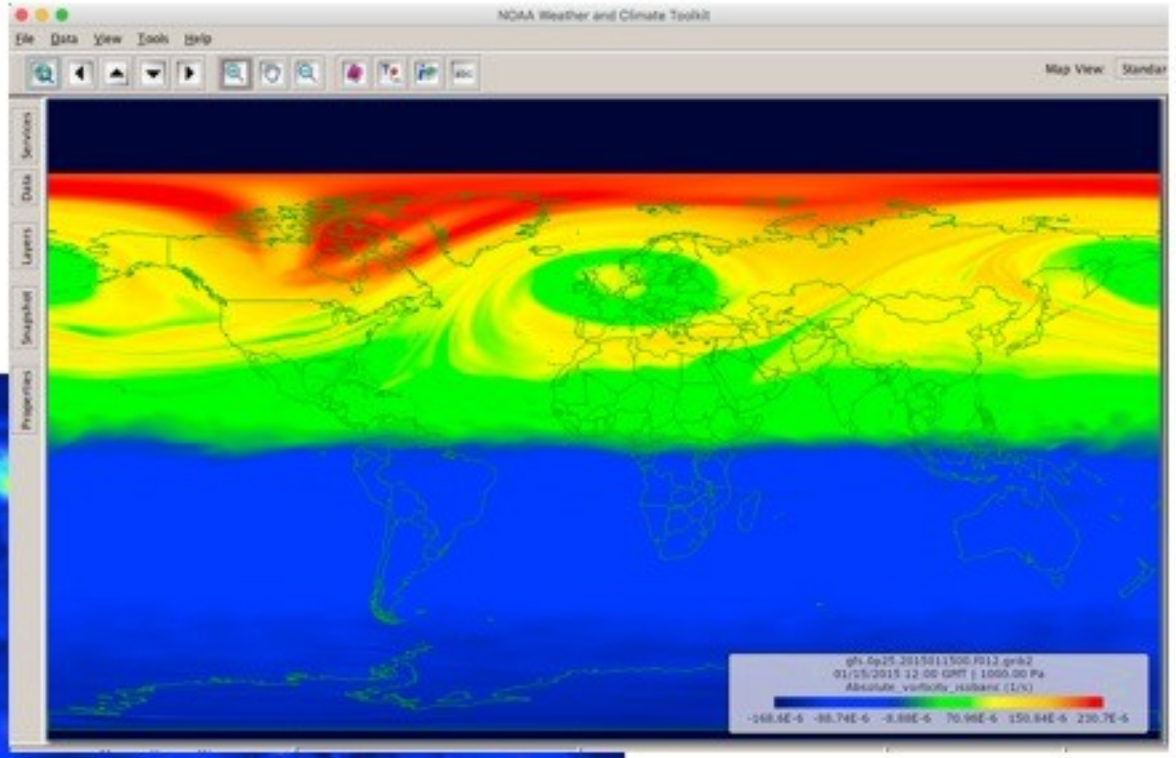
- *Dynamic* distributed processing of *large* volumes of data
- Across *geographically dispersed* HPC and network resources
- Able to *rapidly change resources* to meet application demands.
- Software Defined Networking (SDN)
- Pipelined 12 Gbps real-time video processing workflows coexisting with bulk data transfers between processing nodes.
- 3 – 100 Gbps connections DC-to-SC17 floor plus 100 Gbps connections to Chicago and Oakland

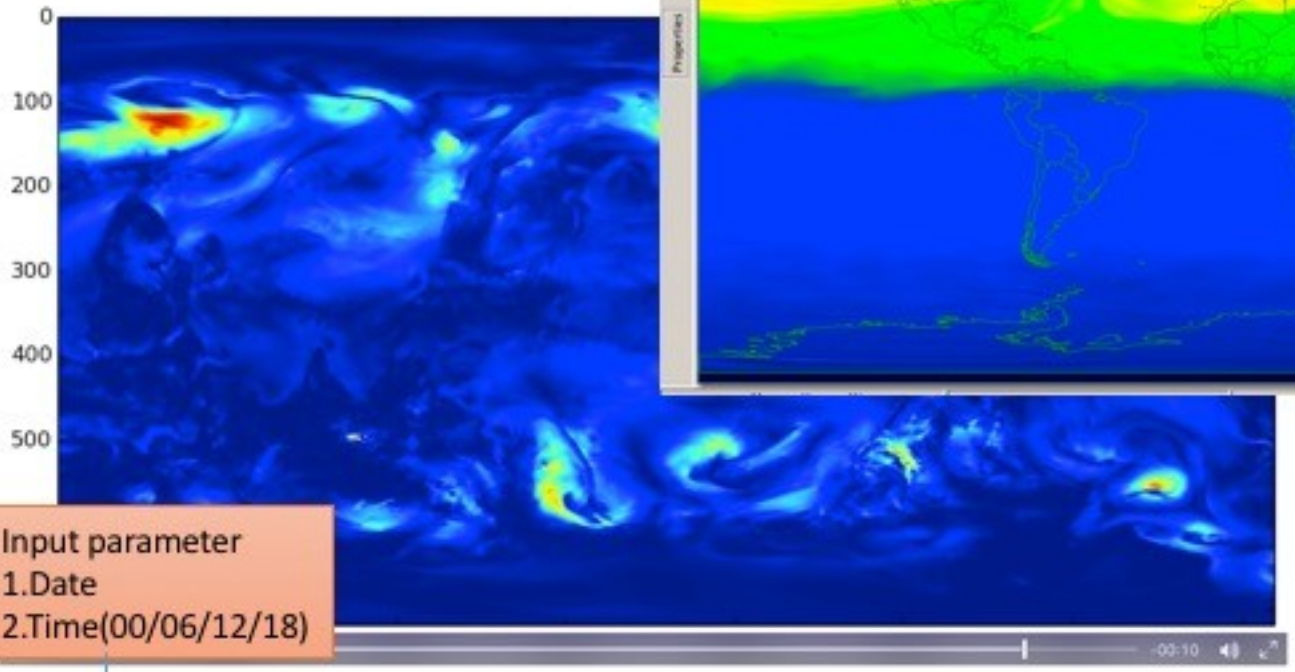
"Interconnected and interlocking problems" call for a high performance dynamic distributed data centric infrastructure

STARLIGHT℠

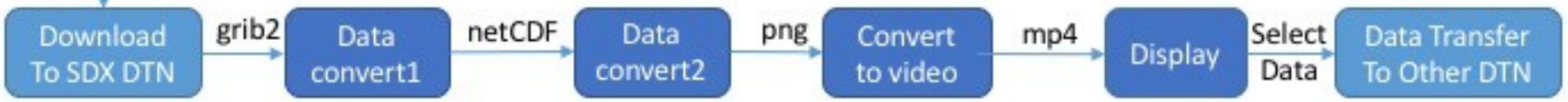

High Speed Research Network
SINET
GÉANT/PSNC/
PIONIER
ICM
10Gbps co-shared
with TEIN*CC
GÉANT/TEIN*CC
100Gbps co-shared
with NICT
Japan
TransPAC / PACIFIC WAVE
GRPnet/StarLight/
MREN
ANA 300
iCAIR
SCinet
SC17
(Denver)
100Gbps co-shared
with INTERNET2
Hong Kong
SOE
Singapore
A*STAR
NSCC
AARNet-X
NCI
100Gbps
10Gbps
ESA Service Prototype

StarLight SDX Geoscience Research Workflow

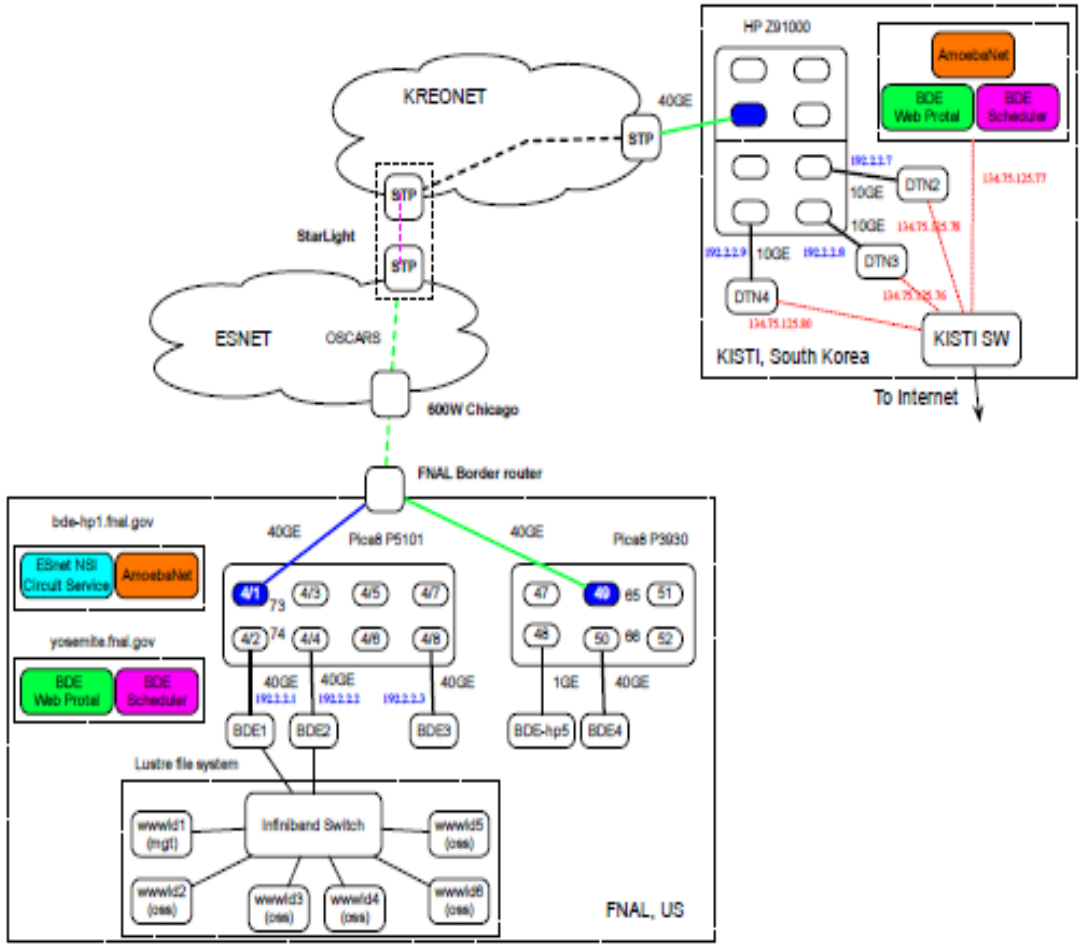




Input parameter
1.Date
2.Time(00/06/12/18)



A Cross-Pacific SDN Testbed



Chameleon

www.chameleoncloud.org

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

Kate Keahey

Joe Mambretti, Pierre Riteau, Paul Ruth, Dan Stanzione

UNIVERSITY OF CHICAGO TACC NORTHWESTERN UNIVERSITY THE OHIO STATE UNIVERSITY UTSA NSF

STARLIGHT SM

GENI – iCAIR P4 Testbed – Integrated With GENI StarLight SDX

- In Partnership With The GENI Initiative, iCAIR Is Developing a P4 Testbed for Computer Science Research.
- The Testbed Will Be Integrated With the GENI SDX At StarLight
- P4 (Programming Protocol-Independent Packet Processors).
- An Emerging Networking Programming Language,
- A Domain Specific Language for Network Protocols.
- Highly Flexible In Contrast To OpenFlow
- Testbed Based on Tofino (Barefoot Networks) Switches
- Compiler (V16) Enables Rules To Be Dynamically Implemented In Chip

Other Notable StarLight Suppotred Testbeds

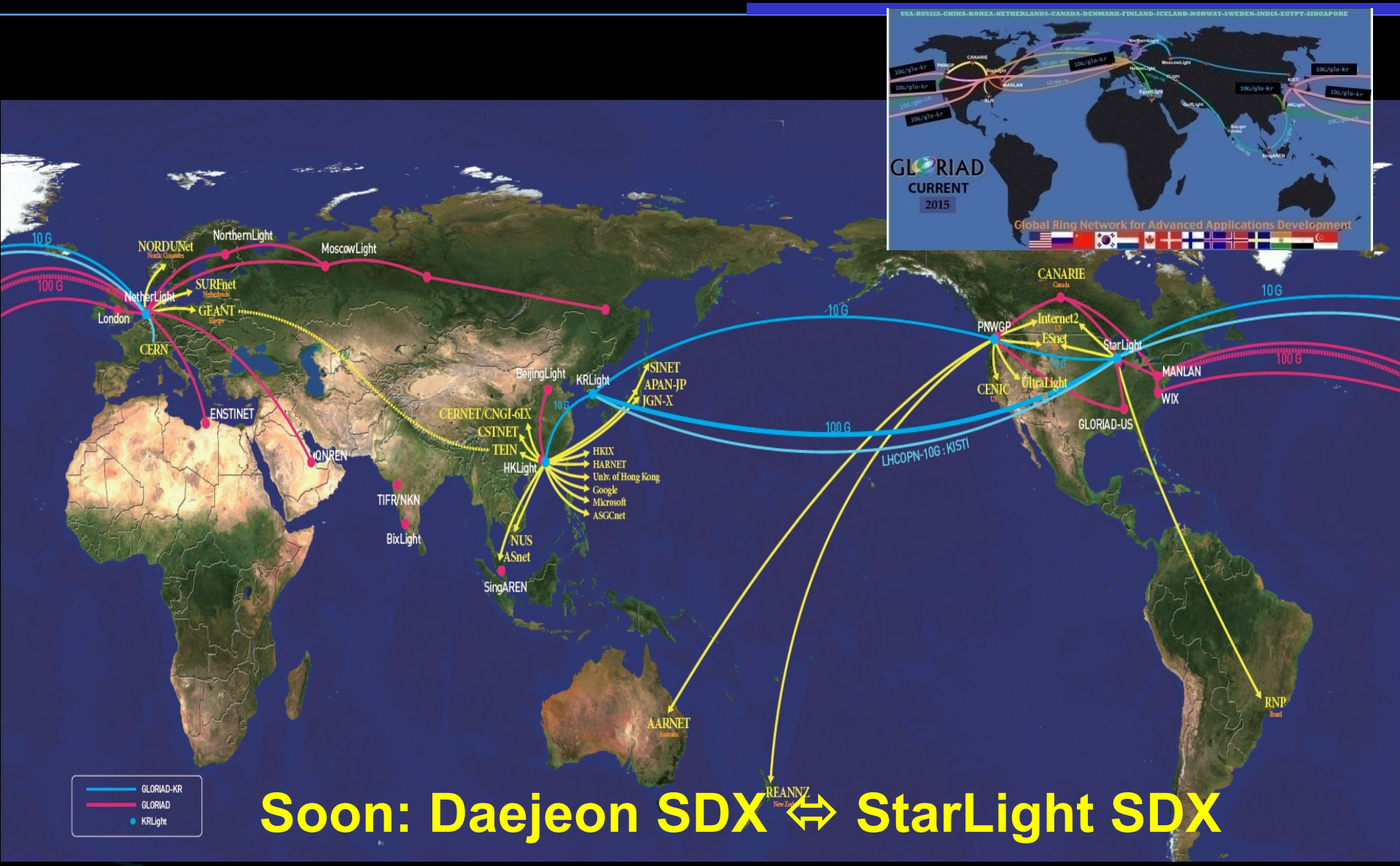
- International AI Testbed (Currently Being Designed)
- International DTN Testbed
- LHC P2P Service
- High Performance Digital Media Network (HPDMnet)
- Geophysical Sciences Testbed
- Content Routing Network
- AutoGOLE
- MEICAN/Network Service Interface (NSI)
- AmoebaNet
- Cisco Information Centric Networking Testbed (ICN)
- SD-WAN Testbed
- ToMaTo
- Et Al

Building the Open Storage Network

Alex Szalay
The Johns Hopkins University

Institute for Data Intensive Engineering and Science
idies

KREONet2 SD-WAN GLORIAD-KR
KISTI Daejeon ⇔ 100 G ⇔ StarLight



Soon: Daejeon SDX ⇔ StarLight SDX

www.startap.net/starlight

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