Development of the LHCONE in Asia

Hsin-Yen CHEN
ASGC
GDB @ Taipei
3 Apr. 2019

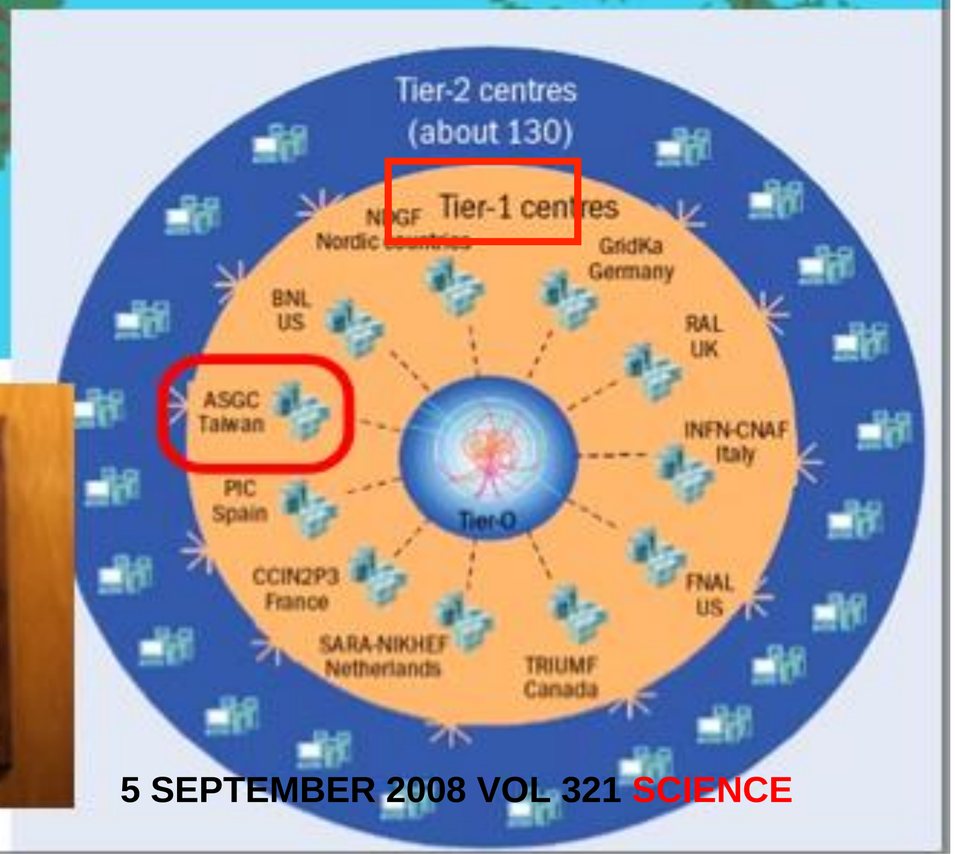
Academia Sinica Grid Computing

After WWW, CERN decided in 2000 to develop and deploy distributed computing to support a new generation of big data driven research. Middleware had been developed for geographically distributed cloud centers to share resources with applications to particle physics research over the past 15 years.

ASGC was established to join the international collaboration centered at CERN to build a platform for distributed computing to support e-Science.

By collaborating with CERN, we stay in the forefront of distributed computing.

WWW was Invented at CERN



5 SEPTEMBER 2008 VOL 321 SCIENCE

Building Advanced Distributed Computing Platform

Strategy: Collaborations with Research Groups - Applications Drive & Technology Push
R&D: DiCOS, System Efficiency & Machine Learning Applications

Application (Science)

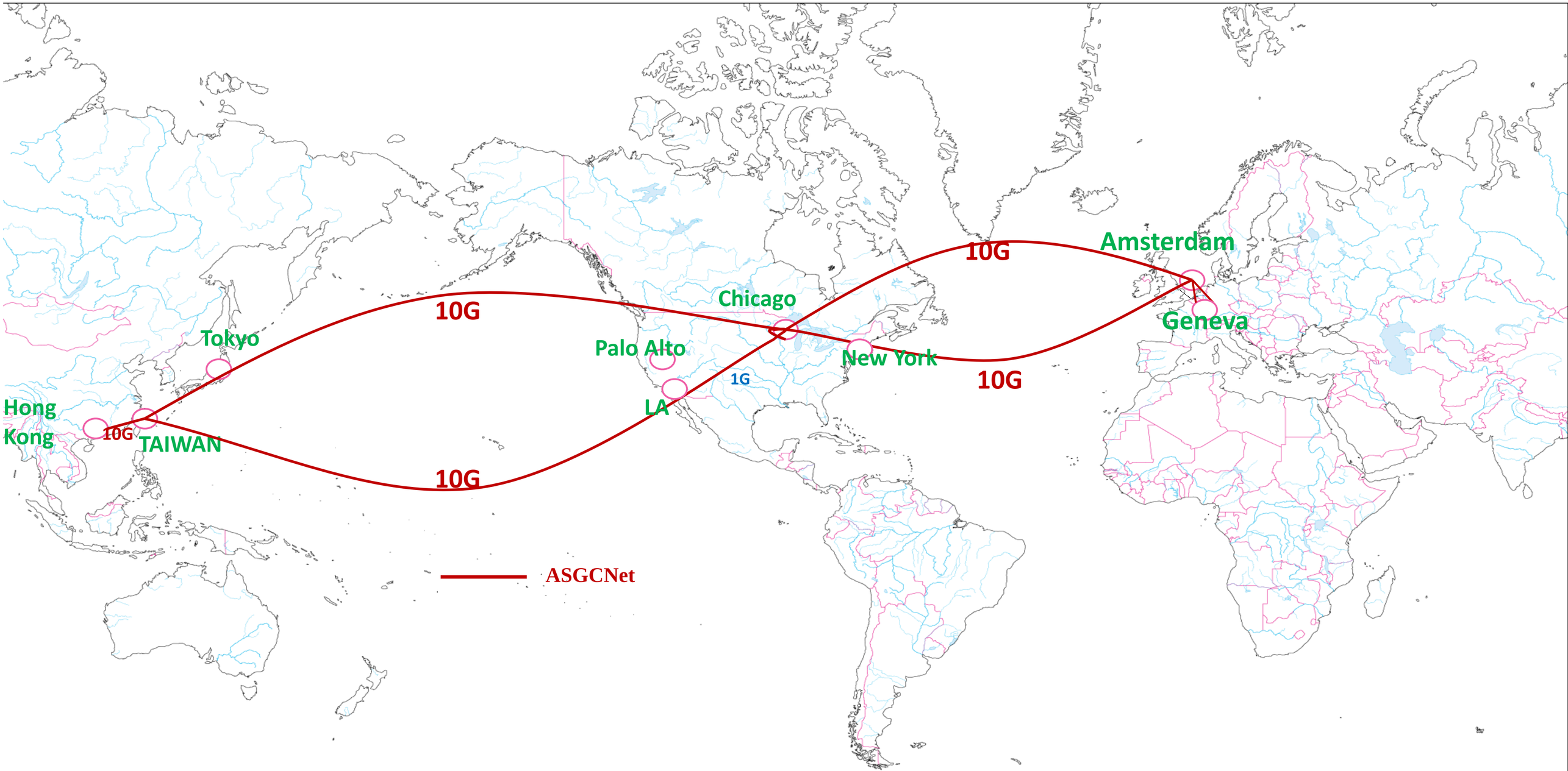
- **ATLAS, CMS (High Energy Physics)**
- **Alpha Magnetic Spectrometer (Particle & Astronomy)**
- **KAGRA, VIRGO (Gravitation)**
- **TEXONO (Neutrino)**
- **World Wide Grid Computing (CERN)**
- **Advanced Networking (iCAIR)**
- **Proton Therapy (NCU, CGU/CGMH)**
- **Deeper Understanding Natural Disaster**
- **Soundscape Monitoring Network**
- **Earth Science**
- **Cryo-EM (2017)**
- **Computational Biology (2017)**
- **Bioinformatics (U. Chicago)**

DiCOS: Distributed Cloud Operating System

- **Leveraging WLCG technologies and moving from petabyte-scale towards Exabyte scale:**
  - **~100PB in 2018 and expected to have ~1000PB in 2025;**
  - **Mobilizing 10PB/month**
  - **2M+ jobs/day**
- **Extending beyond high energy physics**
- **Growing our own R&D Capability**

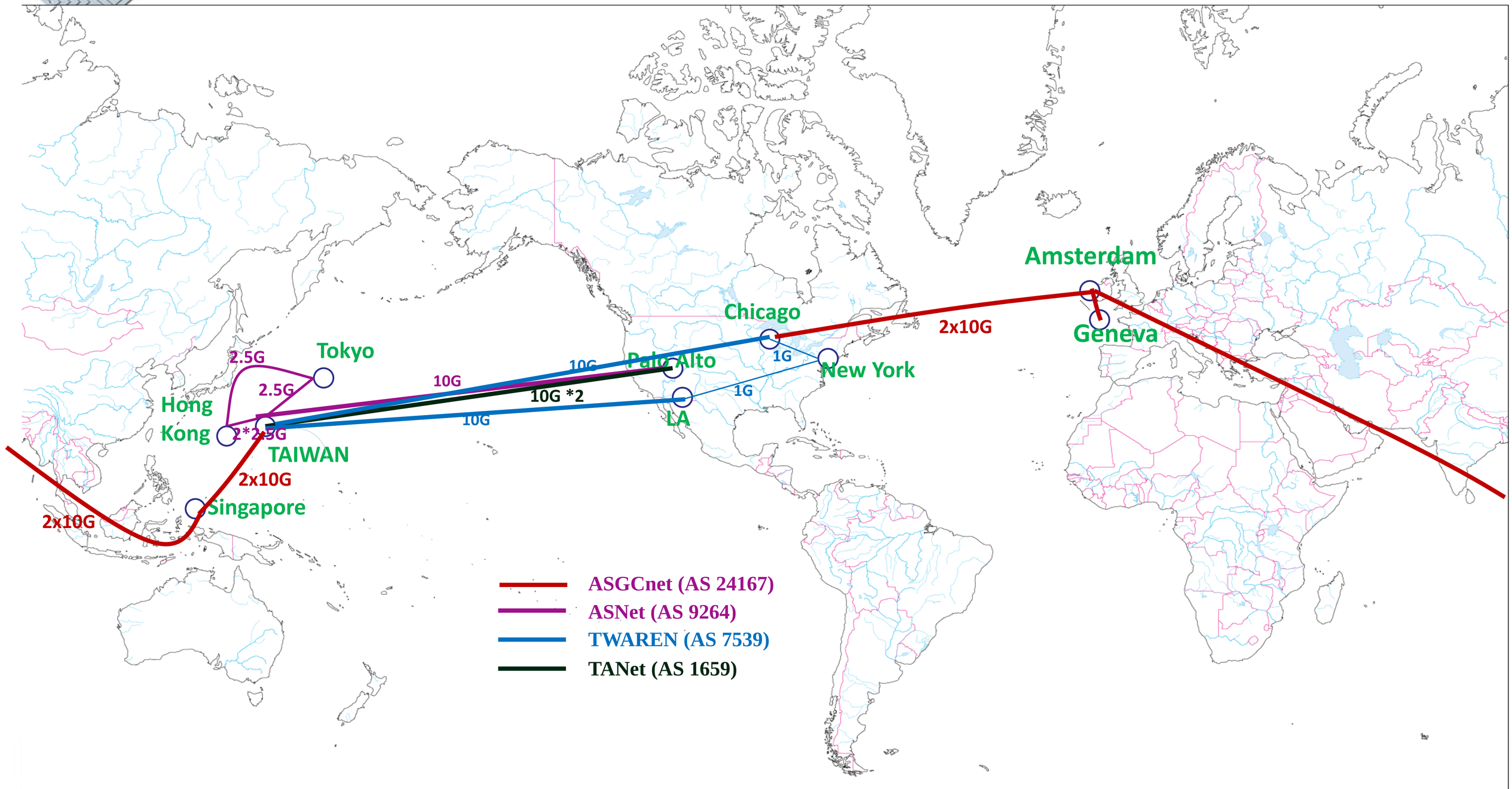
ASGC Global Network

Sep. 2013 ~ Sep. 2018

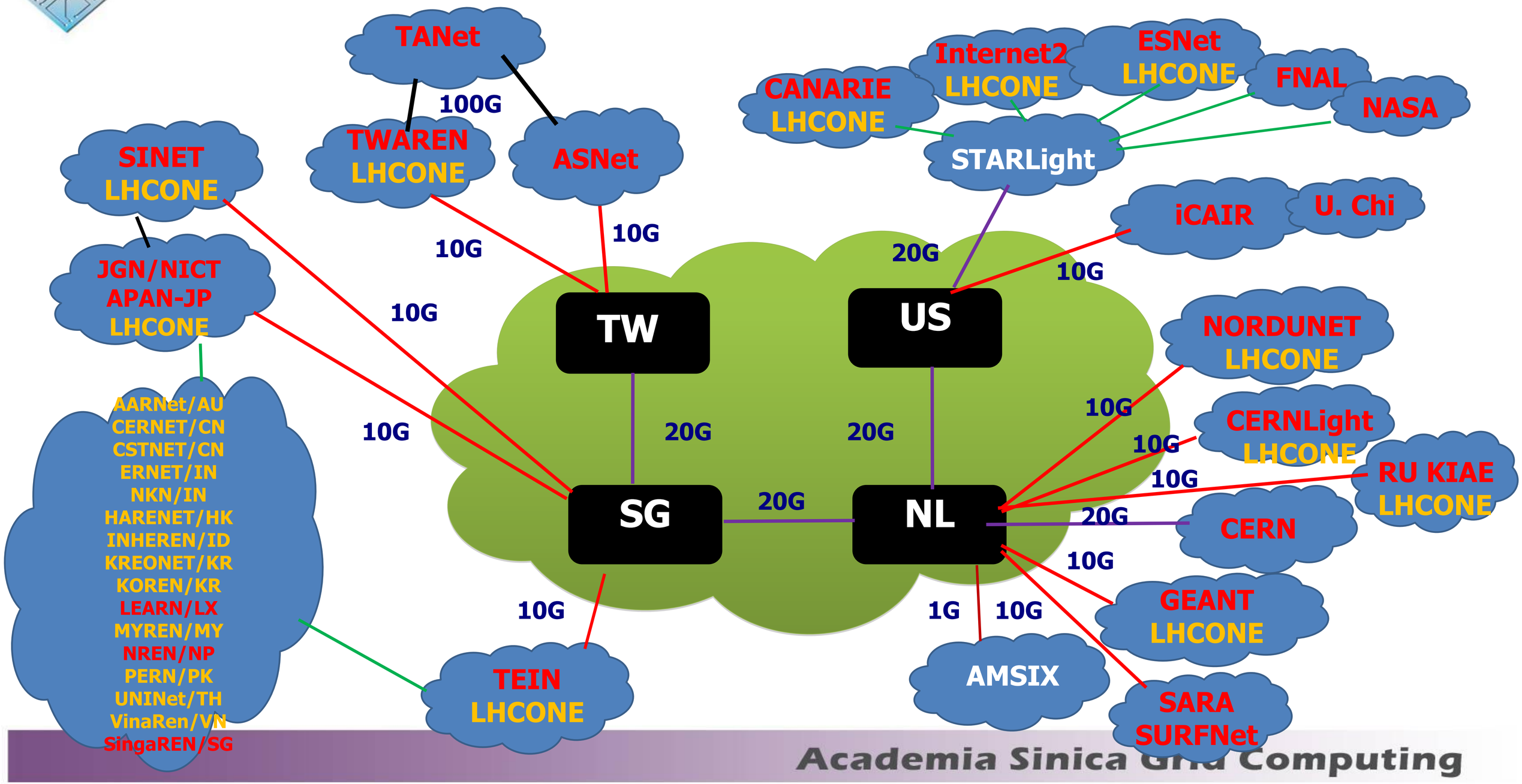


ASGC Global Network
1 Sep. 2018

TAIWAN Global R&E Network



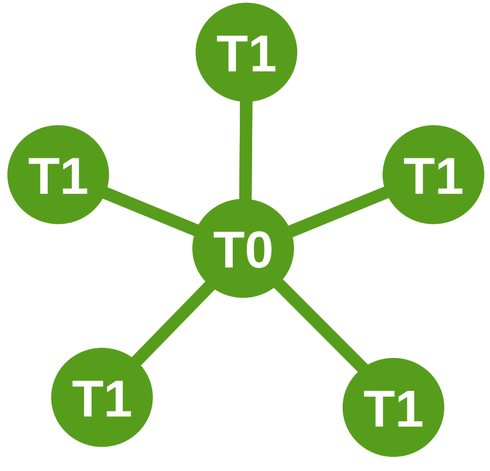
ASGC e-Science Global Network



LHCOPN

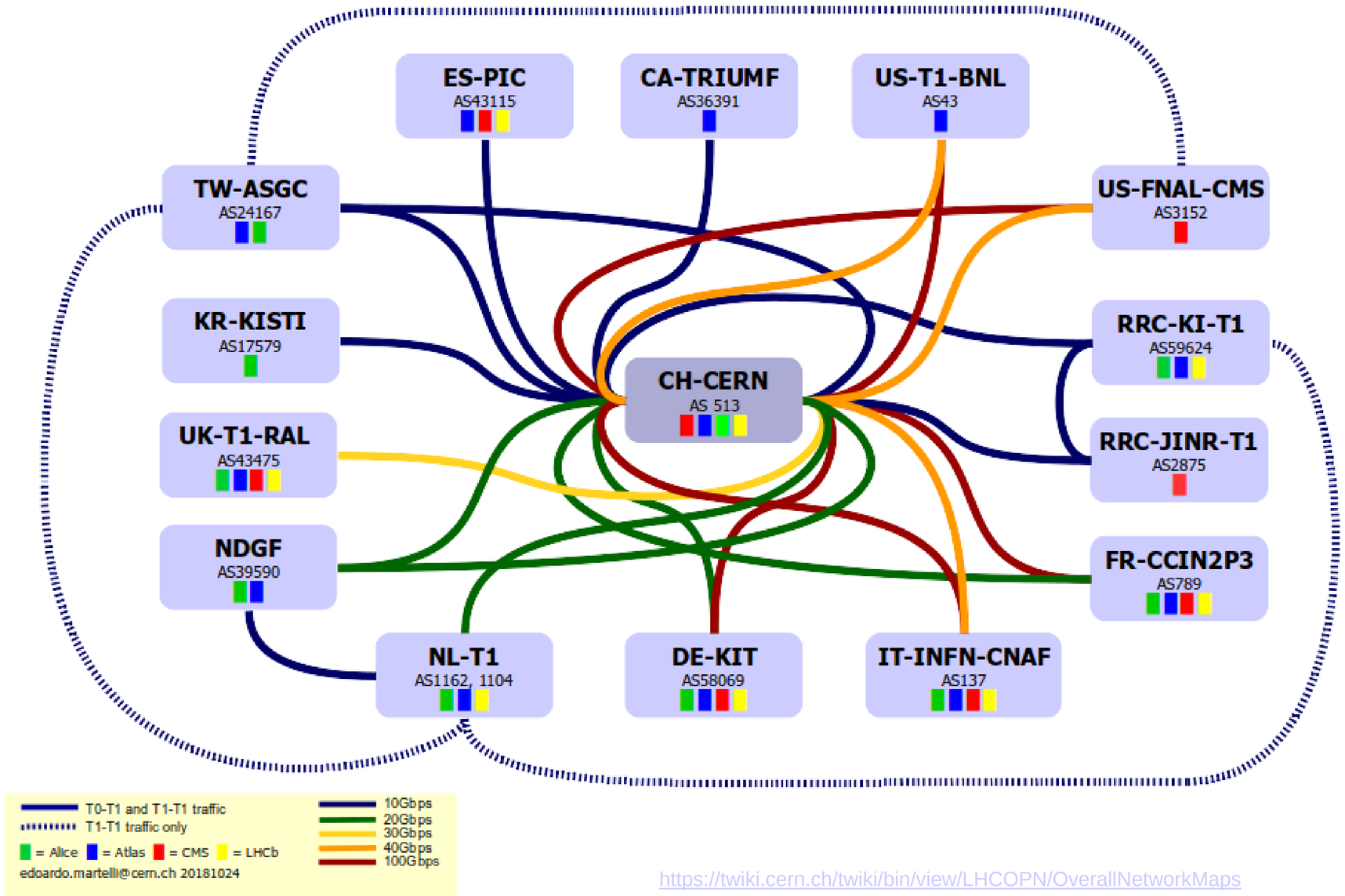
Private network connecting Tier0 and Tier1s

- Dedicated to LHC data transfers and analysis
- Secured: only declared IP prefixes can exchange traffic
- Advanced routing: communities for traffic engineering, load balancing.



LHCOPN

LHCOPN

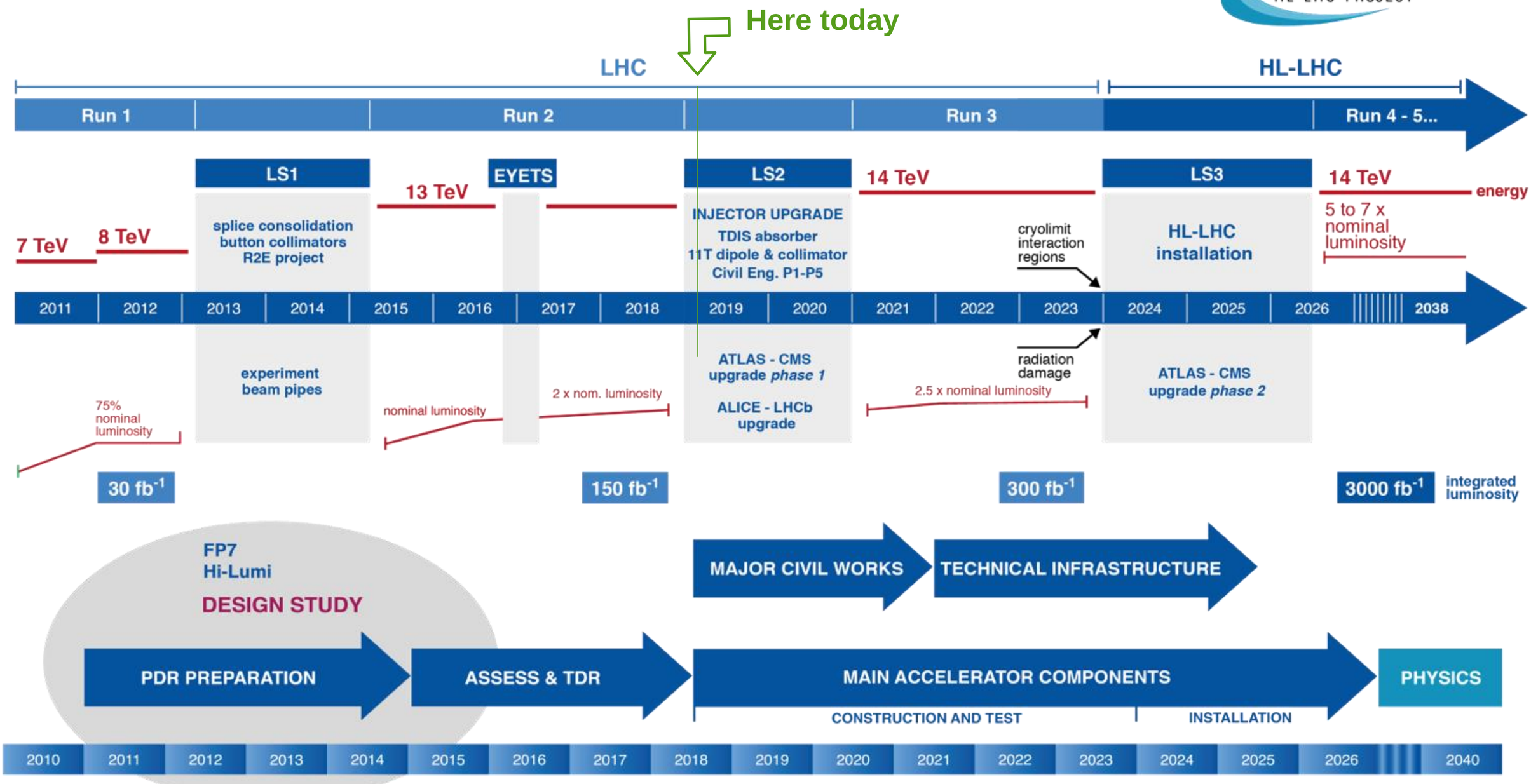


https://twiki.cern.ch/twiki/bin/view/LHCOPN/OverallNetworkMaps

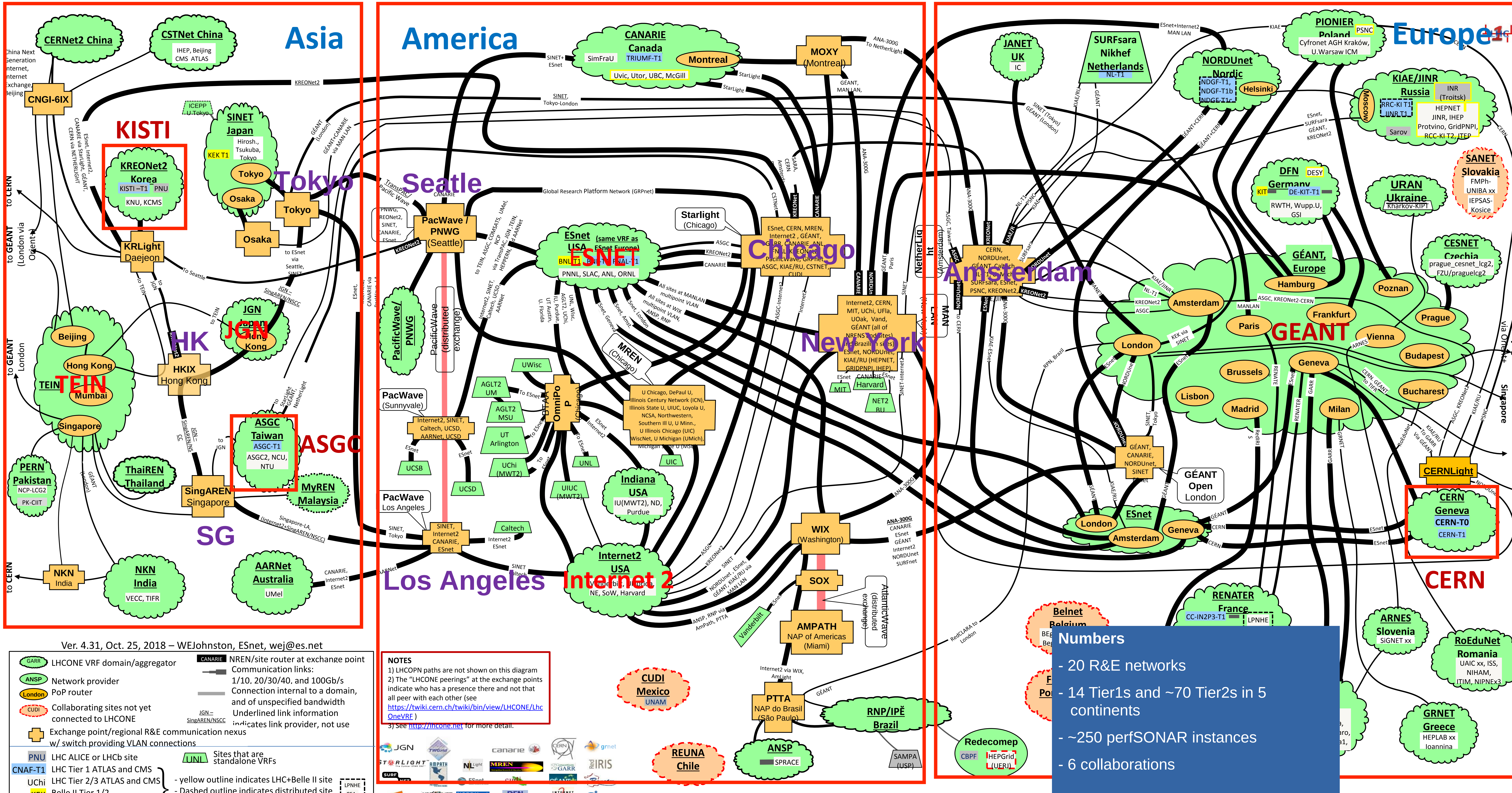
Numbers

- 14 Tier1s + 1 Tier0
- 12 countries in 3 continents
- Dual stack IPv4-IPv6
- 660 Gbps to the Tier0
- Moved ~160 PB in the last year

HL-LHC plan


Here today
LHC
HL-LHC
Run 1
Run 2
Run 3
Run 4 - 5...
LS1
EYETS
LS2
LS3
14 TeV
14 TeV
energy
7 TeV
8 TeV
13 TeV
splice consolidation
button collimators
R2E project
INJECTOR UPGRADE
TDIS absorber
11T dipole & collimator
Civil Eng. P1-P5
cryolimit
interaction
regions
HL-LHC
installation
5 to 7 x
nominal
luminosity
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2038
experiment
beam pipes
ATLAS - CMS
upgrade phase 1
ALICE - LHCb
upgrade
radiation
damage
ATLAS - CMS
upgrade phase 2
75%
nominal
luminosity
nominal luminosity
2 x nom. luminosity
2.5 x nominal luminosity
30 fb-1
150 fb-1
300 fb-1
3000 fb-1
integrated
luminosity
FP7
Hi-Lumi
DESIGN STUDY
MAJOR CIVIL WORKS
TECHNICAL INFRASTRUCTURE
PDR PREPARATION
ASSESS & TDR
MAIN ACCELERATOR COMPONENTS
PHYSICS
CONSTRUCTION AND TEST
INSTALLATION
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2040

LHCONE VRF: A global high performance Science DMZ network infrastructure for High Energy Physics data analysis
(LHC, Belle II, Pierre Auger Observatory, NOvA, XENON, DUNE)
Bold black lines in the following plot are 100Gb/s backbone of LHCONE to support the ExaBytes science data transfer

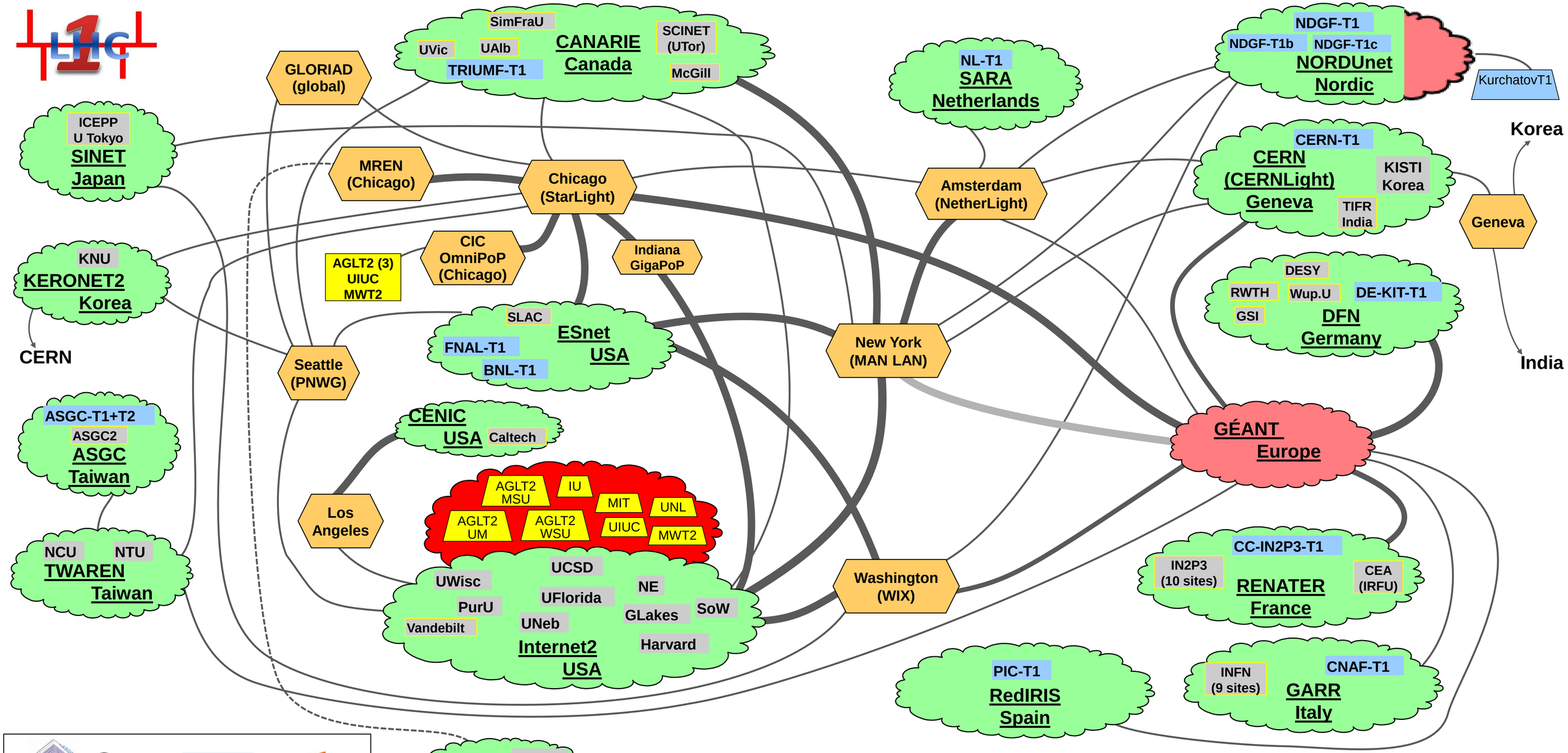


Numbers

- 20 R&E networks
- 14 Tier1s and ~70 Tier2s in 5 continents
- ~250 perfSONAR instances
- 6 collaborations

LHCONE: A global infrastructure for the LHC Tier1 data center and Tier 2/3 analysis center connectivity

LHCONE workshop @ APAN 38 (2014)



12 August 2014

LHCONE VRF domain

LHCONE VRF aggregator networks

Chicago Regional R&E communication nexus

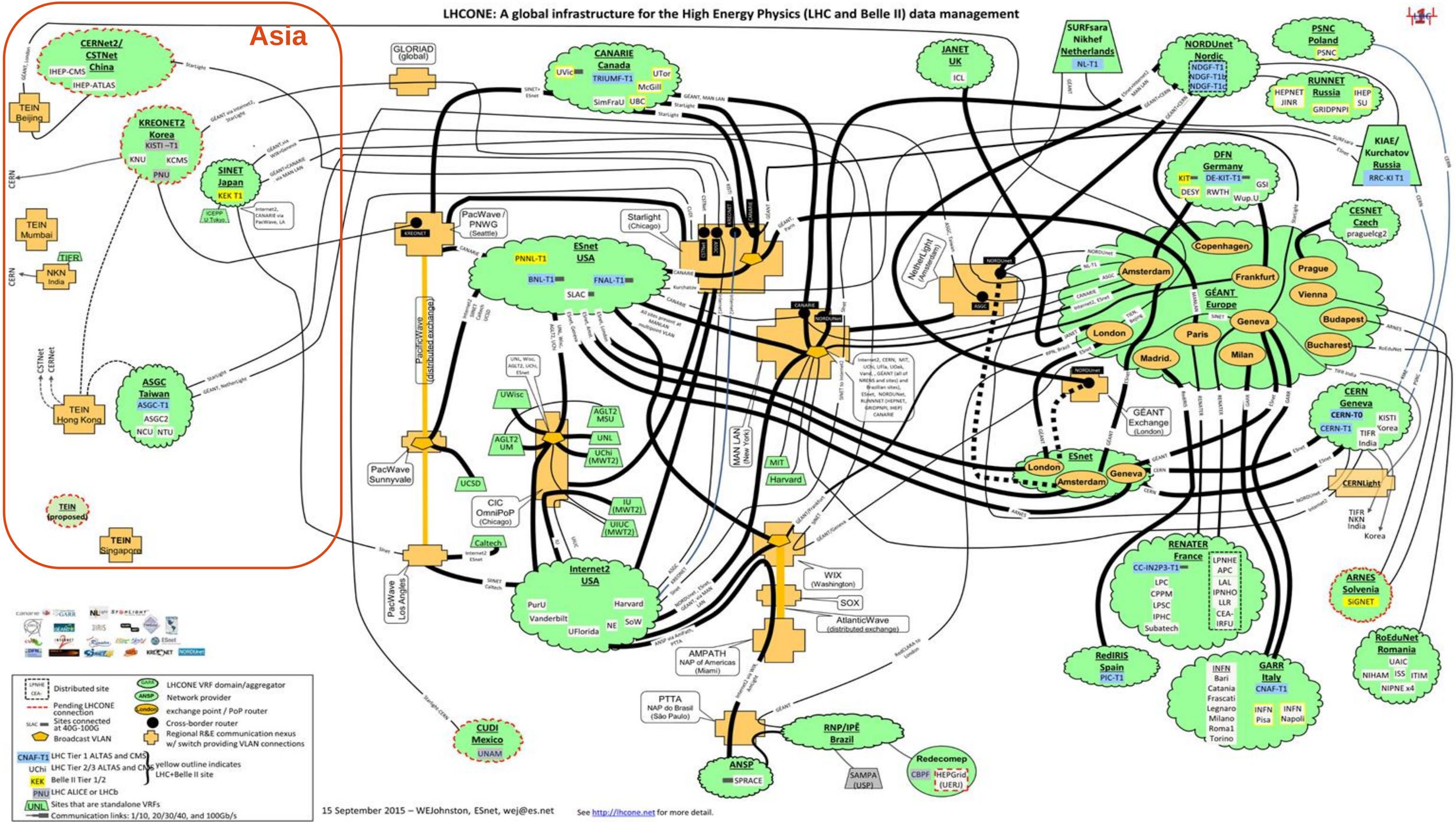
NTU End sites – LHC Tier 2/3 unless indicated as Tier 1

UNL Sites that are standalone VRFs

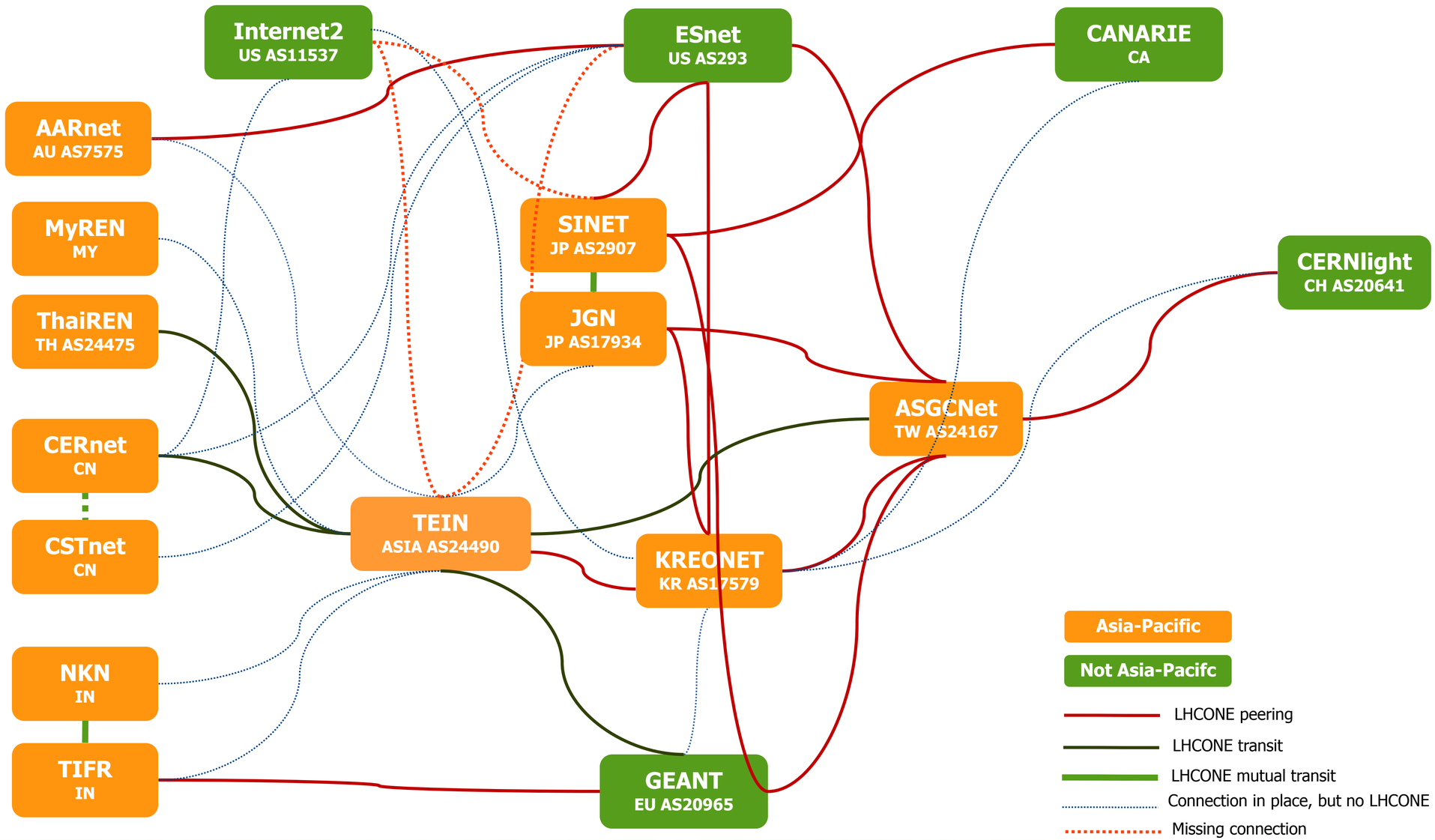
Communication links, 10, 20, 30, and 100Gb/s

See http://lhcone.net for details.

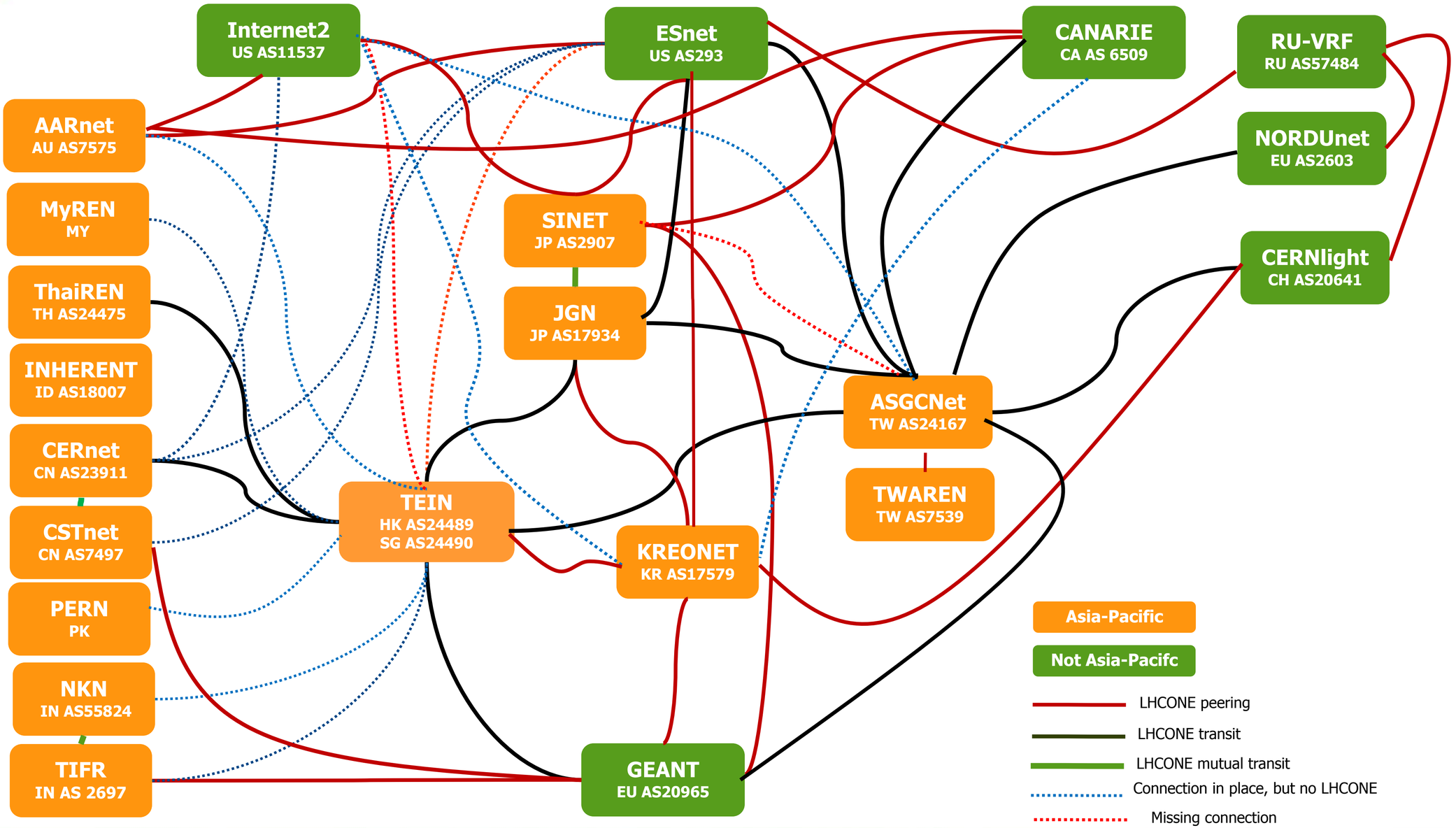
Progresses made in Asia since 2015



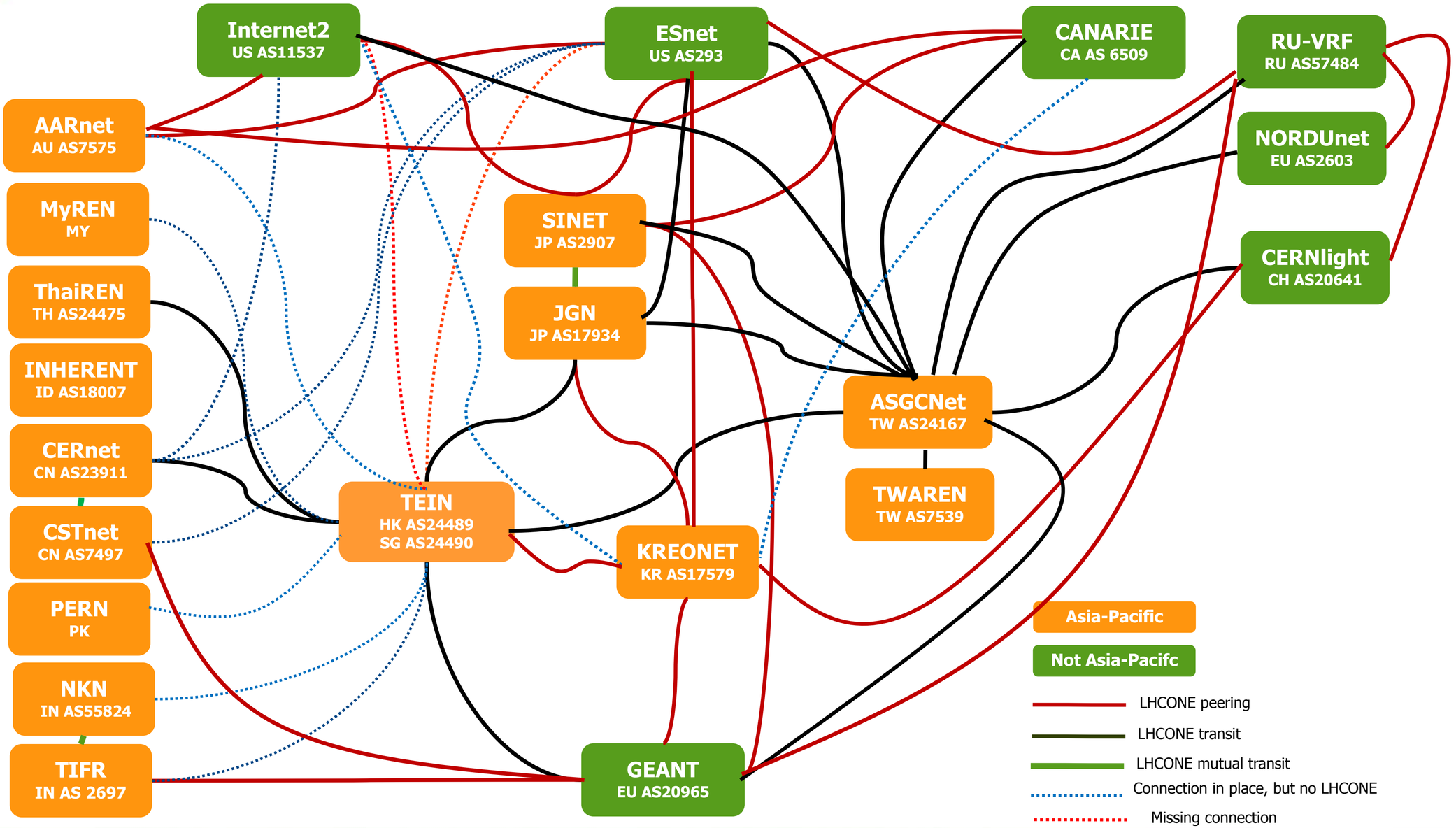
Asia-Pacific VRFs 2017



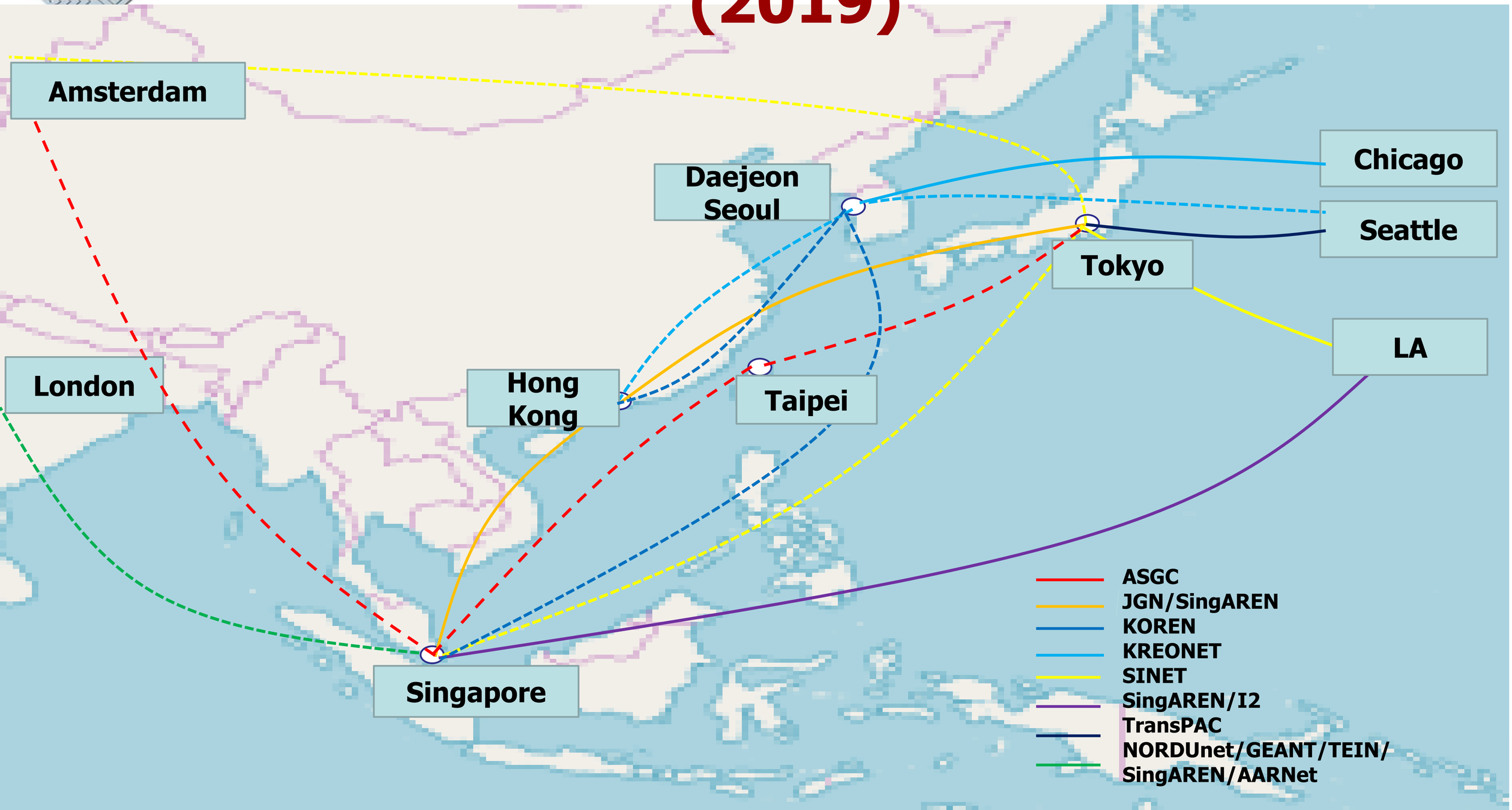
Asia-Pacific VRFs 2018



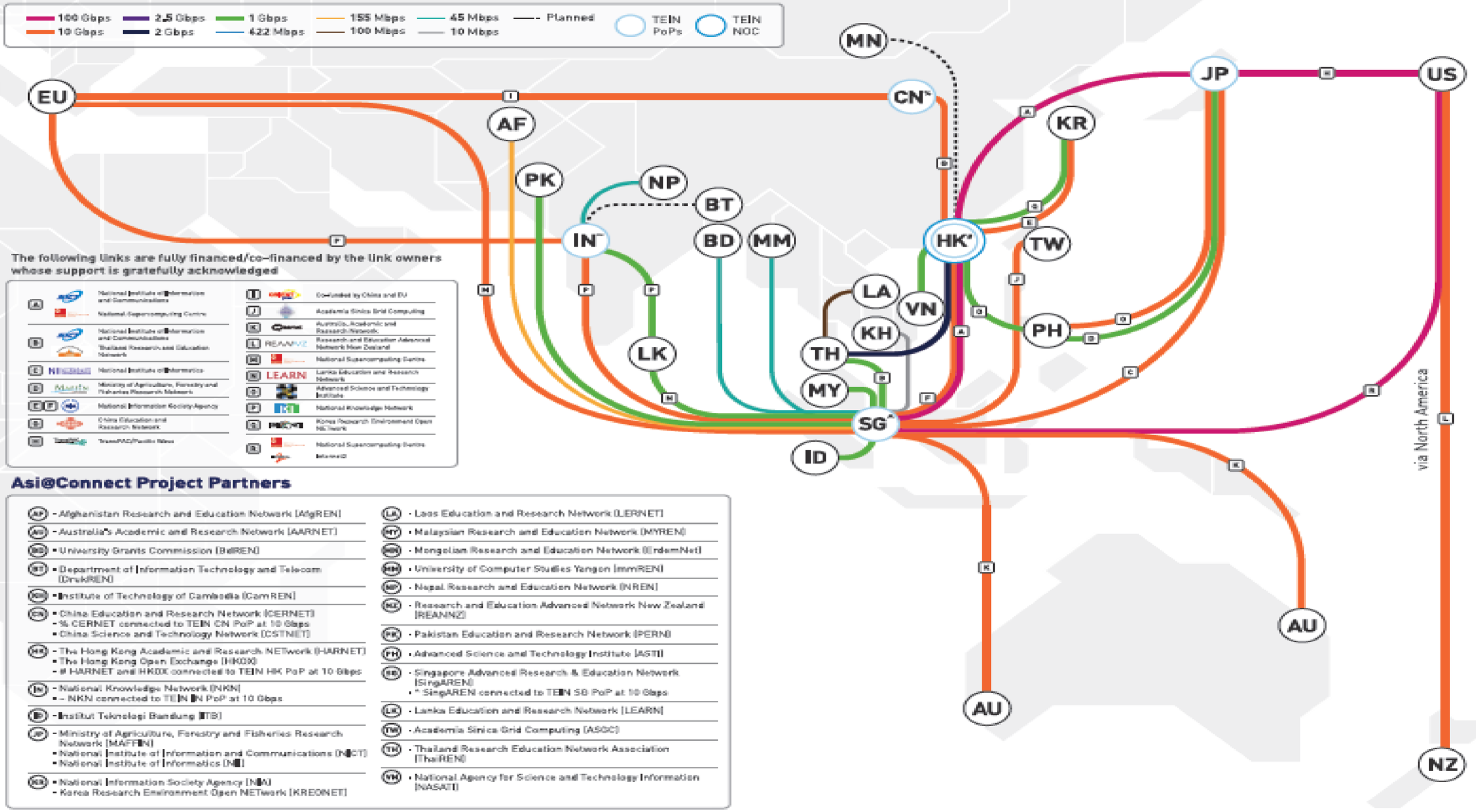
Asia-Pacific VRFs 2019



100G Deployment in Asia (2019)



TEIN Map



The following links are fully financed/co-financed by the link owners whose support is gratefully acknowledged

- A — National Institute of Information and Communications; National Supercomputing Centre
- B — National Institute of Information and Communications; Thailand Research and Education Network
- E — National Institute of Informatics
- E — Ministry of Agriculture, Forestry and Fisheries Research Network
- E F — National Information Society Agency
- G — China Education and Research Network
- H — TransPAC/Pacific Wave
- I — CoreLink by China and EU
- J — Academia Sinica Grid Computing
- K — AARNet, Academic and Research Network
- L — REANNZ, Research and Education Advanced Network New Zealand
- M — National Supercomputing Centre
- N — Lanka Education and Research Network
- O — Advanced Science and Technology Institute
- P — National Knowledge Network
- Q — Korea Research Environment Open NETwork
- R — National Supercomputing Centre; Internet2

Asi@Connect Project Partners

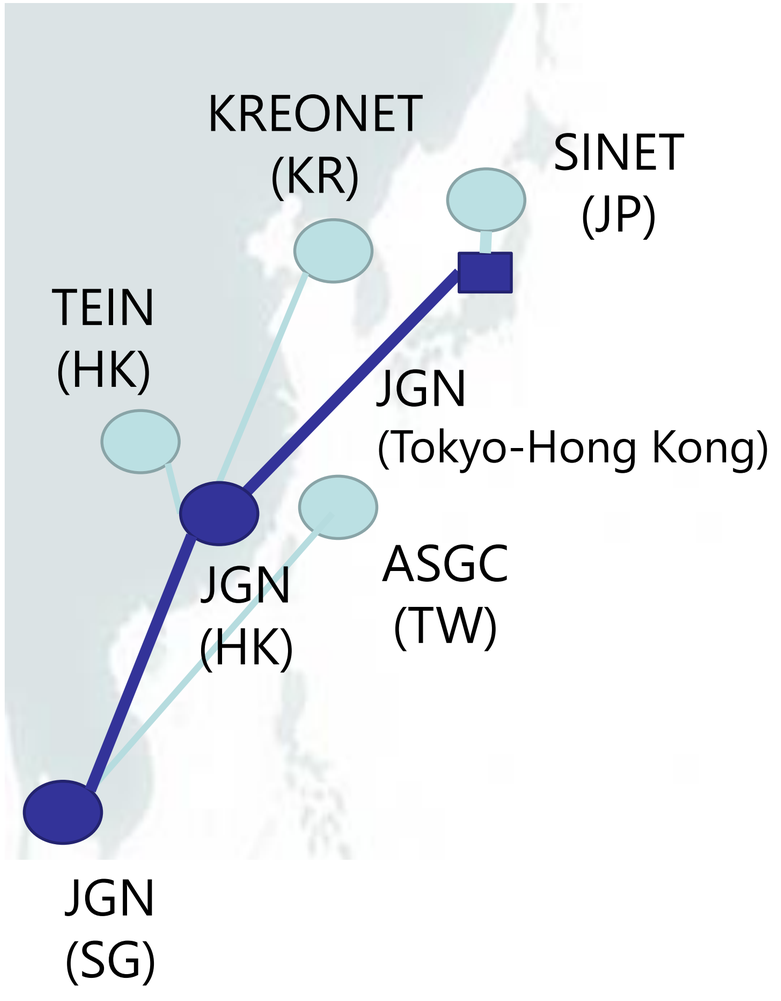
- AF - Afghanistan Research and Education Network (AfgREN)
- AU - Australia's Academic and Research Network (AARNET)
- BD - University Grants Commission (BdREN)
- BT - Department of Information Technology and Telecom (DrukREN)
- KH - Institute of Technology of Cambodia (CamREN)
- CN - China Education and Research Network (CERNET)
  - % CERNET connected to TEIN CN PoP at 10 Gbps
  - China Science and Technology Network (CSTNET)
- HK - The Hong Kong Academic and Research NETwork (HARNET)
  - The Hong Kong Open Exchange (HKOX)
  - # HARNET and HKOX connected to TEIN HK PoP at 10 Gbps
- IN - National Knowledge Network (NKN)
  - – NKN connected to TEIN IN PoP at 10 Gbps
- ID - Institut Teknologi Bandung (ITB)
- JP - Ministry of Agriculture, Forestry and Fisheries Research Network (MAFFIN)
  - National Institute of Information and Communications (NICT)
  - National Institute of Informatics (NII)
- KR - National Information Society Agency (NIA)
  - Korea Research Environment Open NETwork (KREONET)
- LA - Laos Education and Research Network (LERNET)
- MY - Malaysian Research and Education Network (MYREN)
- MN - Mongolian Research and Education Network (ErdemNet)
- MM - University of Computer Studies Yangon (mmREN)
- NP - Nepal Research and Education Network (NREN)
- NZ - Research and Education Advanced Network New Zealand (REANNZ)
- PK - Pakistan Education and Research Network (PERN)
- PH - Advanced Science and Technology Institute (ASTI)
- SG - Singapore Advanced Research & Education Network (SingAREN)
  - * SingAREN connected to TEIN SG PoP at 10 Gbps
- LK - Lanka Education and Research Network (LEARN)
- TW - Academia Sinica Grid Computing (ASGC)
- TH - Thailand Research Education Network Association (ThaiREN)
- VN - National Agency for Science and Technology Information (NASATI)

* As of October 2018, Ongoing updates

** Other regions (Central Asia, Africa and Latin America) can be connected via global R&E networks such as EU(GÉANT) and US(Internet2)

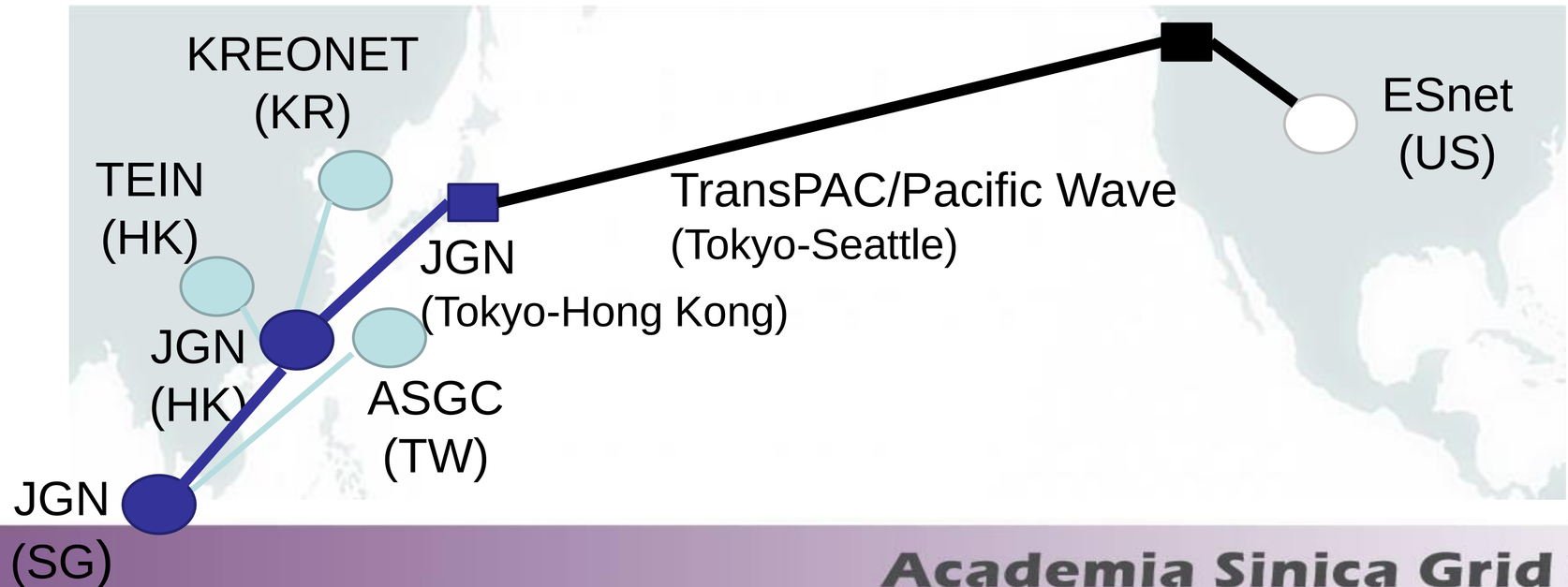
JGN supports LHCONE in Asia

- JGN started the operation of LHCONE router at Hong Kong
  - Big science is a driving force of next-gen ICT infrastructure
- Under the collaboration with SINET, JGN supports LHCONE between Japanese and Asian academic organizations
  - JGN established LHCONE peering with SINET, KREONET, ASGC, and TEIN-HK

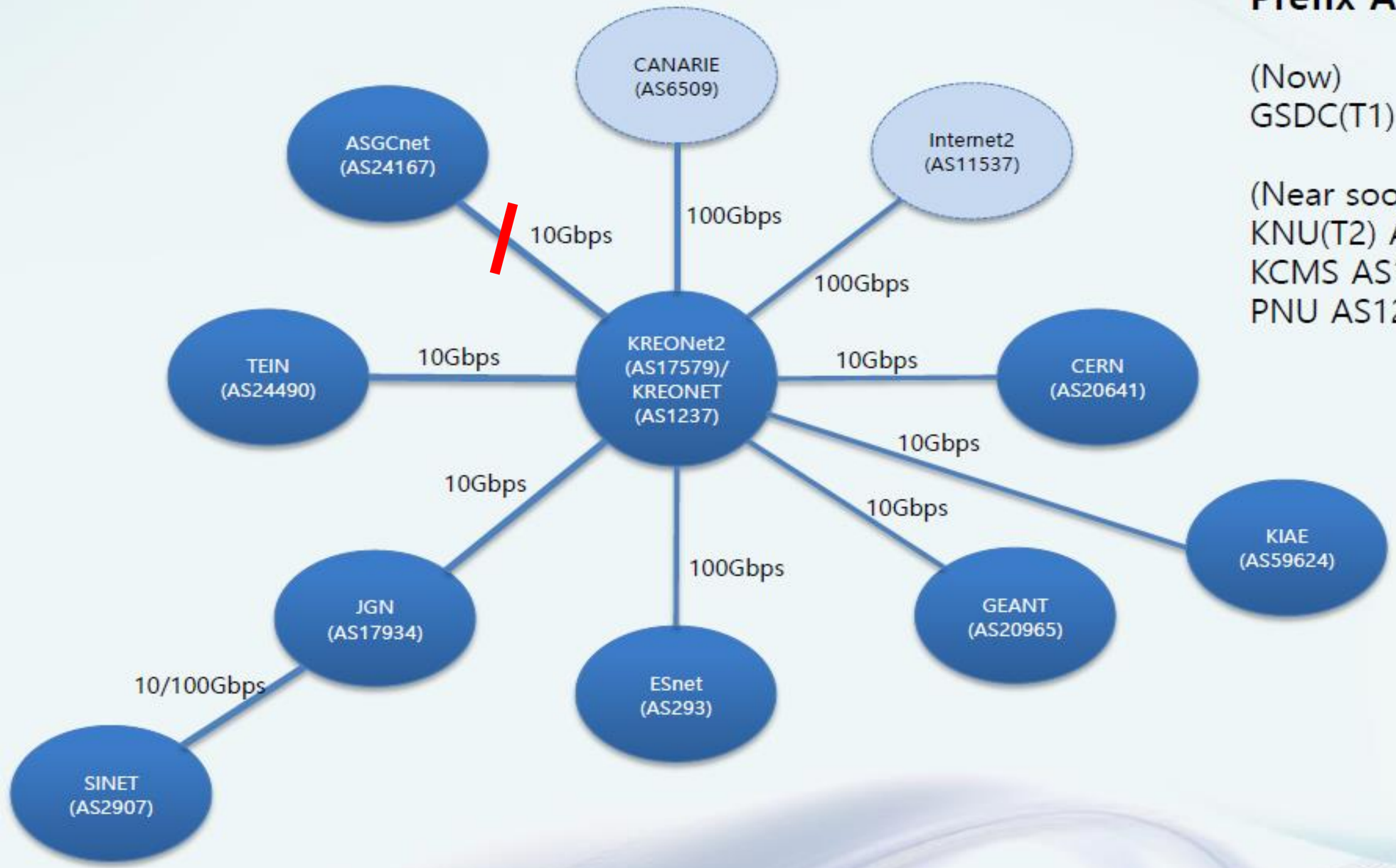


LHCONE between ESnet and Asia

- JGN also started the support of LHCONE between ESnet and Asia
  - JGN established LHCONE peering with ESnet, and exchange routing information between ESnet and Asia (TEIN-HK, ASGC, KREONET)
  - This is under the mutual cooperation with TransPAC
    - We also thank to WIDE to support the interconnection between JGN and TransPAC/Pacific Wave in Tokyo



KREONET/KREONet2 LHCONE VRF Peering

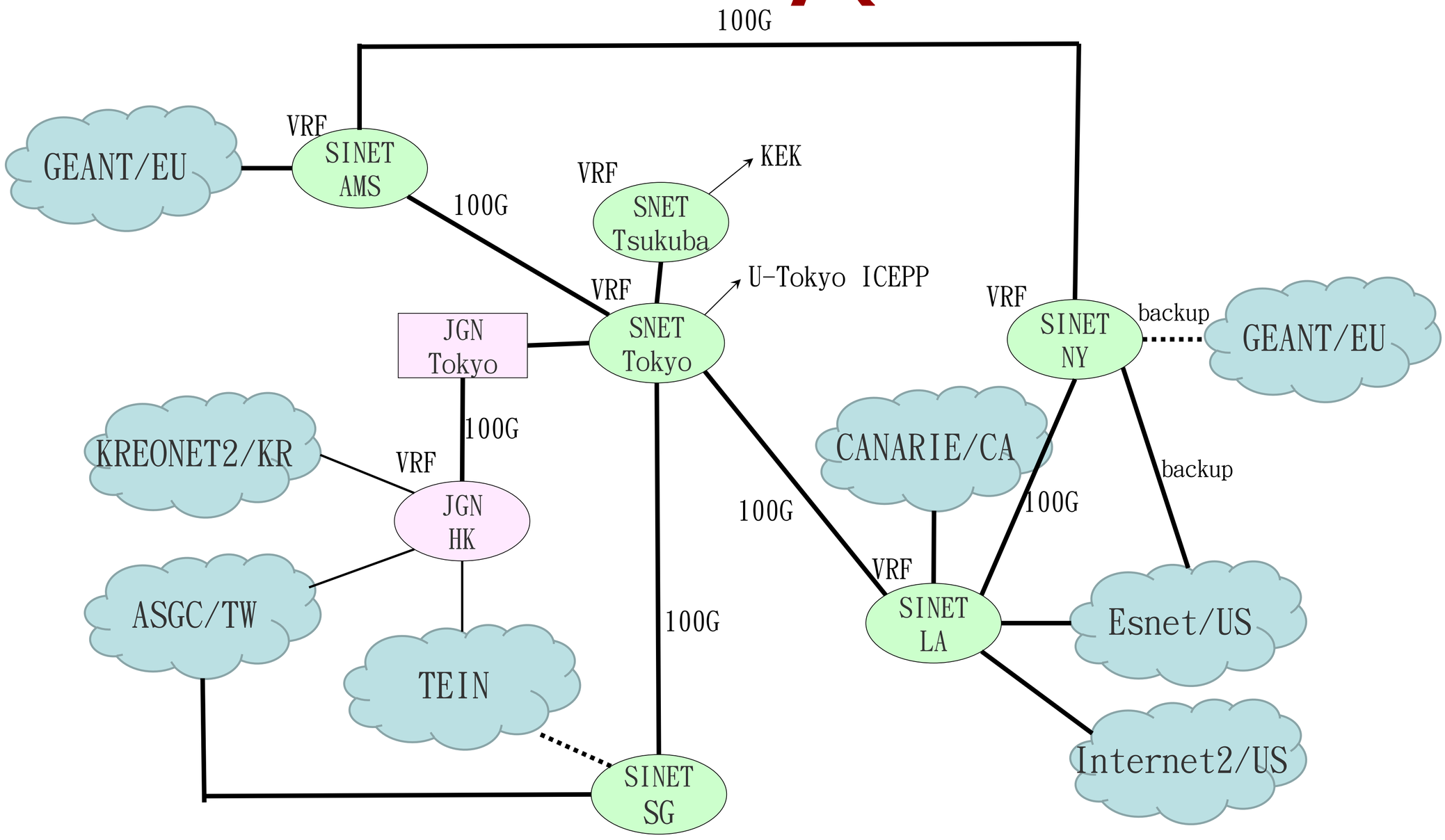


Prefix Advertising

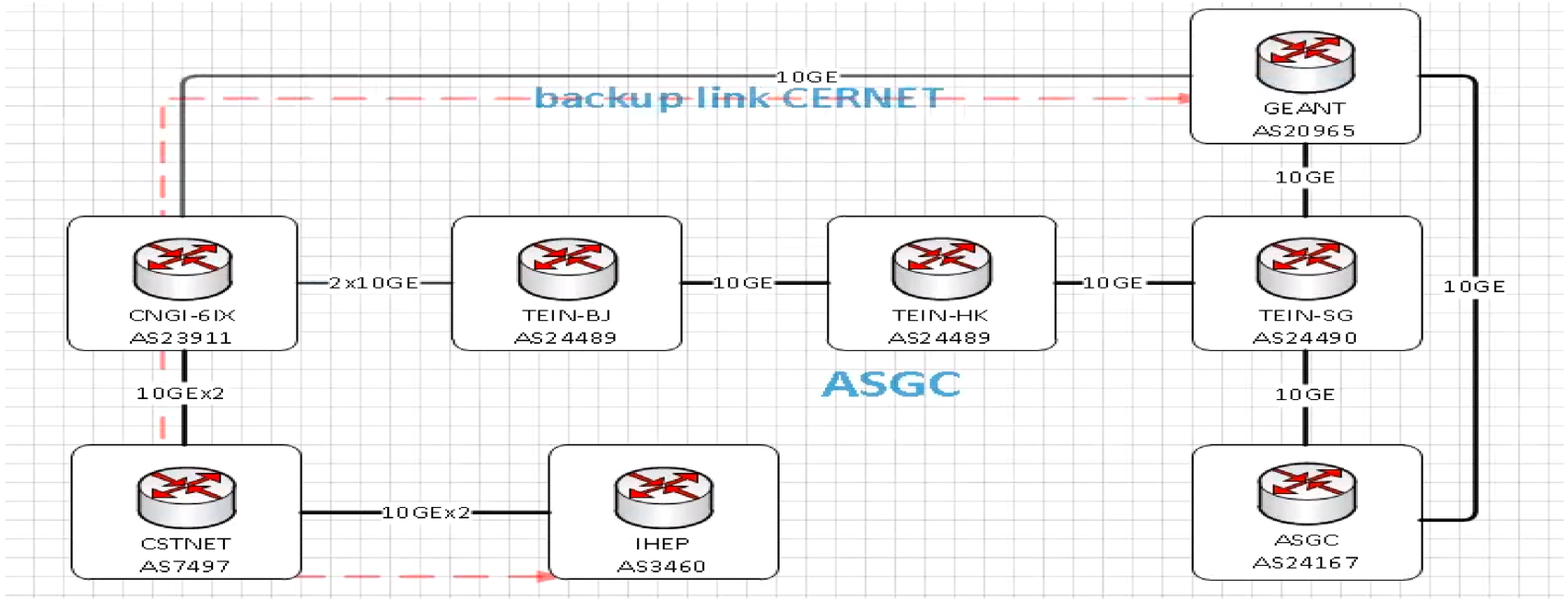
(Now)
GSDC(T1) AS17579 134.75.125.0/24

(Near soon)
KNU(T2) AS1237 155.230.20.0/22
KCMS AS1237 210.117.209.0/25
PNU AS1237 203.253.142.0/24

LHCONE Connectivity (Draft Plan in 2019)



LHCONE in China



- IHEP in China connected to LHCONE in Dec. 2017, Thanks to
  - CERN, CSTNet, CERNet, ASGC, GEANT, ……
- VRF Peerings have been set up for IHEP-Eur. /IHEP-ASGC
  - Peering between CNGI-6IX and TEIN in Beijing
  - VRF Peering between CNGI-6IX and GEANT (over Orient+)
  - VRF Peering between TEIN and ASGC
- More Peerings should be launched
  - Internet2、ESNet、 KREONET ……

CERN

TIFR Mumbai

TIFR Data Centre

10G

GCX P2P L3 dedicated 10G.

10G

CERN LHCONE VRF

GCX ISP CPE MUX

GEANT⇔ ESNET

CERN NKN

NKN Direct L2 peering CERN 10G

10G

10G

Grid Router

10G

Core switch

42 U 42 U 42 U 42 U

400 nodes connected with 10G and 1G

10G

10G

10G

1 G

2x10G

firewall

42 U 42 U 42 U 42 U

Internet2, ESNET, Fermilab, Caltech

NKN Amsterdam

NKN India

NKN router TIFR

Internet2, CENIC, SingAREN

NKN Singapore

TIFR ⇔ India CMS⇔ International network

VECC Kolkata

NICERs

IITs

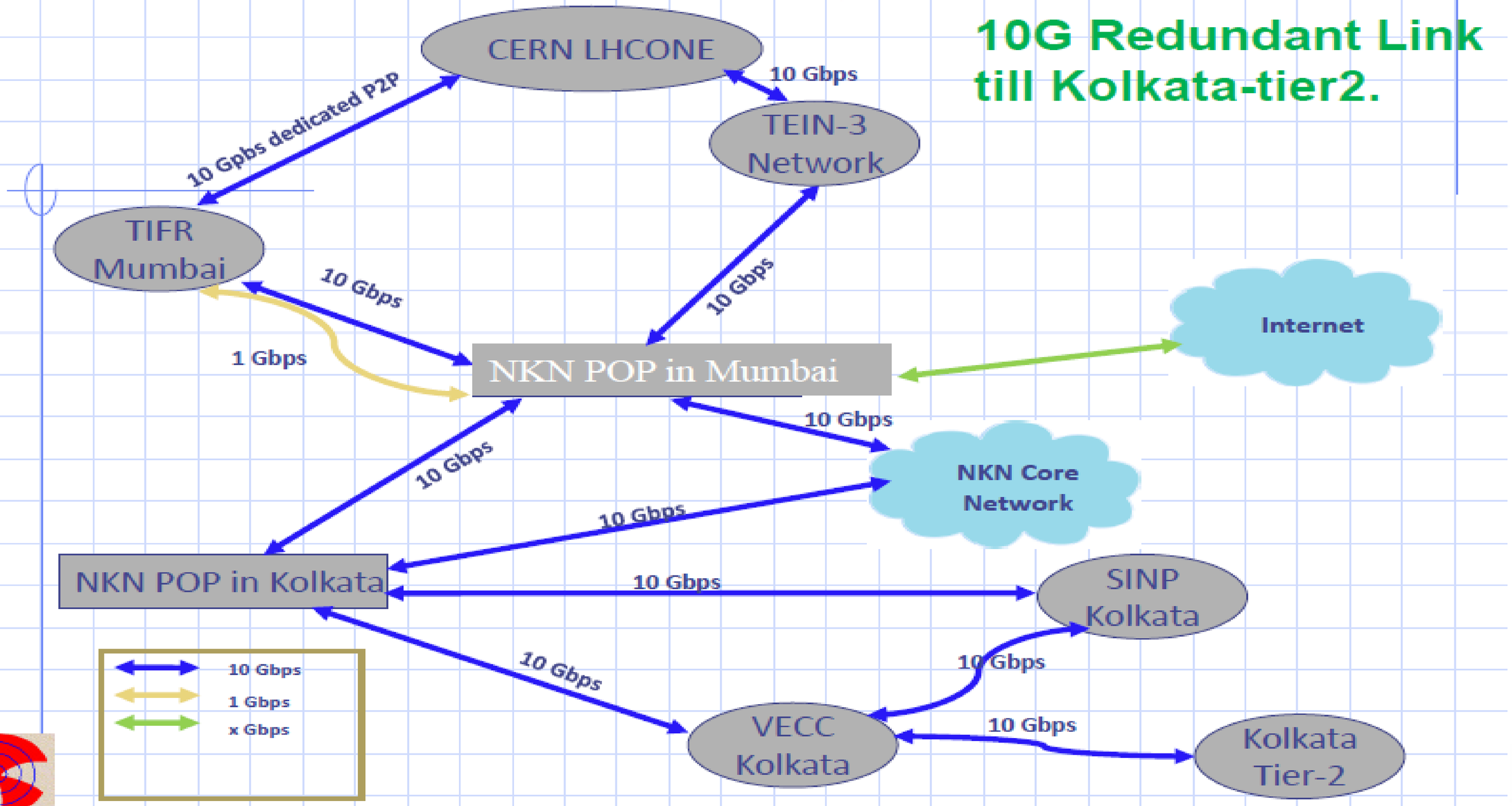
~14 Indian institutes are part of WLCG Network and growing.

IISERs

KOLKATA Tier-2@Alice Grid

Physical Network Connectivity from CERN -- Kolkata, India

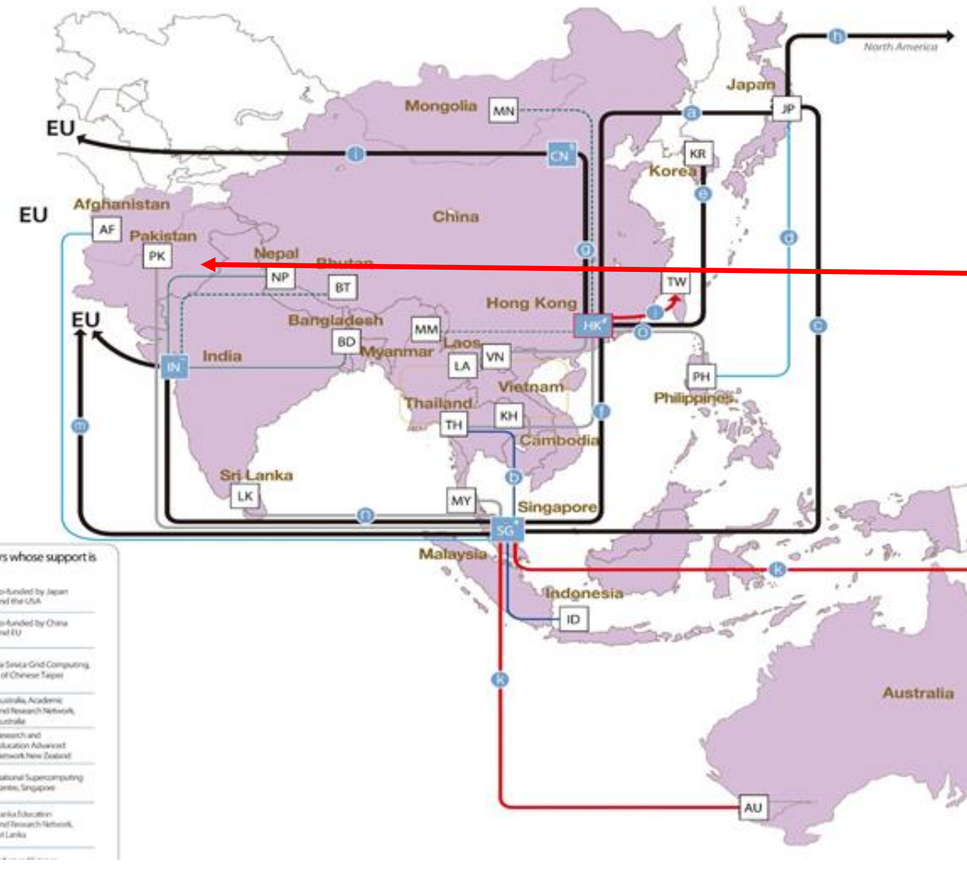
10G Redundant Link till Kolkata-tier2.



E-Infrastructure for R&D

Pakistan's National Education and Research Network, With Other NREN's through Trans-EurAsia Information Network (TEIN)

TEIN
Connecting Asia and Europe's Research and Education Communities
www.tein.asia



TEIN Project Partners

AF Afghanistan	ID Indonesia	NZ New Zealand
AU Australia	JP Japan	PK Pakistan
BD Bangladesh	KR Korea	PH Philippines
BT Bhutan	LA Laos	SG Singapore
KH Cambodia	MM Myanmar	LK Sri Lanka
CN China	MN Mongolia	TH Thailand
HK Hong Kong	MY Malaysia	TW Taiwan
IN India	NP Nepal	VN Vietnam

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- a, b, c, d, e, f: NICT, National Institute of Information and Communications, Japan; Thailand Research and Education Network, Thailand; National Institute of Informatics, Japan; MAFFIN, Ministry of Agriculture, Forestry and Fisheries Research Network, Japan; NIA, National Information Society Agency, South Korea
- h: TransPAC, co-funded by Japan and the USA
- i: ORIENTplus, co-funded by China and EU
- j: ASGC, Academia Sinica Grid Computing, Republic of Chinese Taipei
- k: aarnet, Australia, Academic and Research Network, Australia
- l: REANNZ, Research and Education Advanced Network New Zealand
- m: National Supercomputing Centre, Singapore
- n: LEARN, Lanka Education and Research Network, Sri Lanka

- **155 Mbps Bandwidth in 2008**
- **Upgraded bandwidth 1Gbps in 2015**

Digging in the LHCONE routing table

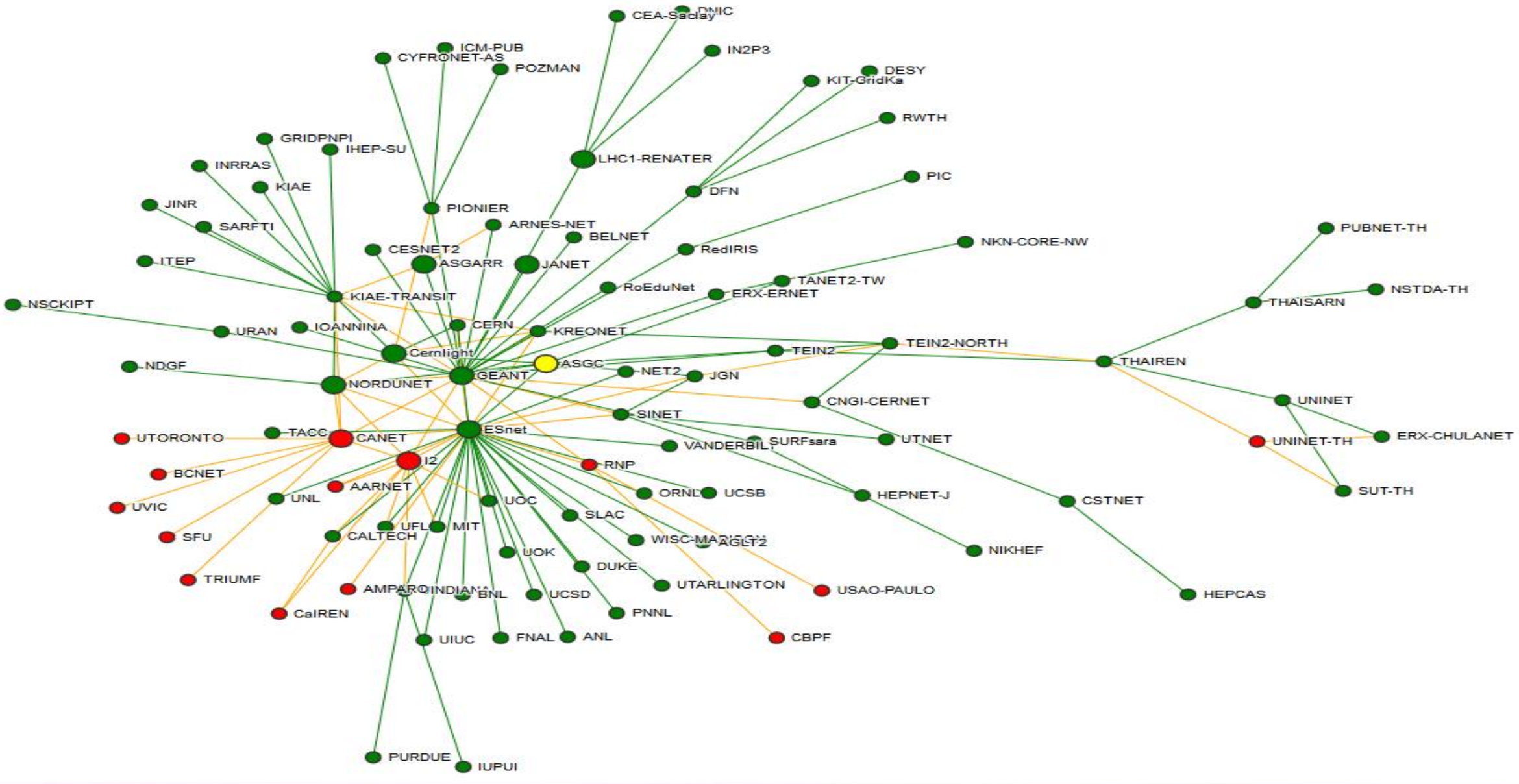
NORDUnet has run an analyses of the routing tables of most of the LHCONE VRFs.

It resulted that **reachability is fragmented**, especially on IPv6:
- Only GEANT has a full view of all LHCONE destinations
- Especially the sites behind TEIN cannot reach a fraction of LHCONE

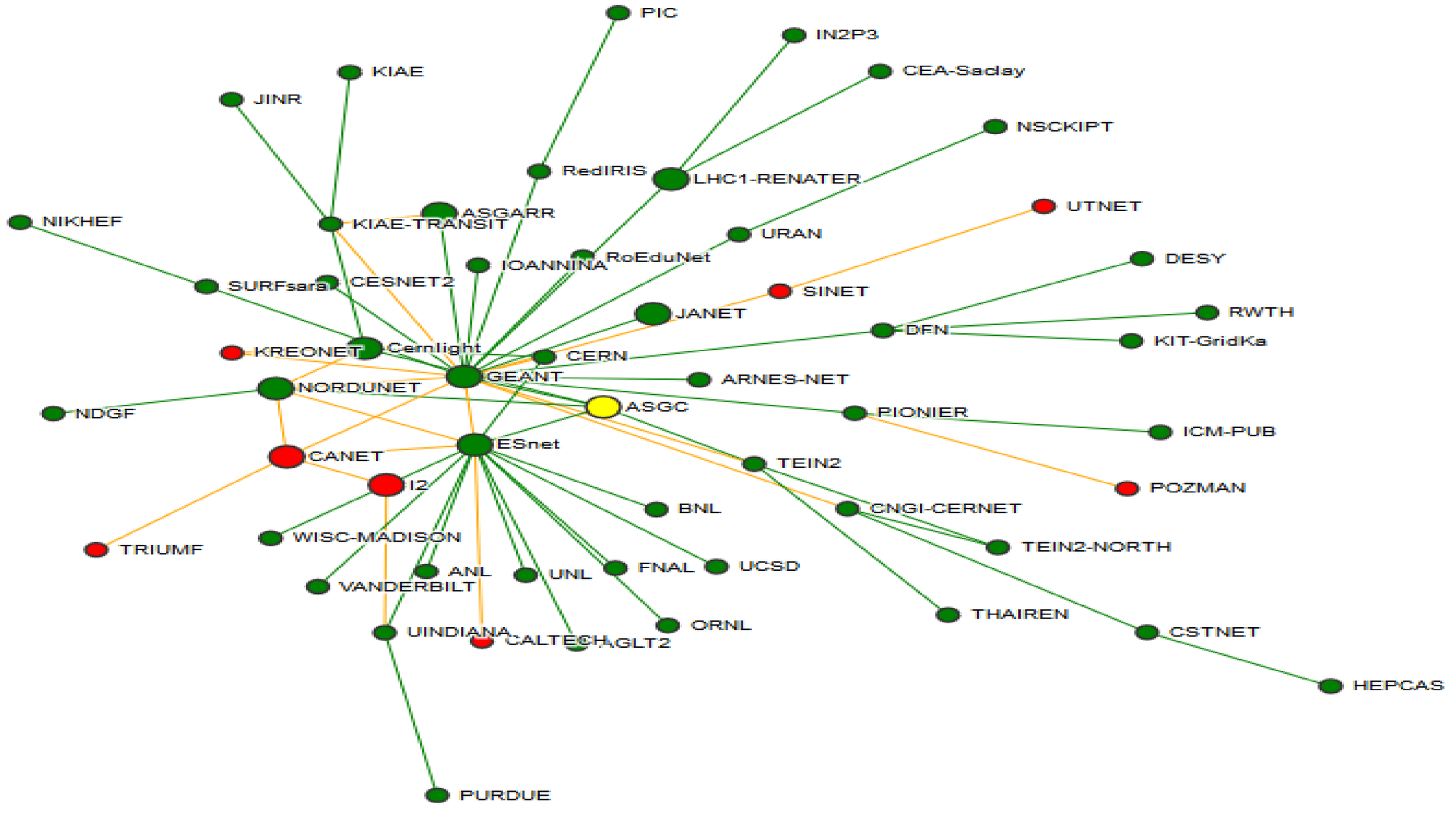
IPv4 reachability map:
https://indico.cern.ch/event/725706/contributions/3149436/attachments/1744301/2823447/go
IPv6 reachability map:
https://indico.cern.ch/event/725706/contributions/3149436/attachments/1744301/2823448/go

The community will work on improving this situation, which will be followed-up in the future meetings

ASGC LHCONE IPv4 Reachability



ASGC LHCONE IPv6 Reachability



LHCONE Looking Glass

- At the LHCONE meeting of March 2018 it was decided to implement a **tool to analyze the routing tables of the different VRFs**
- For this, a Route Server and a Looking Glass web interface have been set up at CERN
- The looking glass can show the prefixes known in the different VRFs and the attributes of the routes
- At the moment the route-server peers with CERNlight and NORDUnet VRFs only. Other peerings will be added in the coming months

The looking glass is accessible at http://lhcone-lg.cern.ch/

Comment/Suggestion

- LHCONE Transit between Asia-US and Asia-EU
  - ASGC, JGN/TransPAC, TEIN/GEANT
- Avoid asymmetric route between Asia and US/EU
- MTU size 9000
- … etc

Following LHCONE/LHCOPN meeting

- 4~5 June 2019, Umeå University, Sweden
  - https://indico.cern.ch/event/772031/
- January 2020: Workshop at CERN with LHC experiments
- March 2020: co-located with ISGC in Taipei

Thanks

- Tony Cass, Edoardo Martelli (CERN)
- William (Bill) Johnston, Michael OConnor (ESnet)
- Vincenzo Capone (GÉANT)
- Lars Fischer, Magnus Bergroth (NORDUnet)
- Andrew Lee (TransPAC)
- Hiroshi Sakamoto (U. Tokyo)
- Tomoaki Nakamura (KEK)
- Eiji Kawai (JGN/NICT)
- Motonori Nakamura (SINET/NII)
- Patch Lee, Zhonghui Li (Asi@Connect)
- Buseung Cho, Sang-Un Ahn (KISTI)
- Gang Chen, Qi Fazhi (IHEP)
- Vikas Singhal (VECC, Klokata)
- Brij Jashal (TIFR)
- Rajesh Verma (NKN, India)
- Saqib Haleem (NCP)
- … etc