Research and Education Networking EcoSystem

Campus Network Design & Operations Workshop

UNIVERSITY OF OREGON

Last updated 1st December 2019

NSRC
Network Startup Resource Center

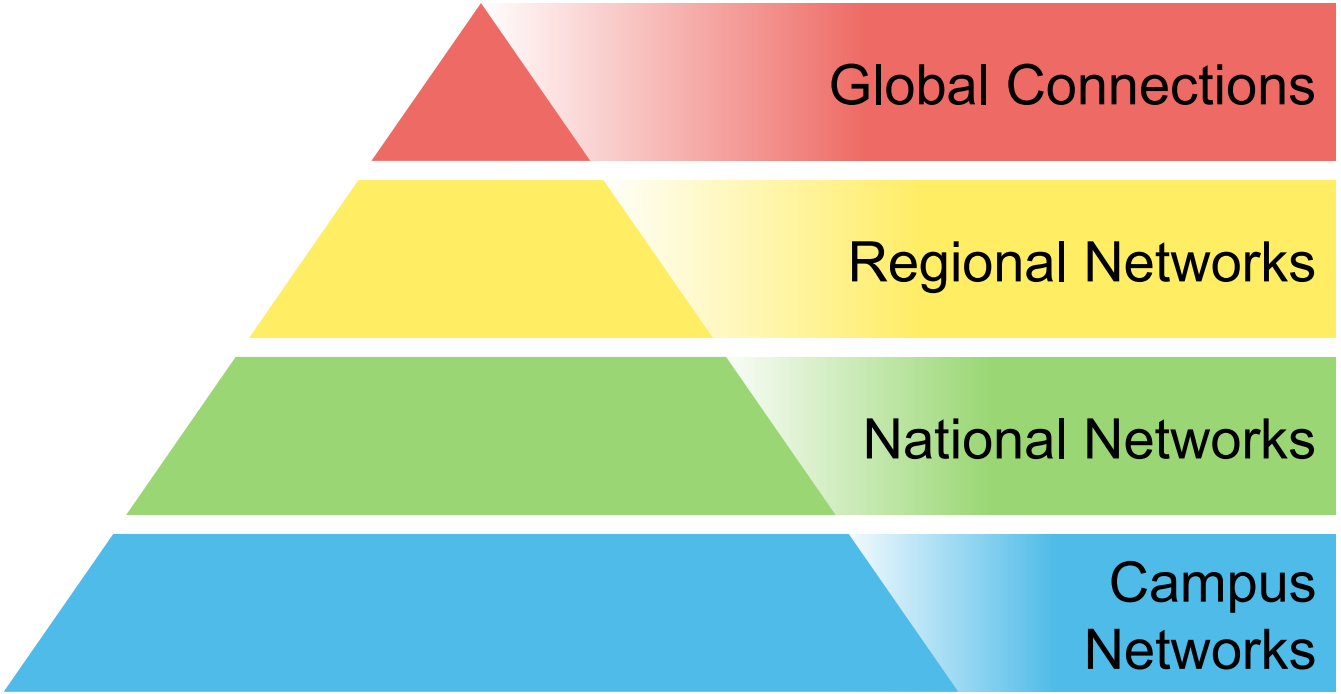
Research and Education Networks

- Some Terminology
  - Research and Education = R&E
  - Research and Education Networks = REN
  - National REN = NREN
- Globally, the REN connectivity is very complex and very difficult to understand

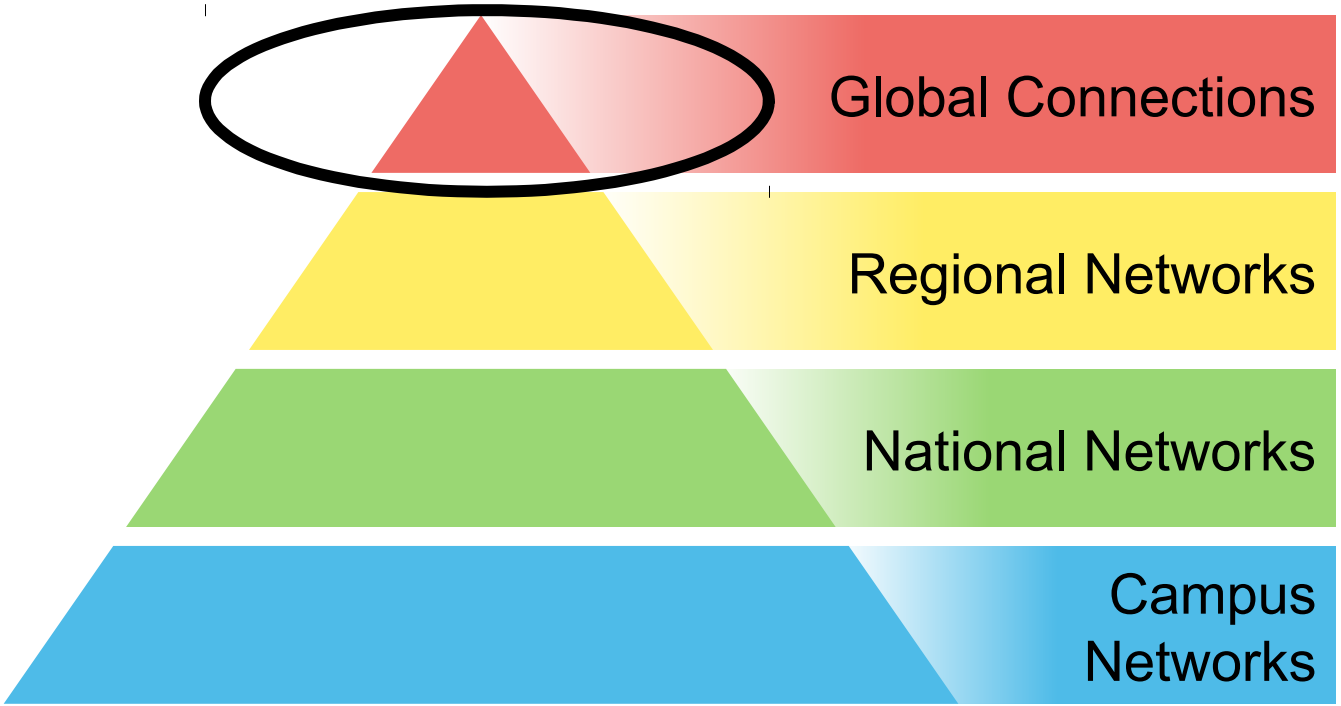
REN Characteristics

- High bandwidth networks
  - 10G backbones with more and more 40G and 100G
  - Some R&E networks are doing pilot roll-outs of 400 Gbps
  - Research typically needs uncongested networks
    - Which means many RENs are lightly used with lots of unused capacity (we call it headroom)
- Low latency
  - Terrestrial fiber
- Open Networks with no filtering
  - Firewalls can make it hard for ad-hoc activities

NREN EcoSystem



NREN EcoSystem

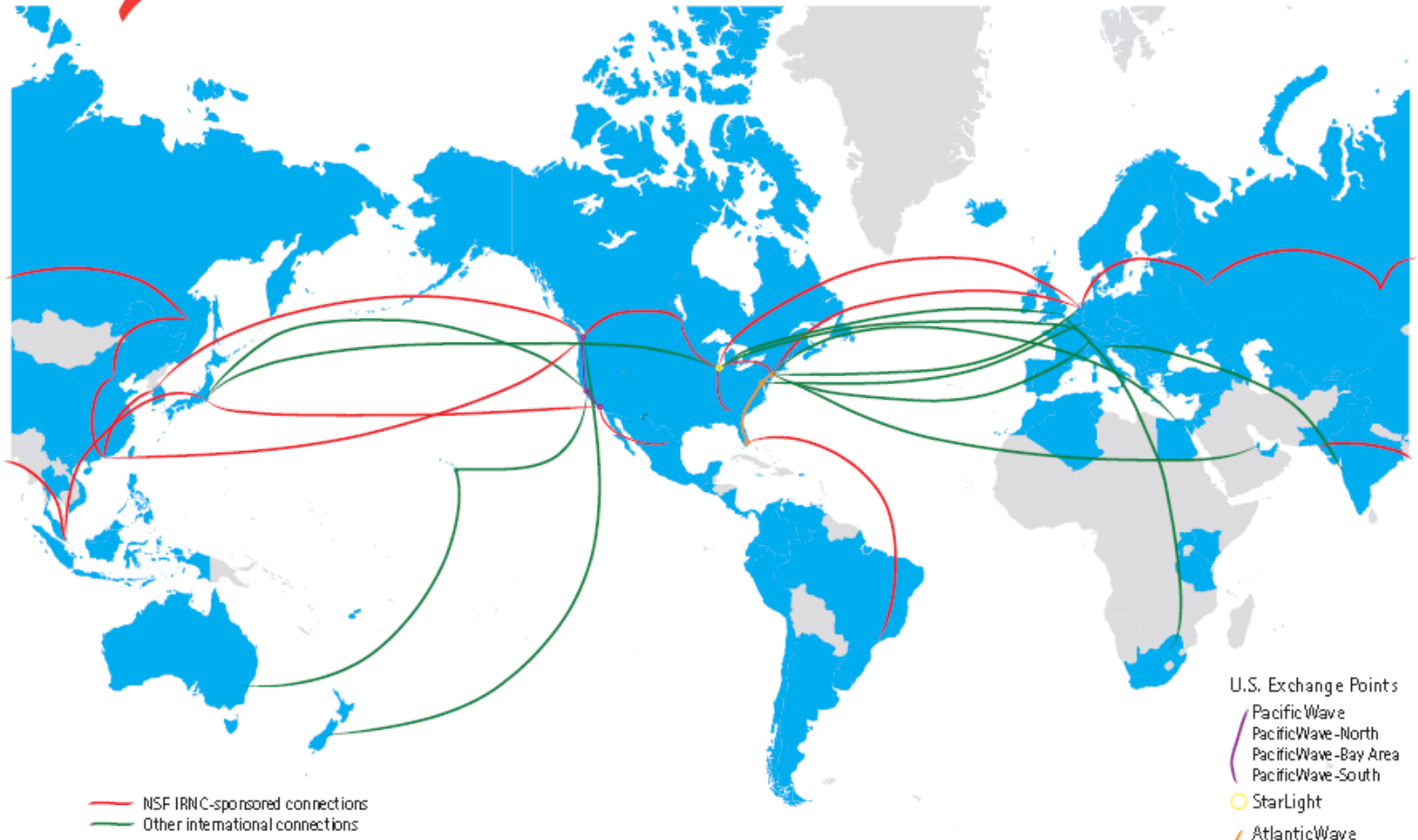


Global REN Connections

- Connect Regional or National networks together
- Tend to be longer, more expensive circuits
- Not always well coordinated
- Routing policies often inconsistent

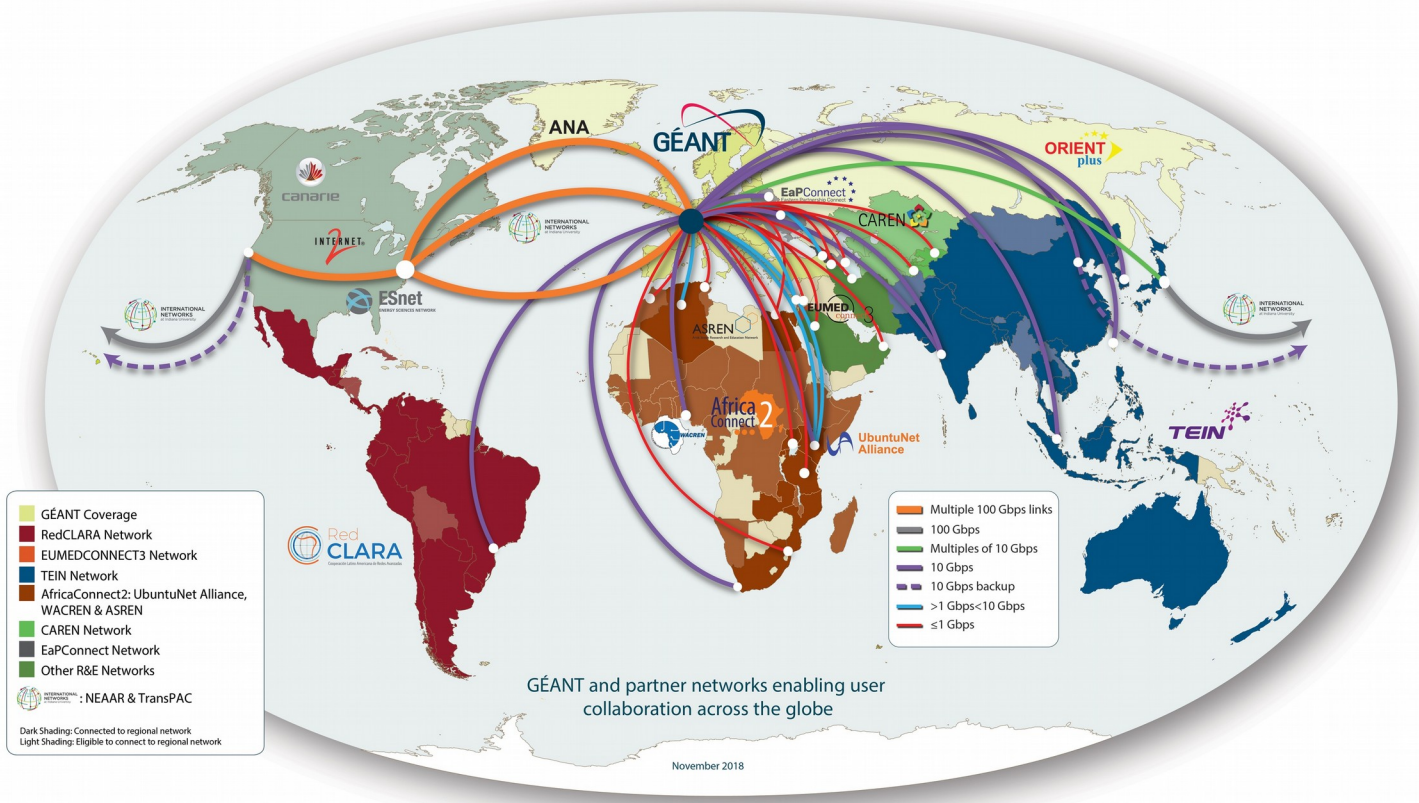
INTERNET2® www.internet.edu

THE INTERNATIONAL REACH OF THE INTERNET2 NETWORK



For further information regarding the international programs of Internet2, visit http://internet2.edu/international or contact Heather Boyles, International Relations Director, international@internet2.edu.
A listing of networks reachable via the Internet2 Network is found on the back of this page.

At the Heart of Global Research and Education Networking



GÉANT
Networks • Services • People
www.geant.org

This document is produced as part of the GÉANT Specific Grant Agreement GN4-2 (No. 731122), that has received funding from the European Union's 2020 research and innovation programme under the GÉANT2020 Framework Partnership Agreement (No.653998).
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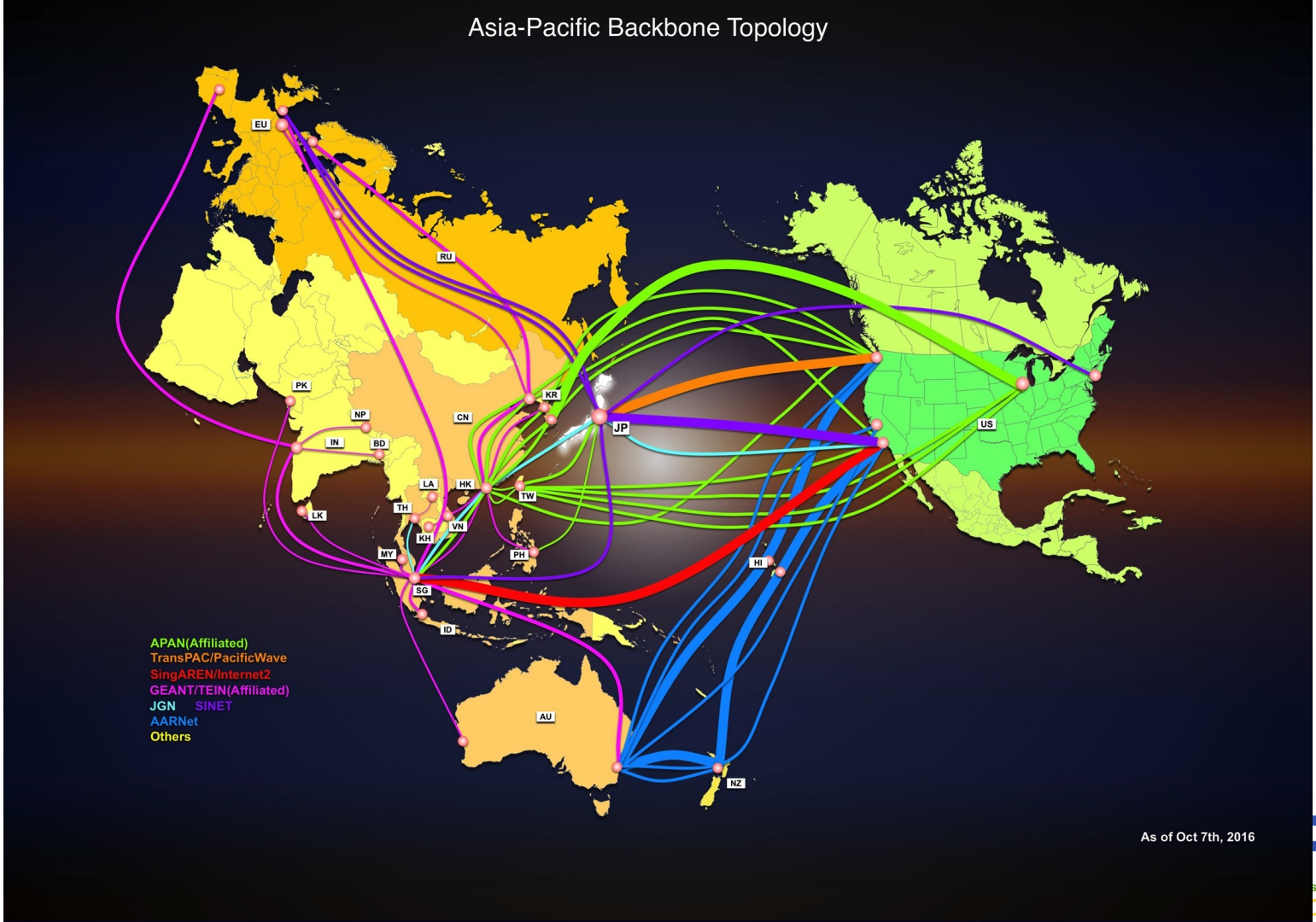
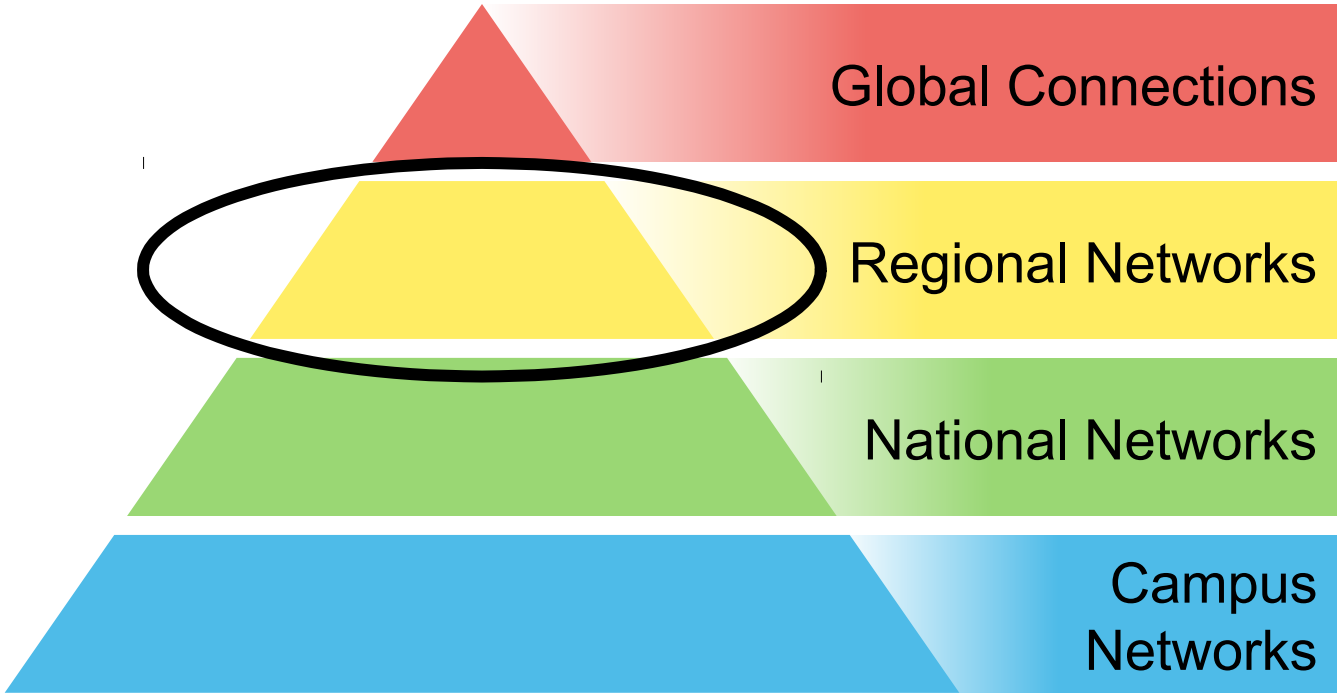
The content of this document is the sole responsibility of GÉANT and can under no circumstances be regarded as reflecting the position of the European Union.

Funded by the European Union

RC Resource Center

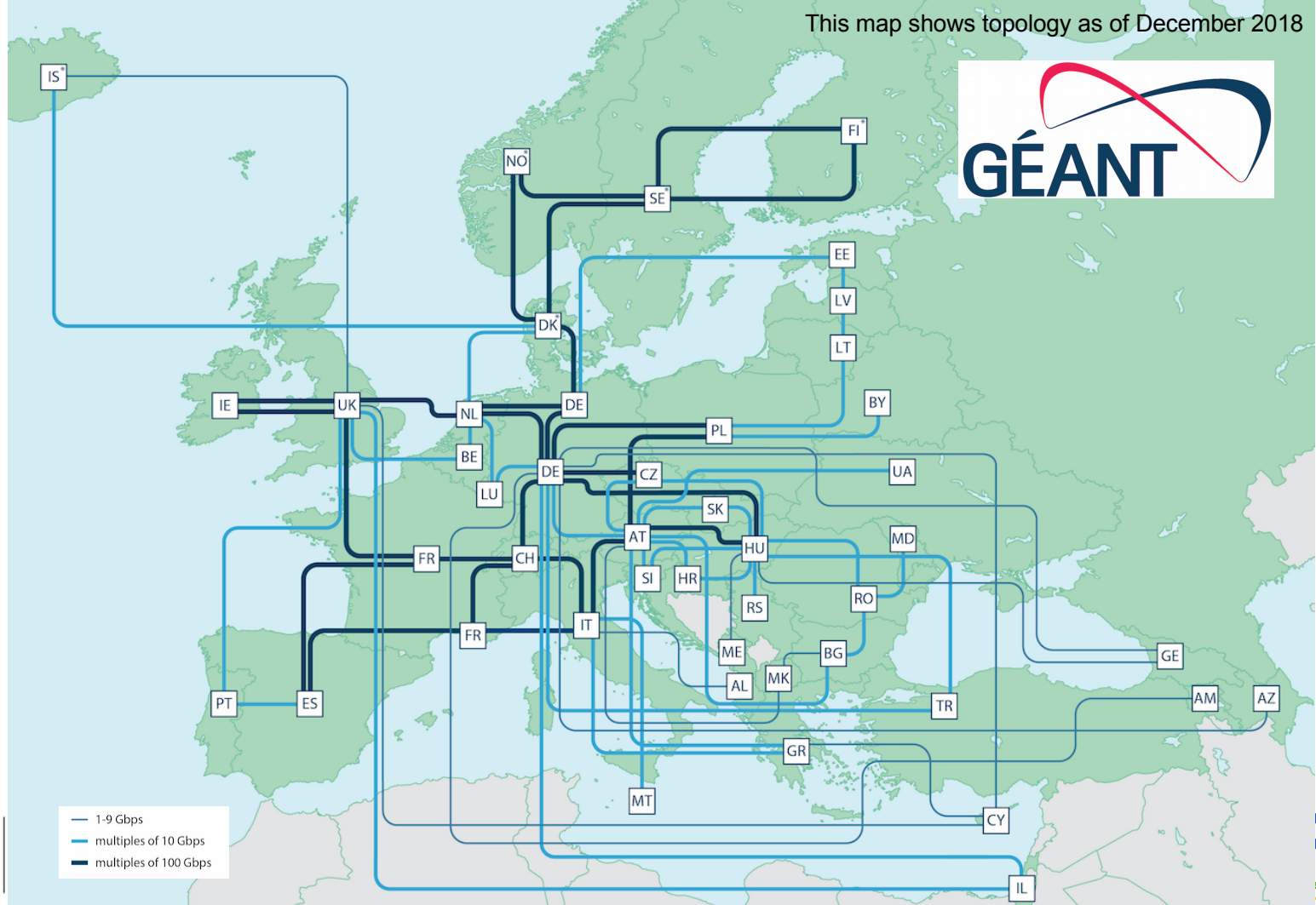

Asia-Pacific Backbone Topology
EU
RU
PK
NP
IN
BD
CN
KR
JP
US
LA
HK
TW
LK
TH
VN
KH
MY
PH
HI
SG
ID
AU
NZ
APAN(Affiliated)
TransPAC/PacificWave
SingAREN/Internet2
GEANT/TEIN(Affiliated)
JGN SINET
AARNet
Others
As of Oct 7th, 2016

NREN EcoSystem



Regional REN Connections

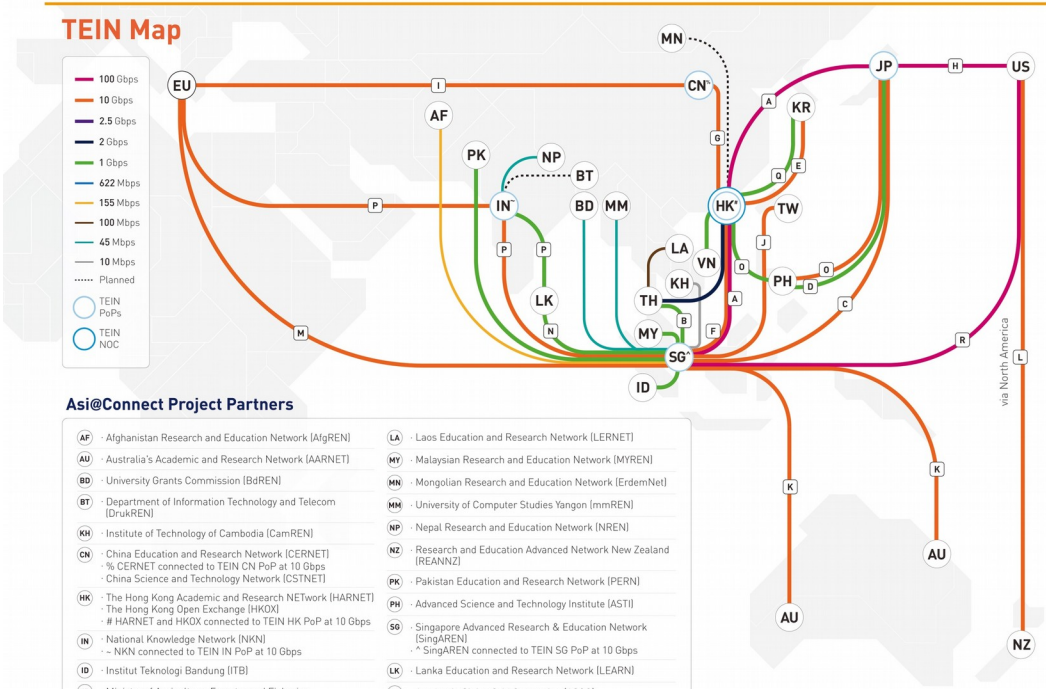
- Regional RENs connect REN of individual countries within a geographic region
- Many regional networks have funding from European Union
  - GÉANT, ASREN, Asi@Connect, ALICE/ALICE2 (RedCLARA), Ubuntunet and WACREN


This map shows topology as of December 2018
GÉANT
IS
NO
FI
SE
EE
LV
LT
DK
IE
UK
NL
DE
BY
PL
BE
DE
CZ
UA
LU
SK
AT
HU
MD
FR
CH
SI
HR
RS
RO
FR
IT
ME
BG
GE
AL
MK
PT
ES
TR
AM
AZ
GR
MT
CY
IL
1-9 Gbps
multiples of 10 Gbps
multiples of 100 Gbps

Asi@Connect

The EU co-funded Asi@Connect project provides a dedicated regional high capacity and high quality internet network, Trans Eurasia Information Network(TEIN), for Research and Education (R&E) communities across Asia-Pacific and Europe, and leverages e-infrastructures developed for public service projects.

TEIN Map



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)

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

- A · National Institute of Information and Communications, Japan; National Supercomputing Centre, Singapore
- B · National Institute of Information and Communications, Japan; Thailand Research and Education Network, Thailand
- C · National Institute of Informatics, Japan
- D · Ministry of Agriculture, Forestry and Fisheries Research Network, Japan
- E F · National Information Society Agency, South Korea
- G · China Education and Research Network, China
- H · TransPAC/Pacific Wave, USA
- I · Co-funded by China and EU
- J · Academia Sinica Grid Computing, Republic of Chinese Taipei
- K · Australia, Academic and Research Network, Australia
- L · Research and Education Advanced Network New Zealand
- M · National Supercomputing Centre, Singapore
- N · Lanka Education and Research Network, Sri Lanka
- O · Advanced Science and Technology Institute, Philippines
- P · National Knowledge Network, India
- P · Korea Research Environment Open NETwork, South Korea
- R · National Supercomputing Centre, Singapore; Internet2, USA

Telemedicine · Earth Observation · Food Security · e-Science

e-learning · e-Culture · Advanced ICT Technology · Capacity Building Programs

This publication has been produced with co-funding of the European Union for the Asi@Connect project under Grant contract ACA2016-376-562. The contents of this document are the sole responsibility of TEIN*CC and can under no circumstances be regarded as reflecting the position of the European Union.

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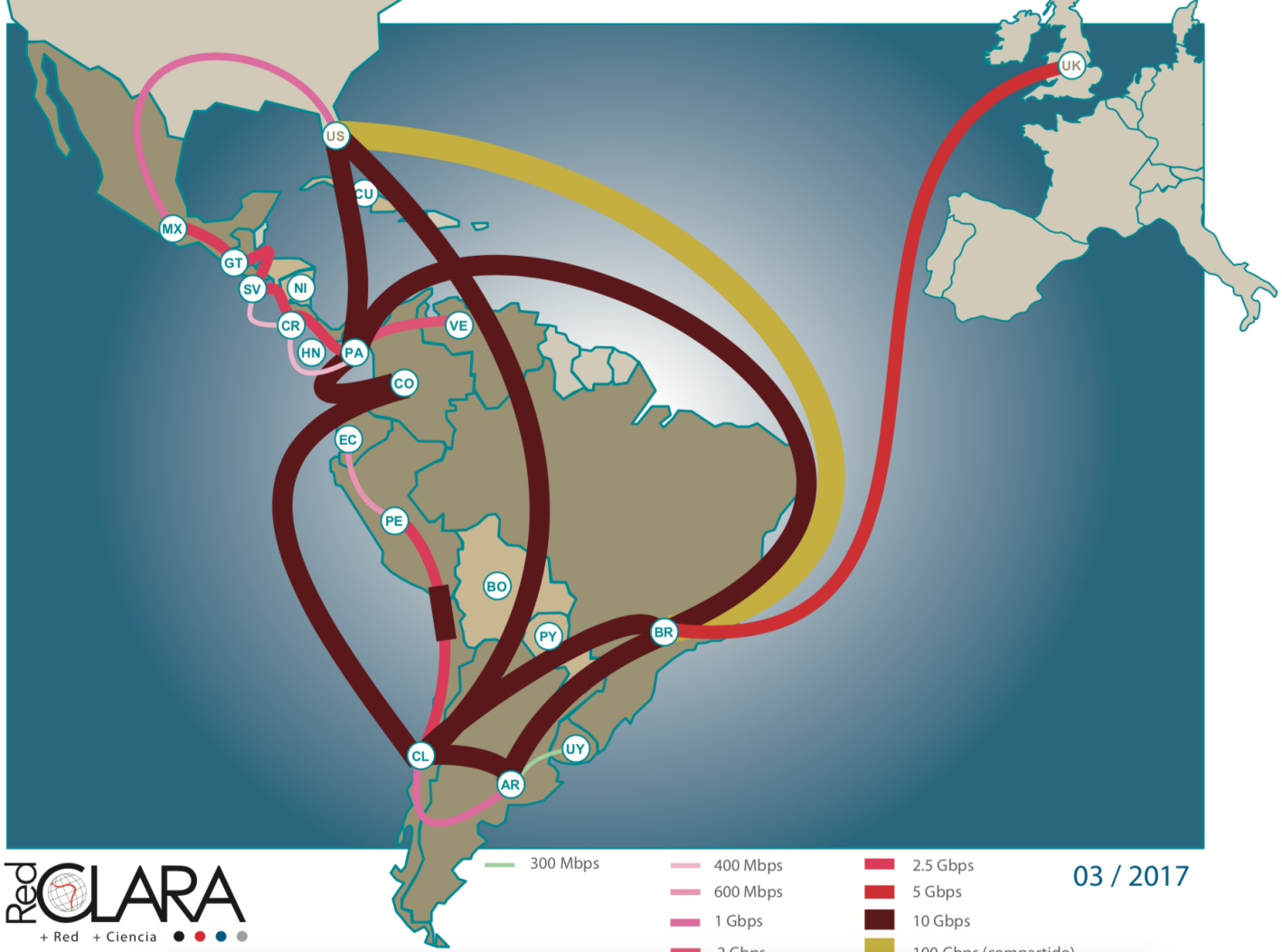
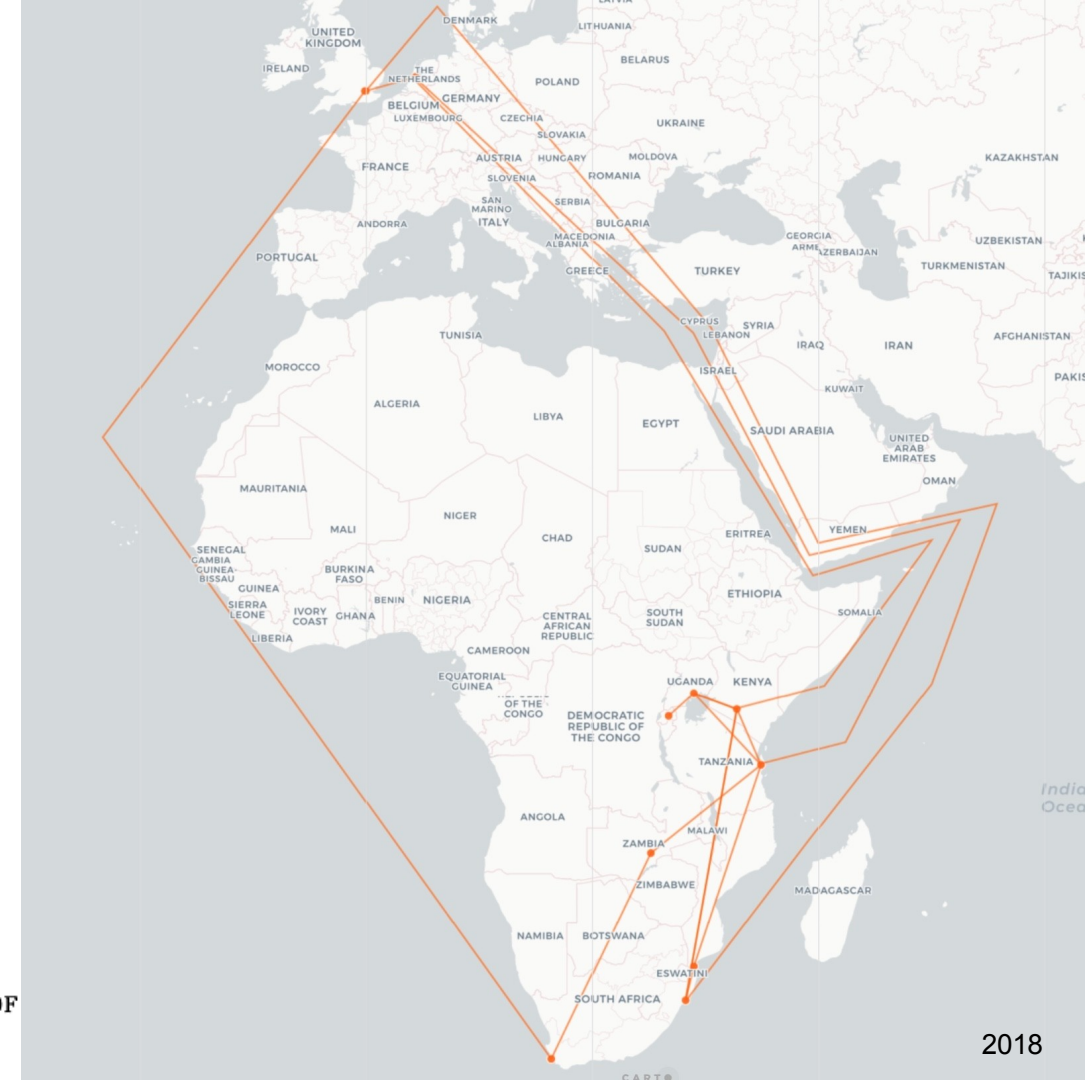
Possibilities with **Asi@Connect**



RedCLARA
+ Red + Ciencia

RC
Resource Center



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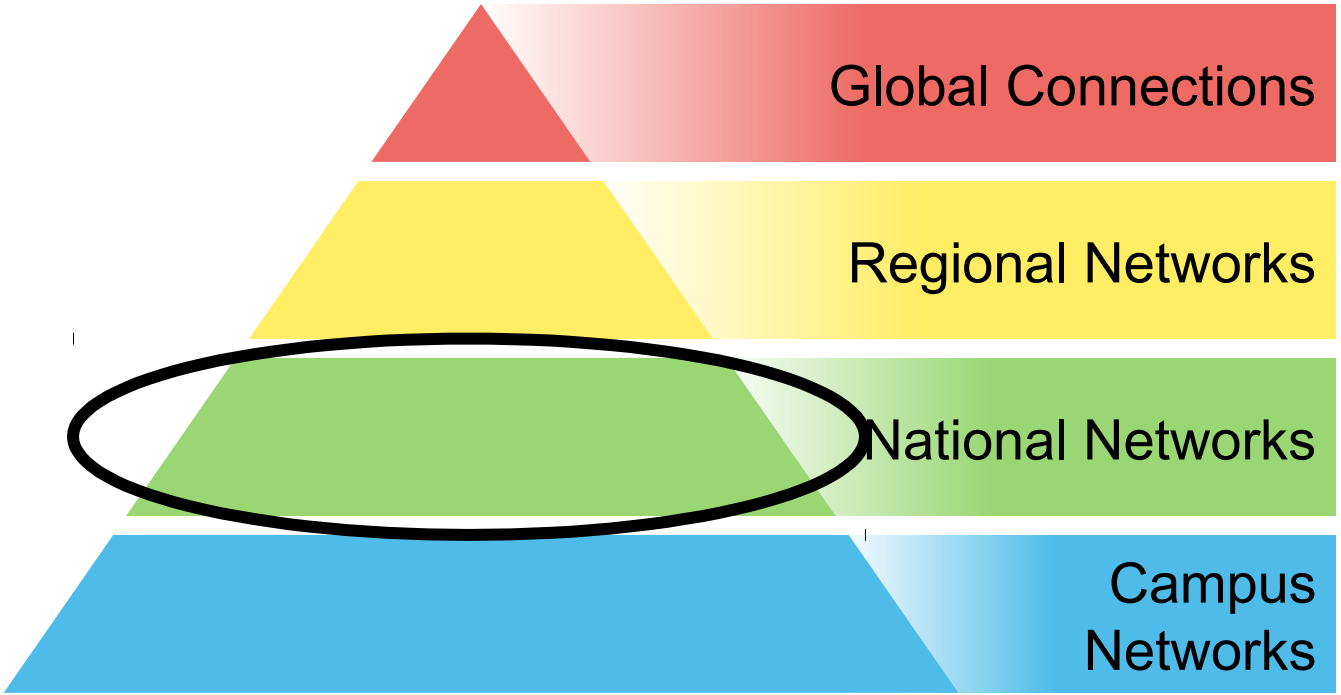
NREN EcoSystem



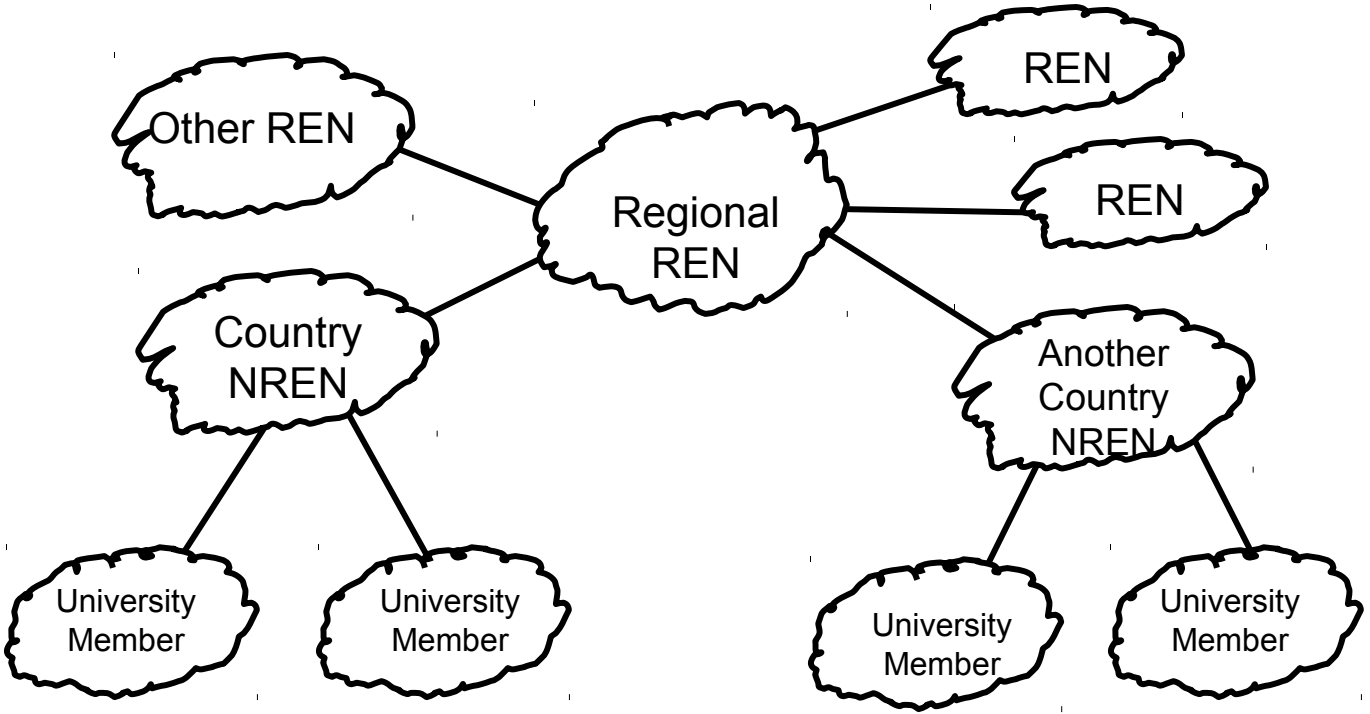
National RENs (NRENs)

- Provides service to Universities, Colleges, research labs, and others in an entire country
- Often hosted and operated by a prestigious university in the country
- Often provides “value add” services to members
  - Video conferencing, e-learning, web hosting, access to donated or discounted hardware, technical capacity building of member institutions, data center space for disaster recovery, etc.

NREN Funding

- NRENs have many different financial models
  - Some receive government funding
  - Some charge members for service
  - Most use a combination of government funding and charging members
  - Funding is easier if NREN provides commercial Internet because Universities expect to pay for Internet, so they can pay the NREN with those funds

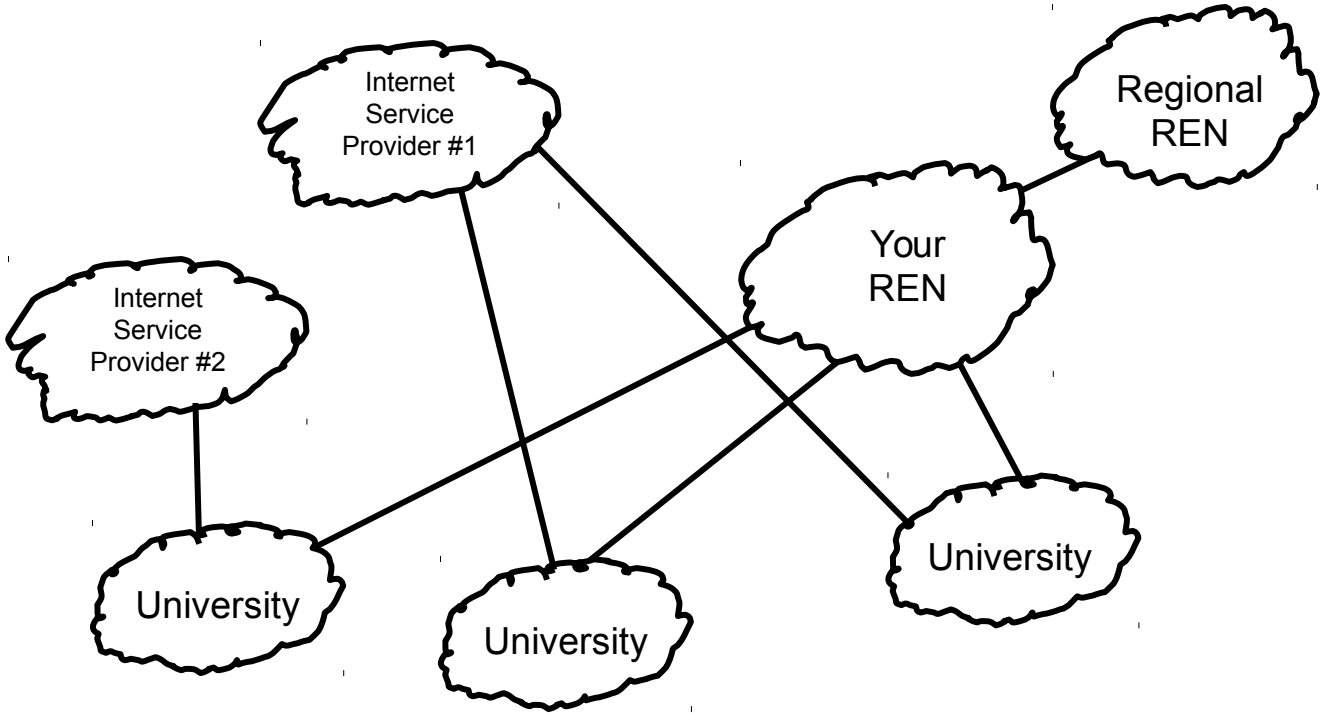
Typical NREN



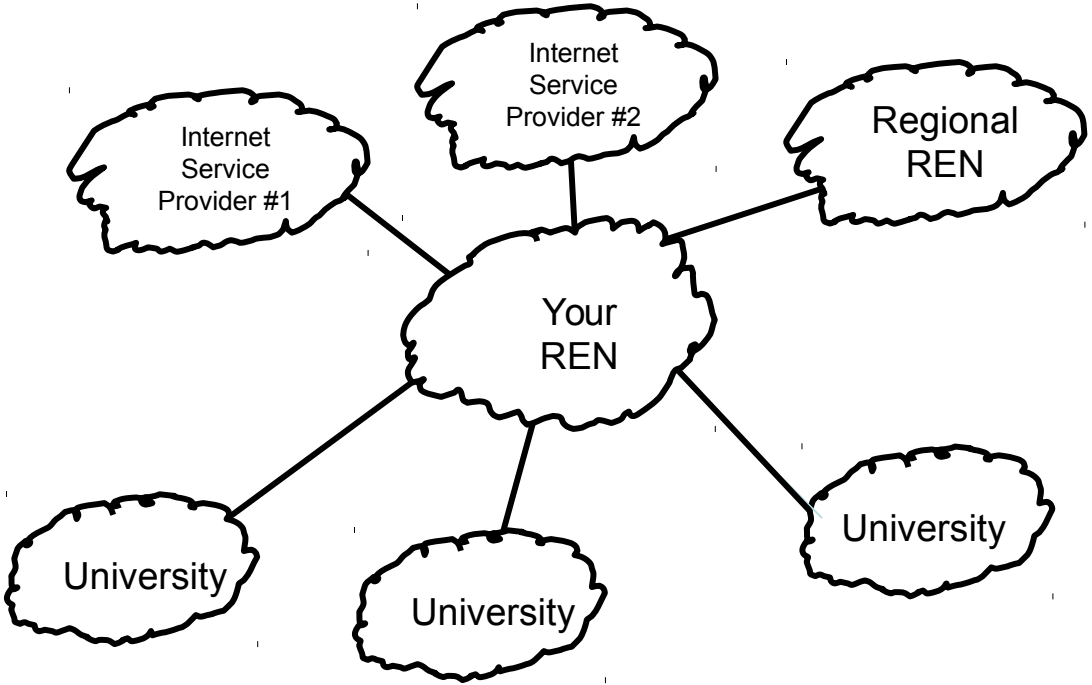
NREN Models of Service

- Two basic models:
  1. Peering network
     - Exchange traffic between members
     - Provide international connections (GÉANT, etc)
     - Can peer with a local commercial exchange (Google, local ISPs, etc)
  2. REN provides all Internet connectivity
     - REN is the ISP
     - In this case, REN also provides peering network

NREN as Peering Network



NREN as ISP


Internet Service Provider #2
Internet Service Provider #1
Regional REN
Your REN
University
University
University

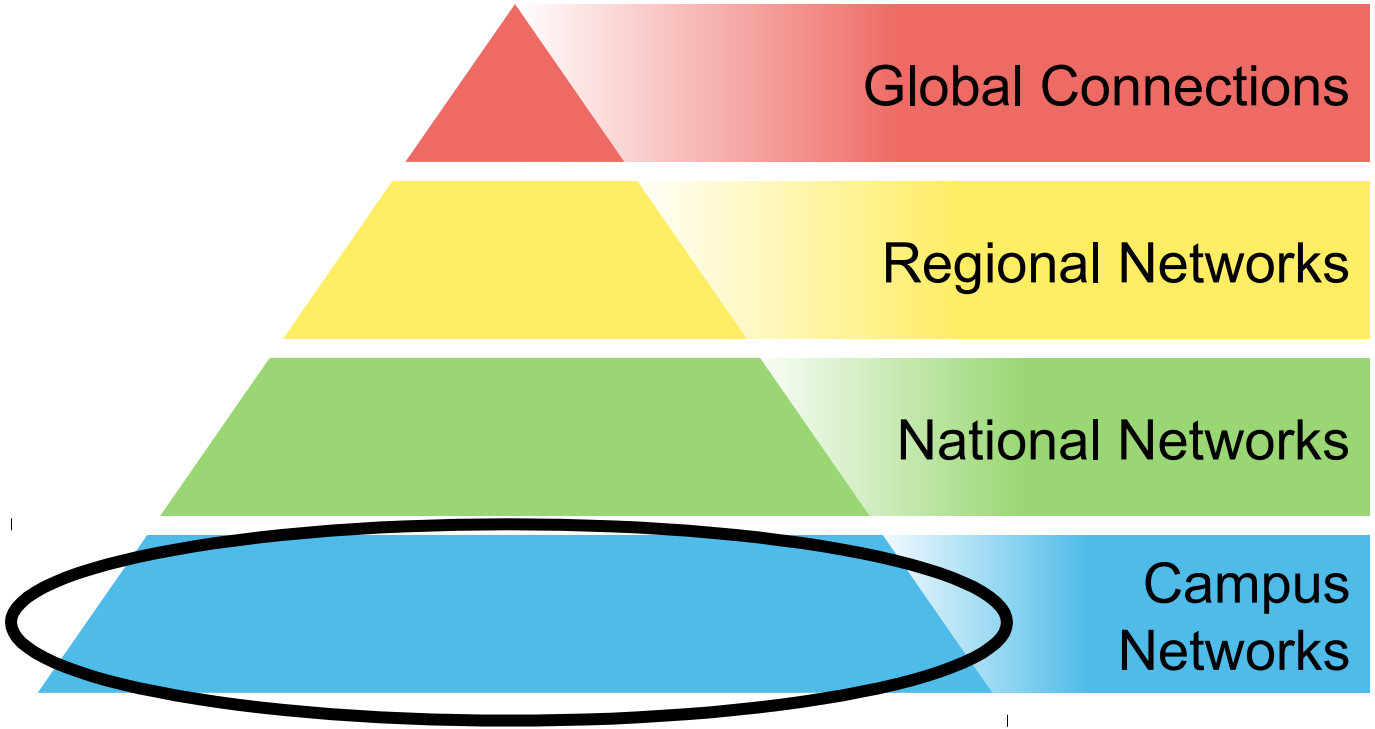
Implications for Universities

- If NREN is a Peering Network
  - Each University still has their own ISP
  - Each University connects to NREN as well
  - The two connections are hard to manage
- If NREN provides all Internet connectivity
  - Simplest for campus members
  - Treats NREN as Internet Service Provider
  - Only one connection to manage

NREN as a Peering Network

- Easiest to implement from a political perspective.
  - The Internet Service Providers like this approach because they keep their University customers
  - Often the legal and regulatory environment allows this use without licensing and/or the license is easier to get
  - The tension between commercial and R&E traffic can be alleviated if NREN keeps local commodity traffic local and buy commodity network access from local ISPs.
- However, there are problems with this approach that we will examine when we talk about campus networks

NREN EcoSystem



Campus Network Role

- No student, researcher, or faculty member is connected directly to a Global, National, or Regional Network.
  - They are all connected to a campus network
- Without a good campus network, the entire ecosystem is affected
  - You can have a 100-gigabit connection to your Regional Network and a 100-gigabit backbone in your national network, but if the users have a poor connections on campus, the entire investment is wasted
- The campus network is the foundation that the entire REN ecosystem is built upon

Foundation Failures

Foundation Failures

Campus Network Challenges

- Many campus networks are not structured properly and can't effectively utilize high bandwidth connections
- Many make heavy use of NAT and firewalls that limit performance
- Many are built with unmanaged network equipment that provide no ability for monitoring or tuning the network
- Some NRENs force campuses to dual home

Campus Network Structure

- Campus networks have often grown organically over time without thought to proper architecture
- Campus networks are often built with outdated fiber optic cabling that can't support high speeds
  - Multi-mode fiber is unsuitable for a campus network – it is limited on speed and distance.
  - We will discuss this in more detail
- But remember, the campus network is the foundation
  - We encourage the entire REN community to look at campus networks and consider improvements and investments

When NREN is a Peering Network

- Universities have two connections
  - How do they decide which one to use?
    - On the surface, this seems easy.
    - Just use one as a backup of the other
    - Or load balance between them
  - It is actually quite hard to get it to work the way you might want it to
    - It is made even more difficult when the campuses make heavy use of NAT.

Dual Homed Campus Networks

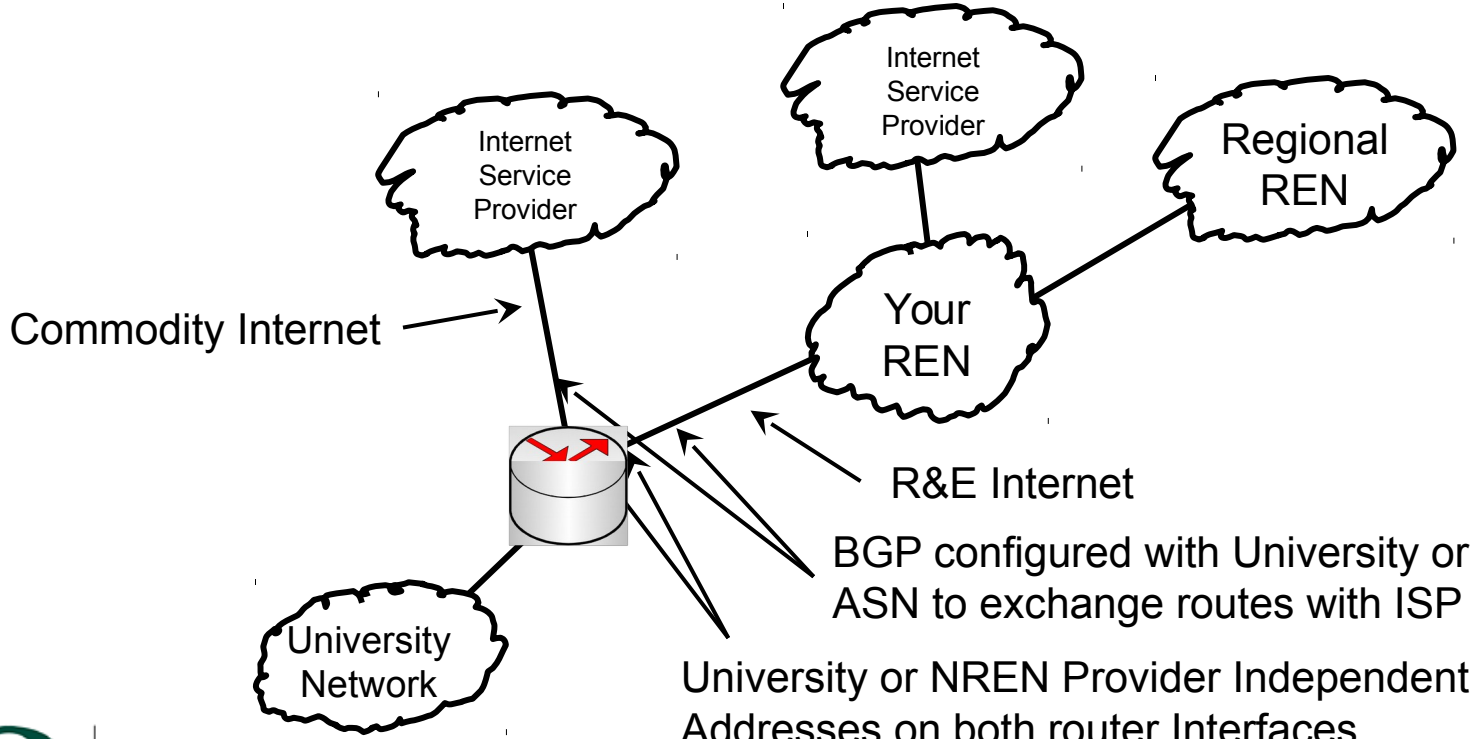
- Three approaches:
  1. Get provider independent address space, an autonomous system number (ASN), and run BGP (can get IP addresses and ASN from the Regional Internet Registry – the NREN can assist with this)
  2. Get an IP address from the ISP and an IP address from the NREN, and run special software and configuration on a NAT box
  3. Split the campus network into NREN and Internet

- What do we find around the world?

NRENs Around the World

- Most NRENs act as the Internet Service Provider, so dual homing is not an issue
  - The NREN provides all Internet access for the campus
- For those NRENs that do Peering Only
  - Many campuses follow the correct way to dual home, which is to have their own IP addresses, ASN, and run BGP
  - Some campuses split their network into two parts: the Internet and the NREN
    - Many places turn the NREN into a video conferencing or special e-learning network.
  - A few attempt to use NAT to multihome

The Correct way to Dual Home



Conclusion

- The Global Research and Education Network ecosystem is large, complex, and is a result of many billions of dollars of investments
- The campus network is the foundation that all of that investment relies upon.
- Campus networks are often not properly built and need to be improved
- The need for improvement is the motivation for this course

Questions/Discussion?