Research and Education Networking: Introduction, architecture and operations

WACREN Webinar:

Research and Education Networks: Architecture, Routing and Peering

01/12/2020

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 40G and 100G coming
  - 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

Why a REN?

- **Enable research or services that could not be accomplished otherwise**
- Cost Savings (buyers club)
  - Aggregate demand from multiple parties
- Vision of building alliances
- Successful RENs find that there are unanticipated benefits

Why Are We Doing This?

- Our goal is to build networking capacity to support Research and Education
  - Remember: University = Research & Education
- Buying all service from your local ISP is a losing game – you will spend more money and not have control of the network
- The pattern around the world is to build regional, national, and larger Research and Education Networks (RENs)
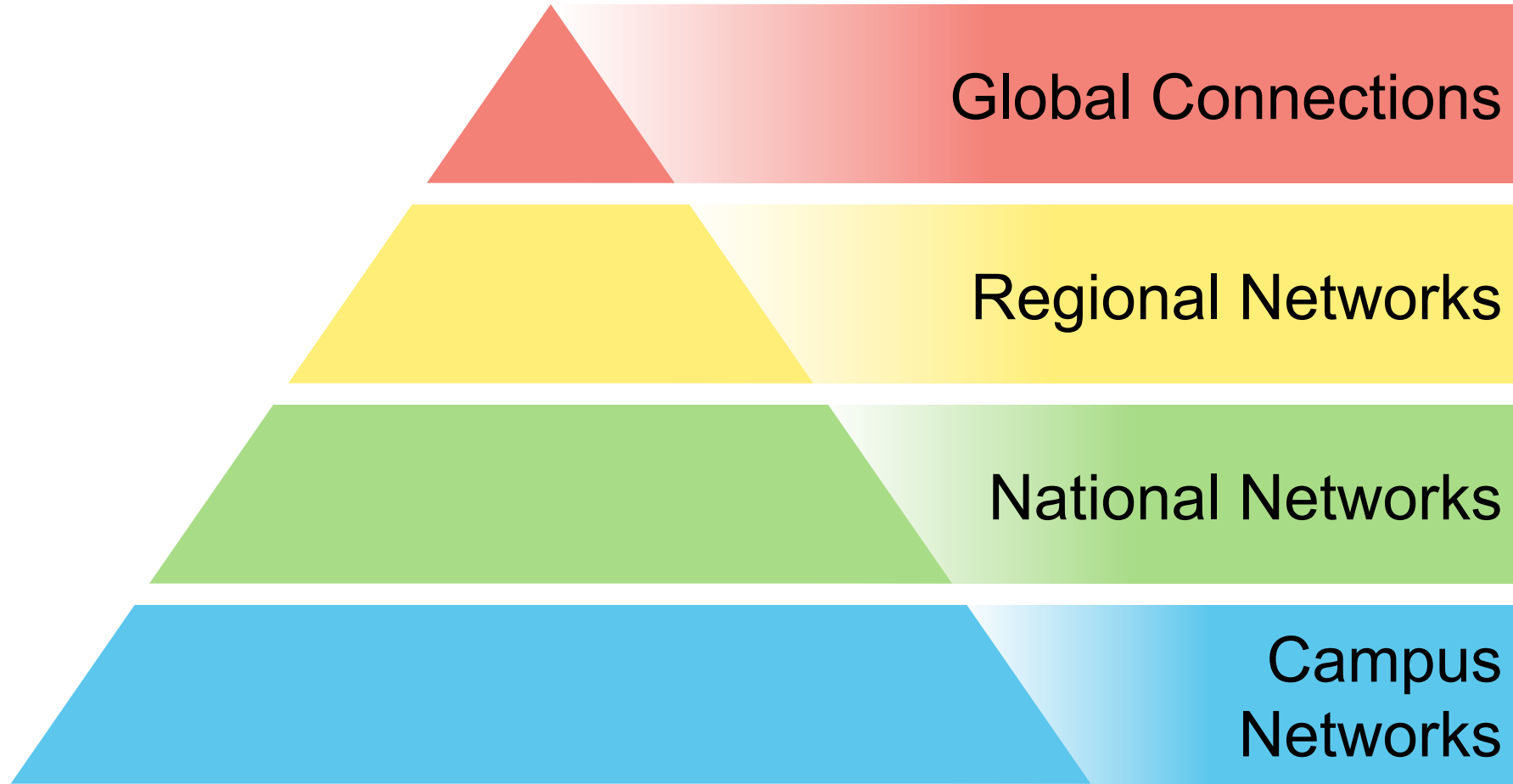
REN Ecosystem

- A layered model
  - Global Connectivity
  - Regional RENs
  - National Research and Education Networks
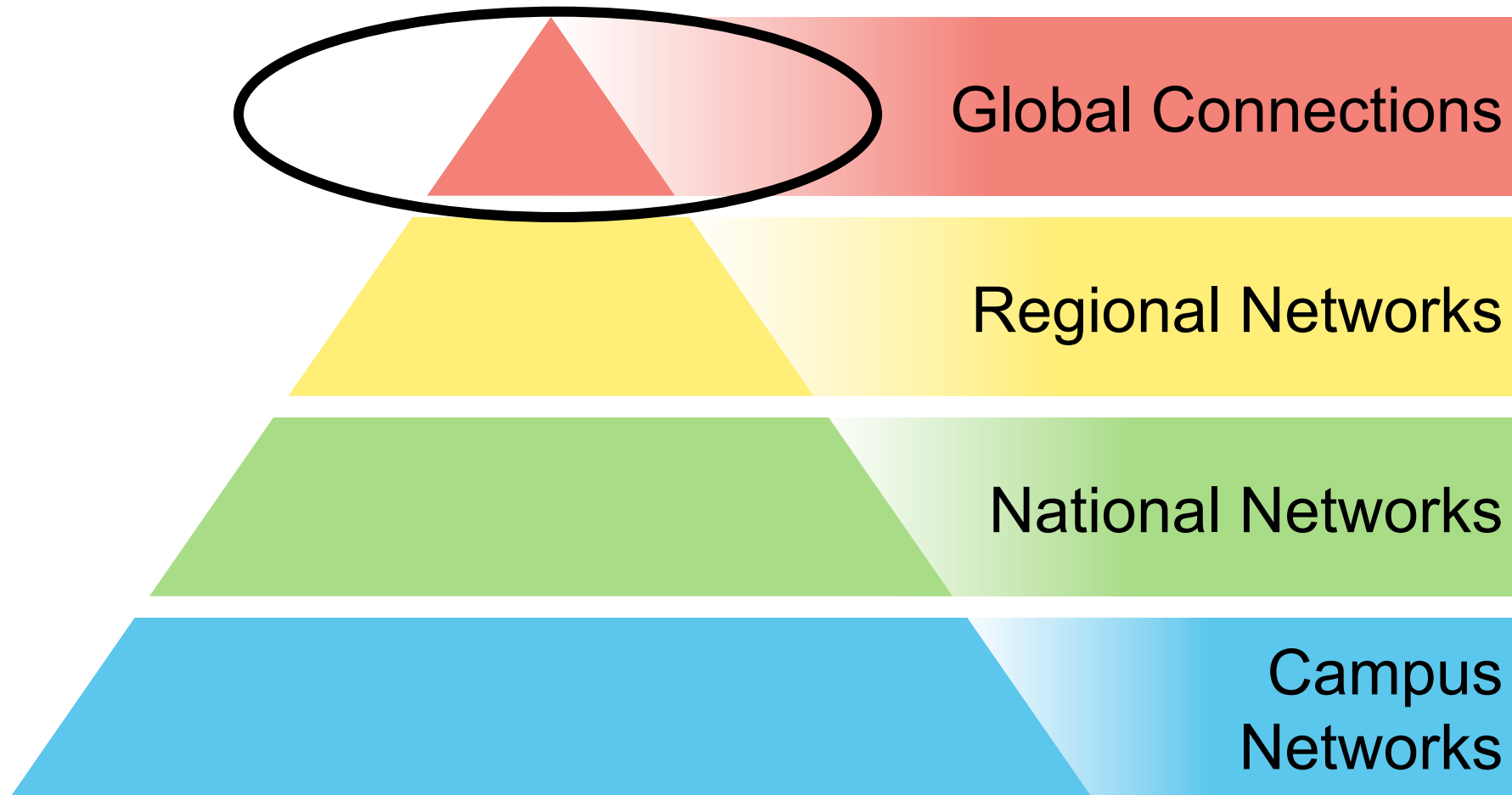 - All users are connected at the campus network level

REN Topics

- A look at the Global and Regional REN environment
- NREN IP Transport Models and implications for campus networks
- Importance of Campus Networks to the REN ecosystem
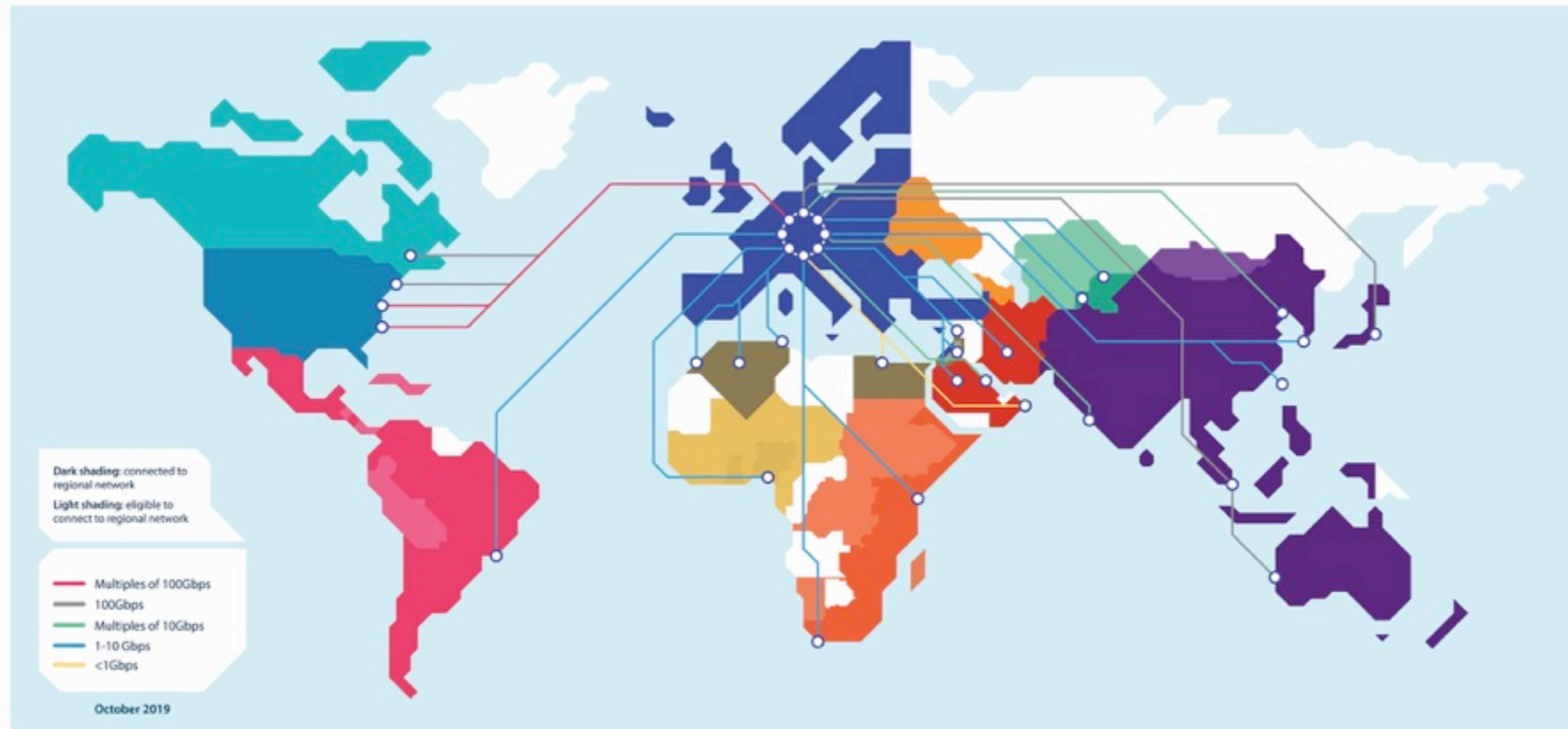
REN EcoSystem

REN EcoSystem

Global Connections

Regional Networks

National Networks

Campus Networks

Global REN Connections

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

AT THE HEART OF GLOBAL RESEARCH
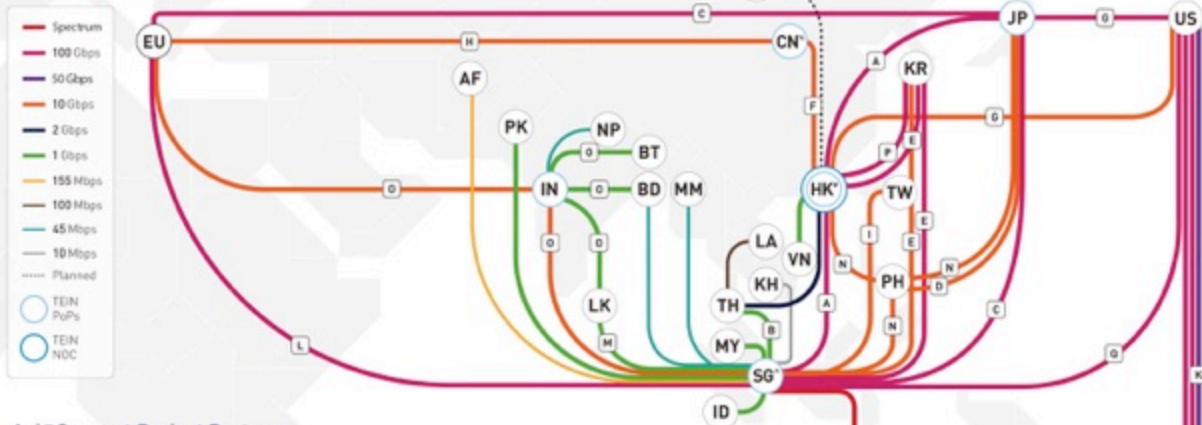AND EDUCATION NETWORKING

GÉANT

Dark shading: connected to regional network

Light shading: eligible to connect to regional network

Multiples of 100Gbps
100Gbps
Multiples of 10Gbps
1-10 Gbps
<1Gbps

October 2019

| Canada & USA | Latin America | Europe | North Africa & Eastern Mediterranean | West & Central Africa | Eastern & Southern Africa | Central Asia | Asia-Pacific | Other R&E Networks |

canarie   ESnet   RedCLARA   GÉANT   EaPConnect   ASREN   UbuntuNet Alliance   CAREN   TEIN

INTERNET.

GÉANT
Networks • Services • People

This map is produced as part of the GÉANT Specific Grant Agreement GN4-3 (No. 856726), that has received funding from the European Union's 2020 research and innovation programme under the GÉANT2020 Framework Partnership Agreement (No. 653998). 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.

geant.org

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

Legend:
- Spectrum
- 100 Gbps
- 50 Gbps
- 10 Gbps
- 2 Gbps
- 1 Gbps
- 155 Mbps
- 100 Mbps
- 45 Mbps
- 10 Mbps
- Planned
- TEIN PoPs
- TEIN NOC

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

- **A** — NICT National Institute of Information and Communications Technology; National Supercomputing Centre; Singapore Advanced Research & Education Network
- **B** — NICT National Institute of Information and Communications Technology; Thailand Research and Education Network
- **C** — National Institute of Informatics
- **D** — Ministry of Agriculture, Forestry and Fisheries Research Network
- **E** — National Information Society Agency
- **F** — China Education and Research Network; TEIN Cooperation Center
- **G** — TransPAC/Pacific Wave
- **H** — Co-funded by China and EU
- **I** — Academia Sinica Grid Computing
- **J** — Australia's Academic and Research Network
- **K** — Research and Education Advanced Network New Zealand
- **L** — GÉANT, NORDUnet, etc., TEIN
- **M** — LEARN Lanka Education and Research Network
- **N** — Advanced Science and Technology Institute
- **O** — National Knowledge Network
- **P** — KREONET Korea Research Environment Open NETwork
- **Q** — National Supercomputing Centre; Internet2; Singapore Advanced Research & Education Network

Asi@Connect Project Partners

- **AF** — Afghanistan Research and Education Network (AfgREN)
- **AU** — Australia's Academic and Research Network (AARNET)
- **BD** — Bangladesh Research and Education Network(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)
- **ID** — Indonesia Research and Education Network (IDREN)
- **JP** — Ministry of Agriculture, Forestry and Fisheries Research Network (MAFFIN)
  - National Institute of Information and Communications Technology (NICT)
  - National Institute of Informatics (NII)
- **KR** — National Information Society Agency (KOREN)
  - Korea Institute of Science and Technology Information (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 NZ Ltd. (REANNZ)
- **PK** — Pakistan Education and Research Network (PERN)
- **PH** — Advanced Science and Technology Institute (PREGINET)
- **SG** — Singapore Advanced Research & Education Network (SingAREN)
  - ^ SingAREN connected to TEIN SG PoP at 100 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 (VinaREN)

* As of December 2019.
** Other regions (Central Asia, Africa and Latin America) can be connected via global R&E networks such as EU(GÉANT) and US(Internet2)
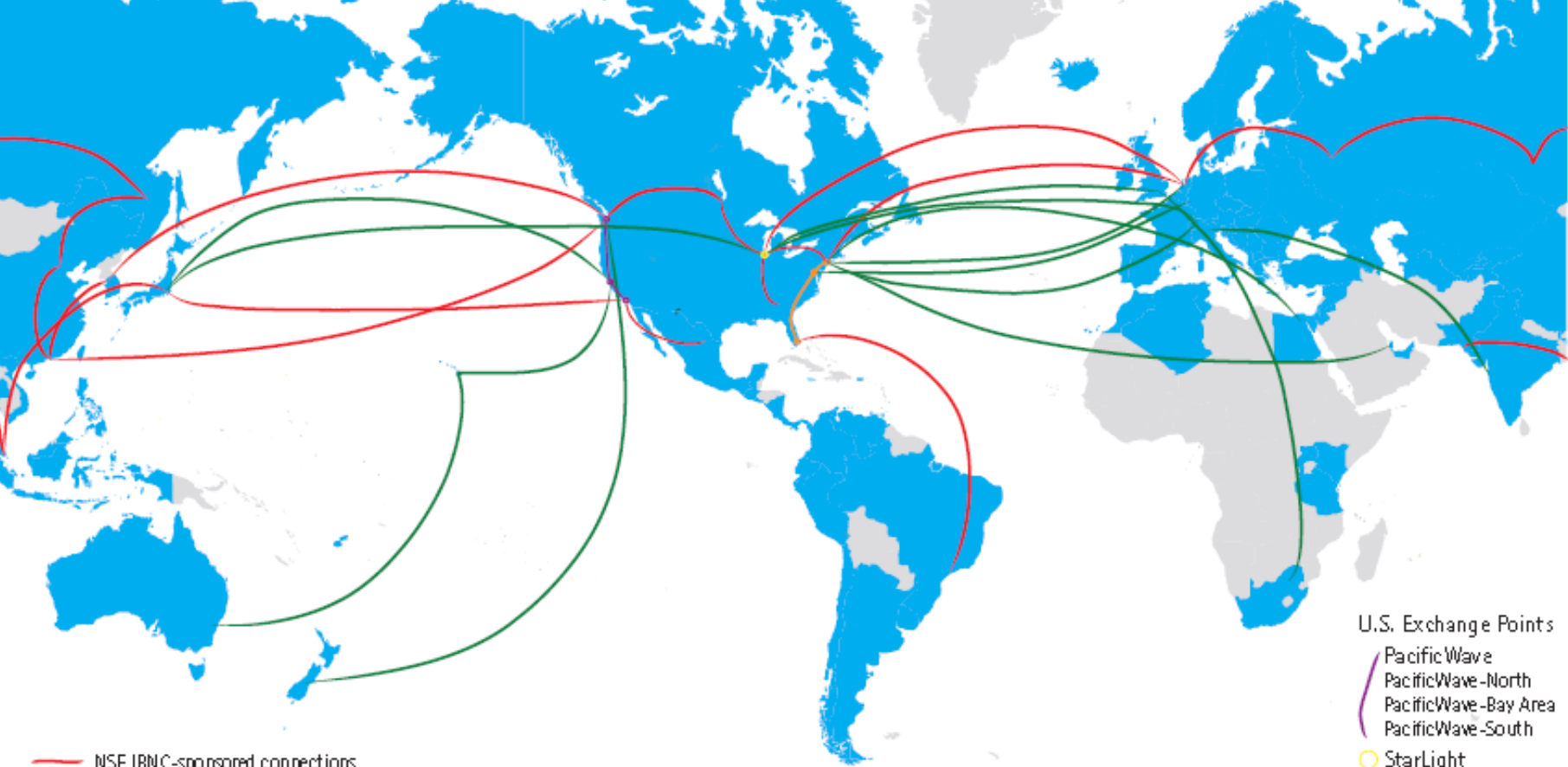
Icons: Telemedicine, Earth Observation, Food Security, e-Science, e-learning, e-Culture, Advanced ICT Technology, Capacity Building Programs

Possibilities with Asi@Connect

NSF IRNC-sponsored connections
Other international connections

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

U.S. Exchange Points

PacificWave
PacificWave-North
PacificWave-Bay Area
PacificWave-South

StarLight

AtlanticWave
MANLAN
NGIX-East
AMPATH

Asia-Pacific Backbone Topology

APAN(Affiliated)
TransPAC/PacificWave
SingAREN/Internet2
GEANT/TEIN(Affiliated)
JGN   SINET
AARNet
Others

As of Oct 7th, 2016
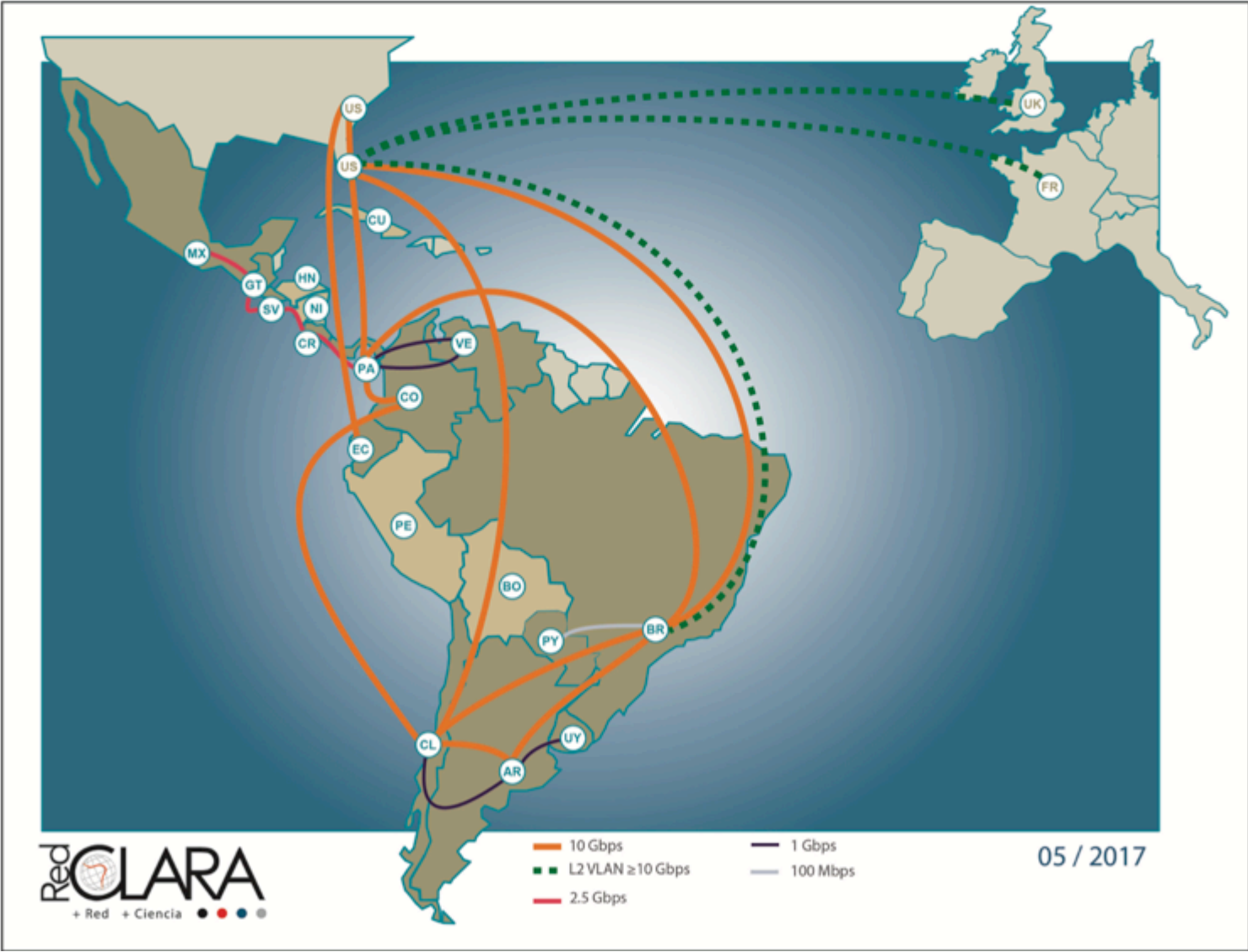
REN EcoSystem
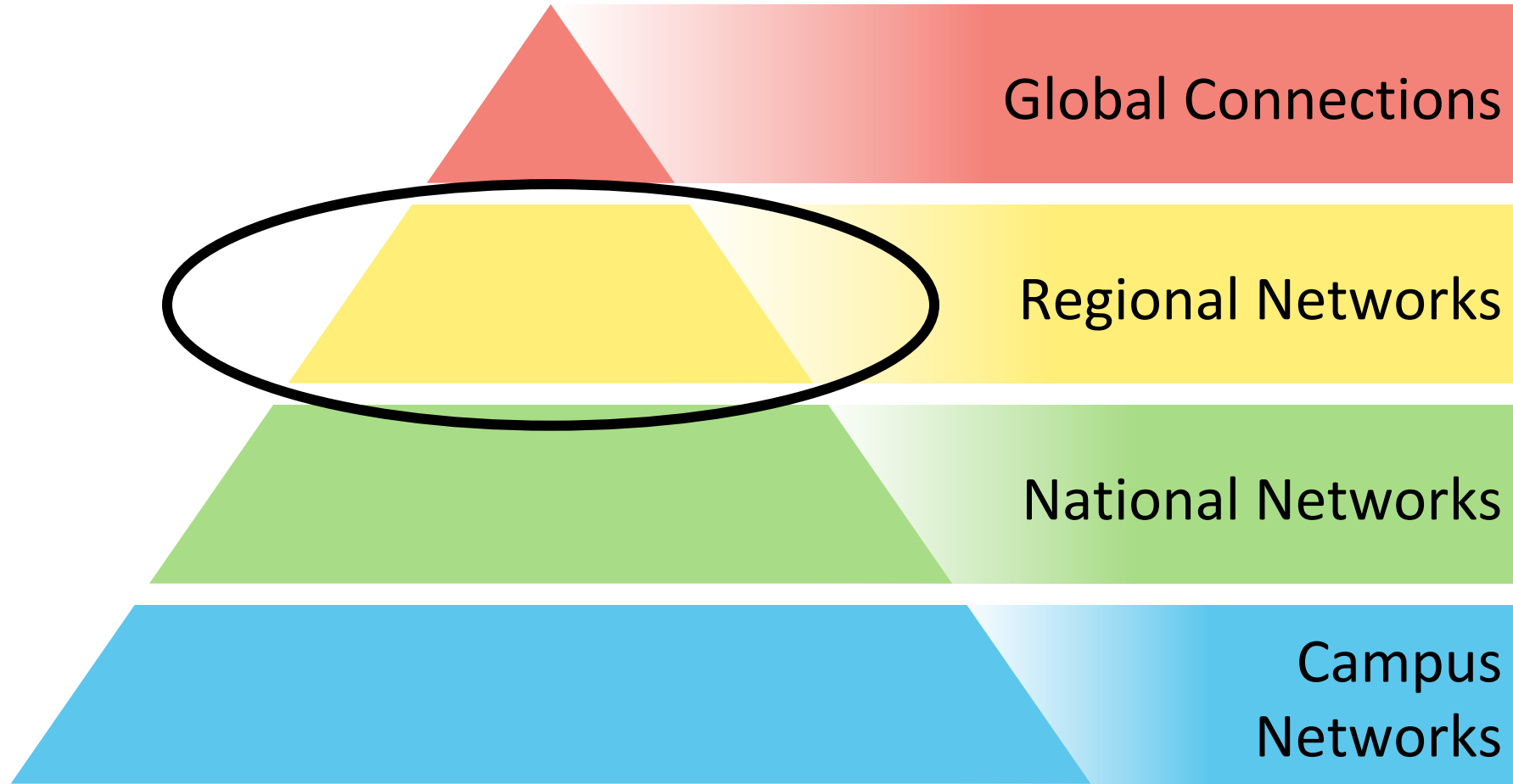
Regional REN Connections

- Regional RENs connect REN of individual countries within a geographic region
- Many regional networks have funding from European Union
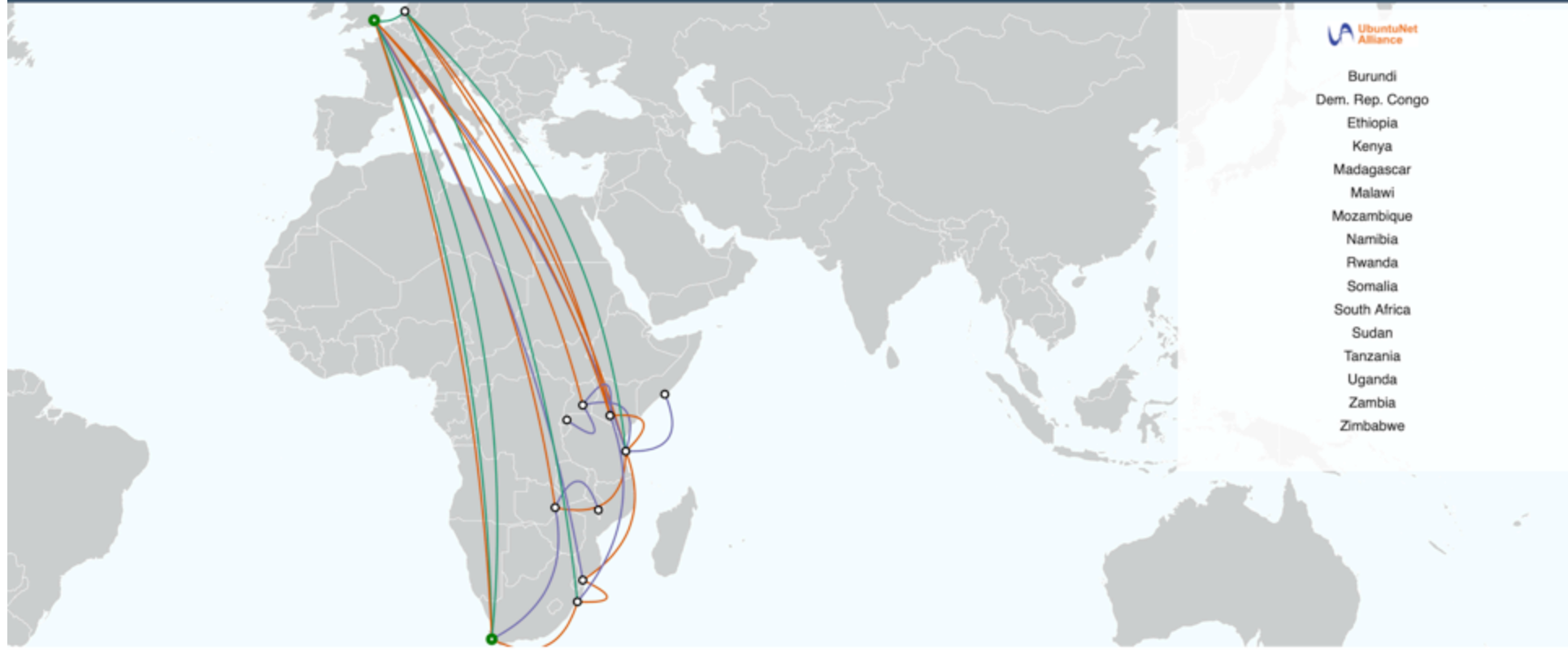 - GEANT, ASREN, TEIN5/Asi@Connect, ALICE/ALICE2 (RedCLARA), Ubuntunet, WACREN, and ASREN

Typical REN

Legend:
- 1-9 Gbps
- multiples of 10 Gbps
- multiples of 100 Gbps
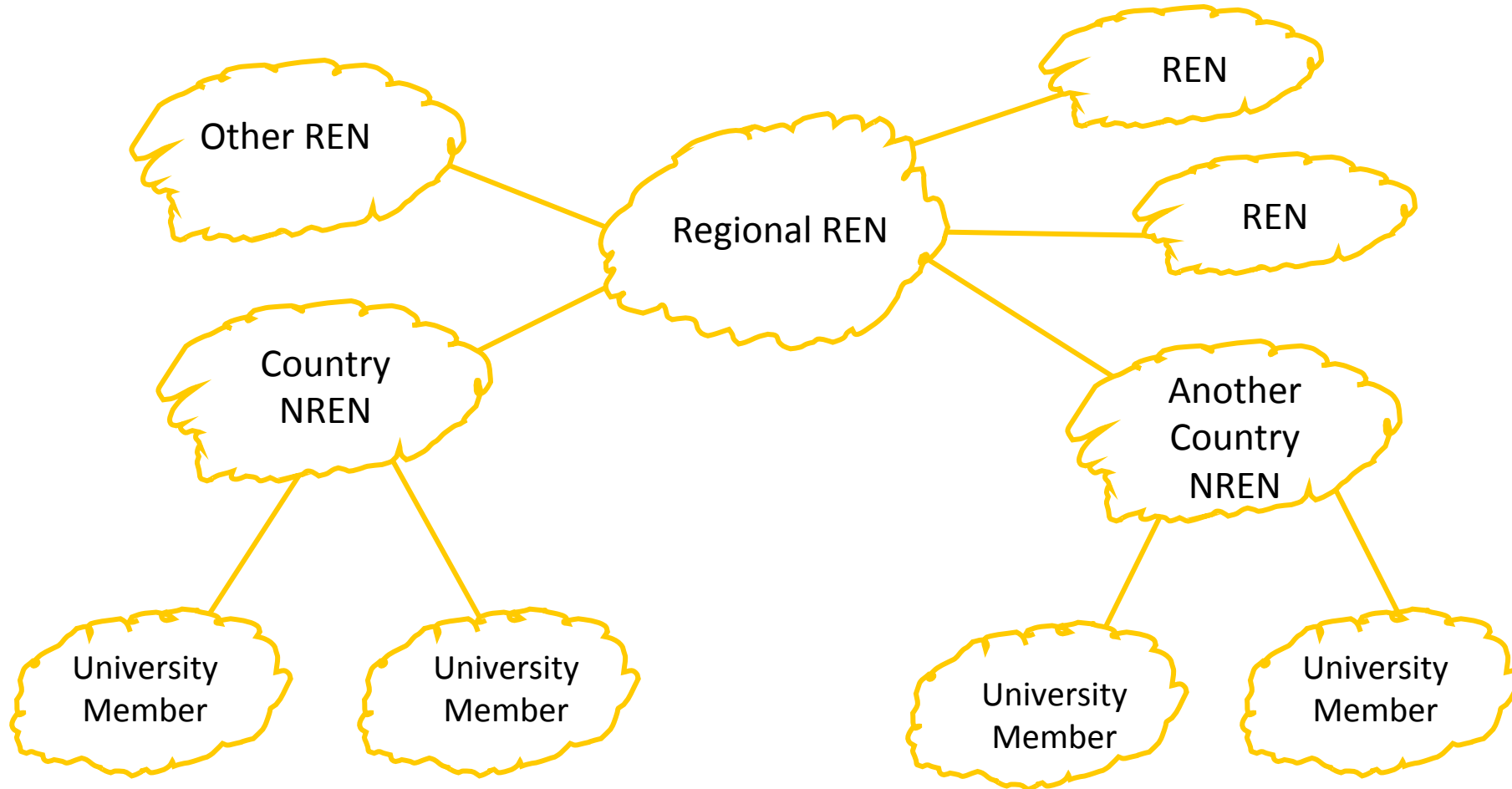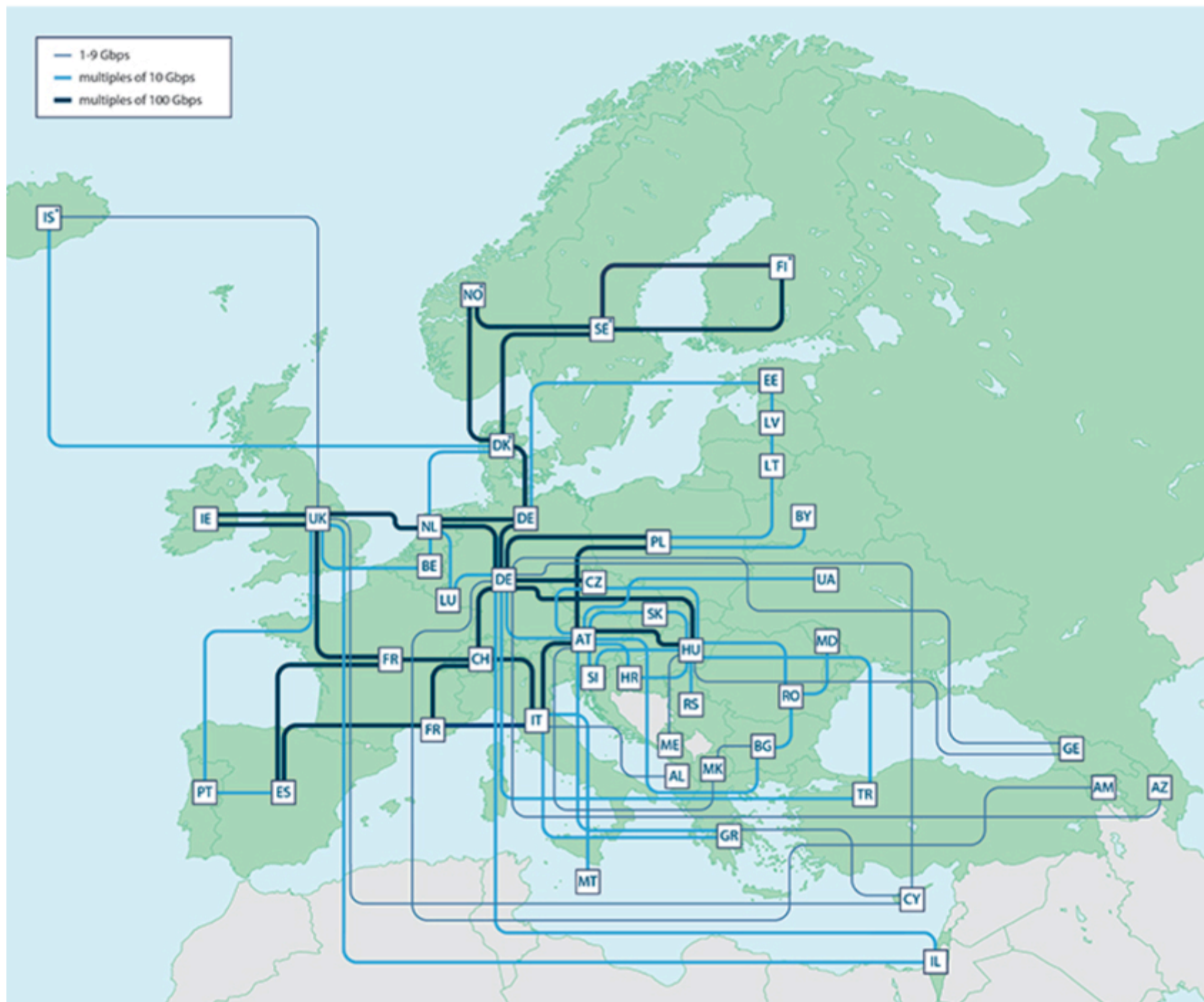
Current RedCLARA's Network Topology

05 / 2017

Legend:
- 10 Gbps
- L2 VLAN ≥10 Gbps
- 2.5 Gbps
- 1 Gbps
- 100 Mbps

UbuntuNet Alliance

Burundi
Dem. Rep. Congo
Ethiopia
Kenya
Madagascar
Malawi
Mozambique
Namibia
Rwanda
Somalia
South Africa
Sudan
Tanzania
Uganda
Zambia
Zimbabwe

GÉANT Connectivity Map

The global reach of the GÉANT network enables scientists and academics in Europe to exchange data and collaborate with their peers across the world through links to National Research and Education Networks in 65 countries around the world.
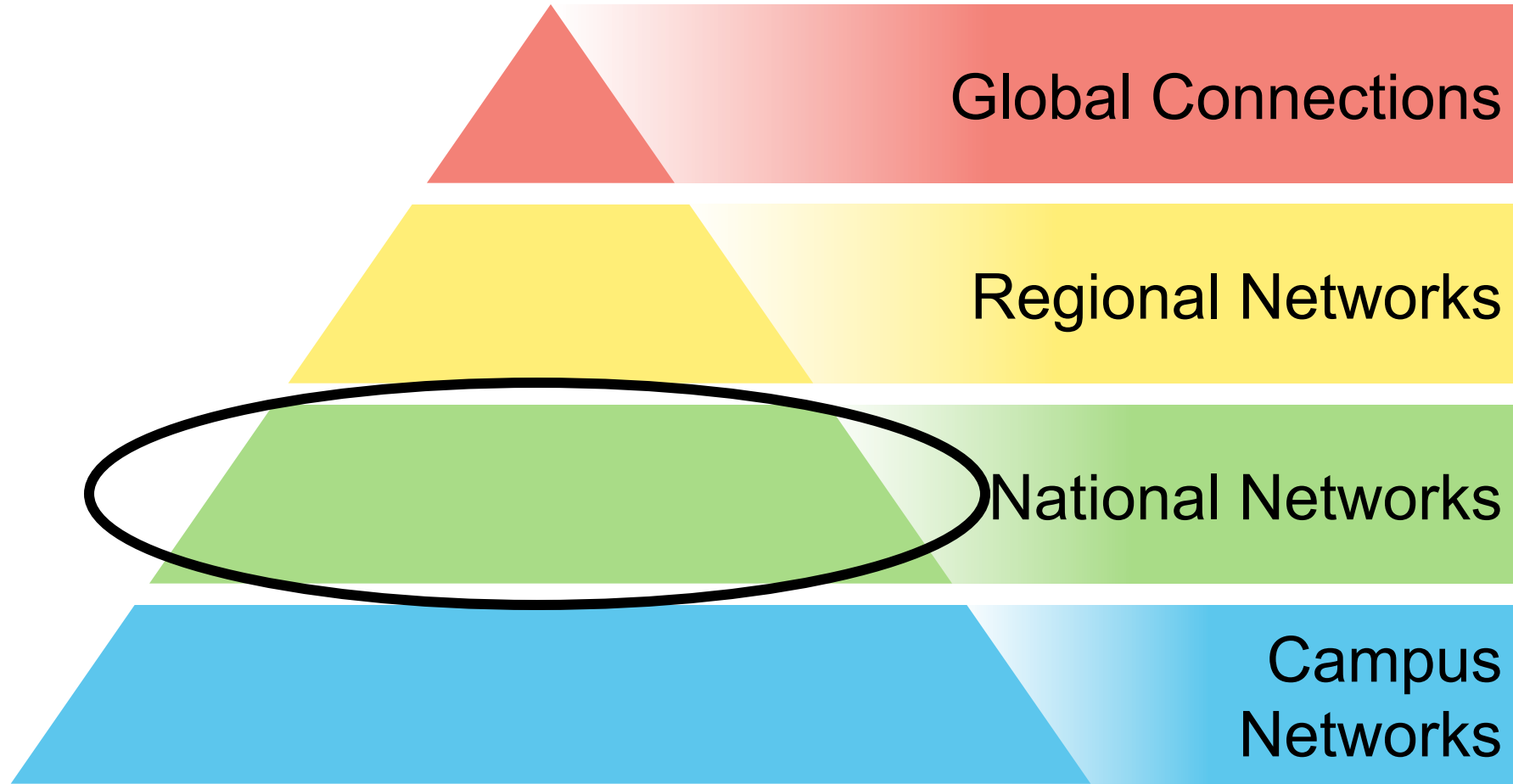
To learn more about connectivity to and within the different world regions reached by GÉANT, click on the links above.

☑ Toggle global links
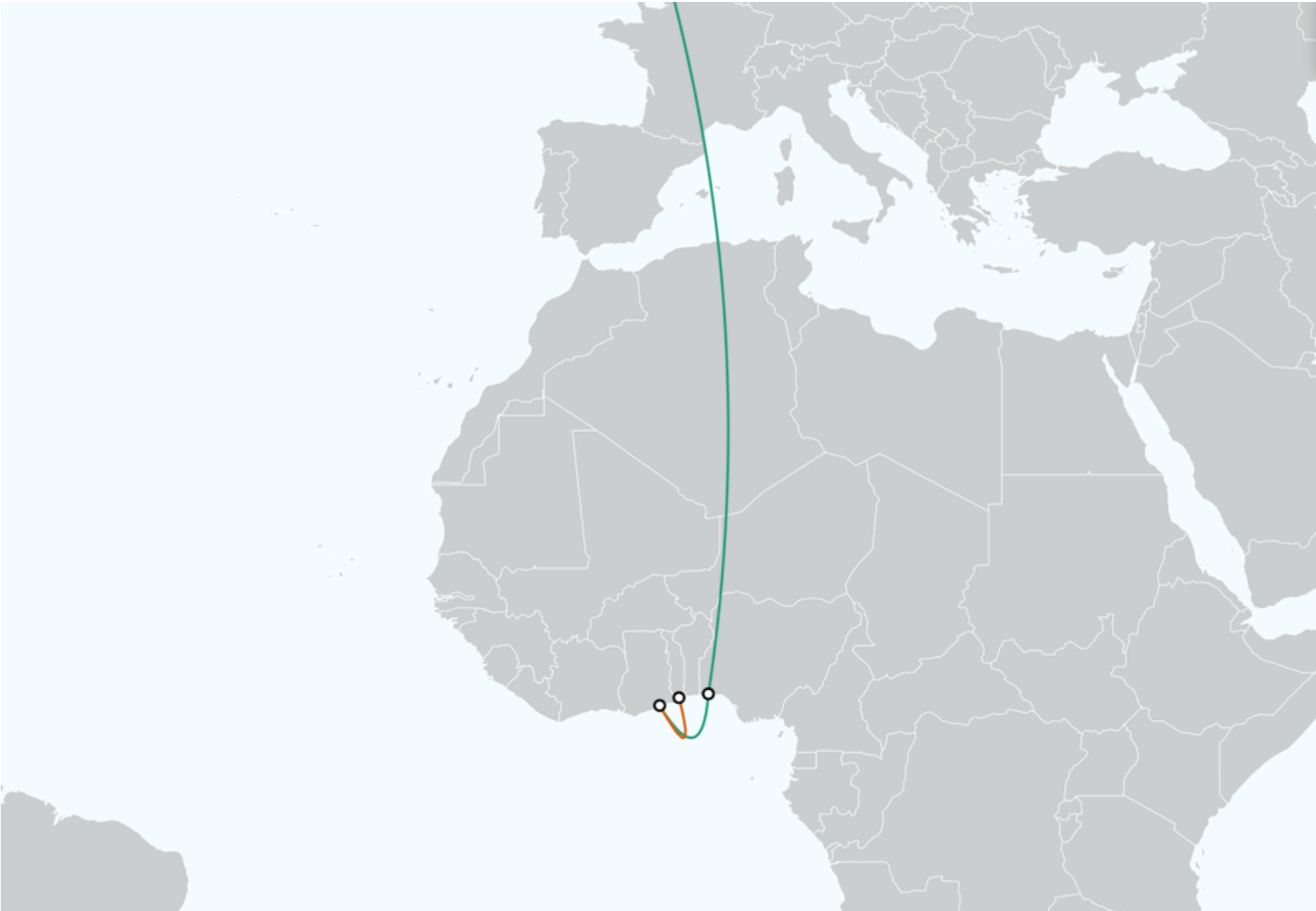
National RENs (NRENs)

- 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, VoIP, e-learning, web hosting, data center space for disaster recovery, etc.
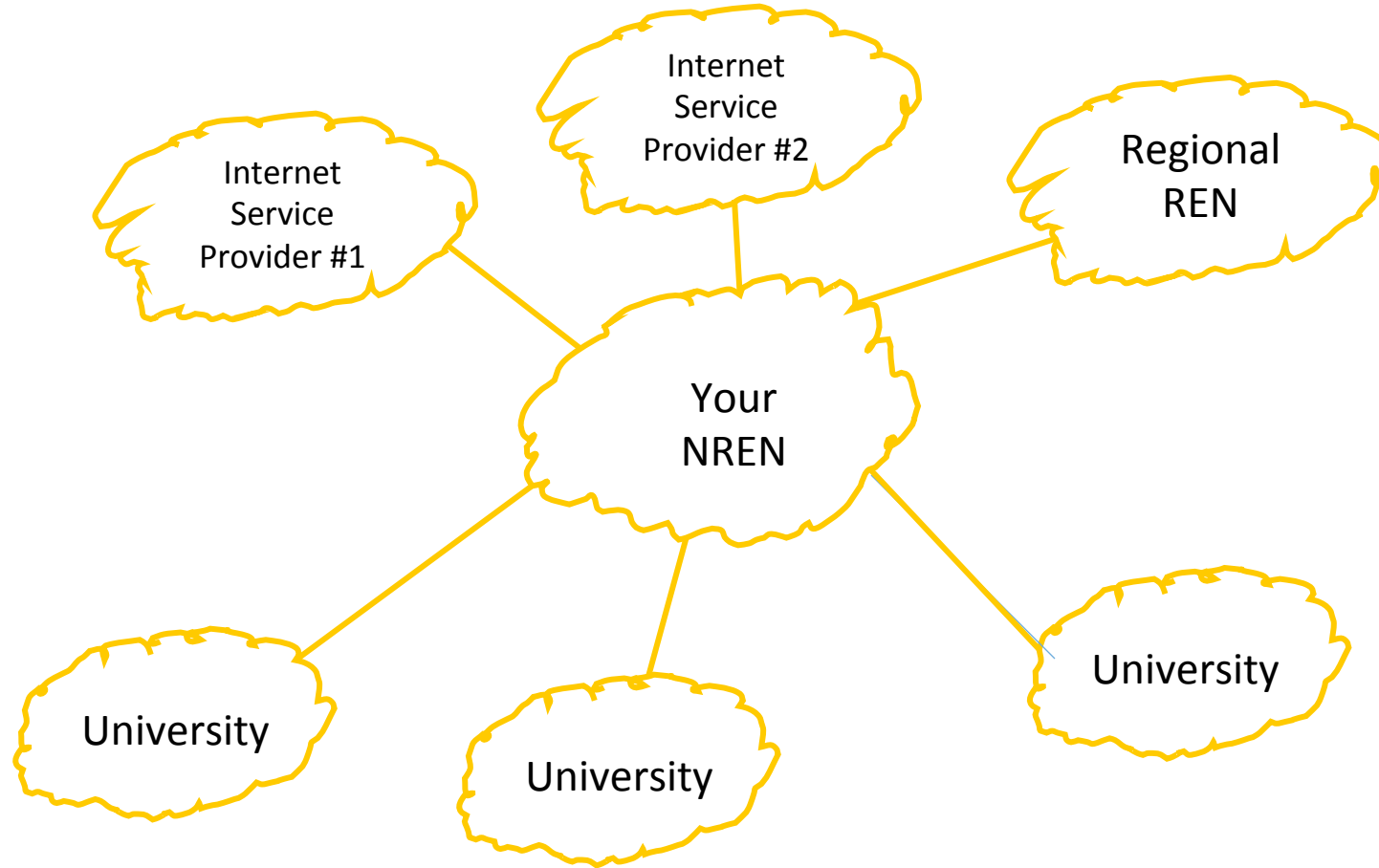
REN Models of Service

- Two basic models:
    1. Peering network
        - Exchange traffic between members
        - Provide international connections (GEANT, 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
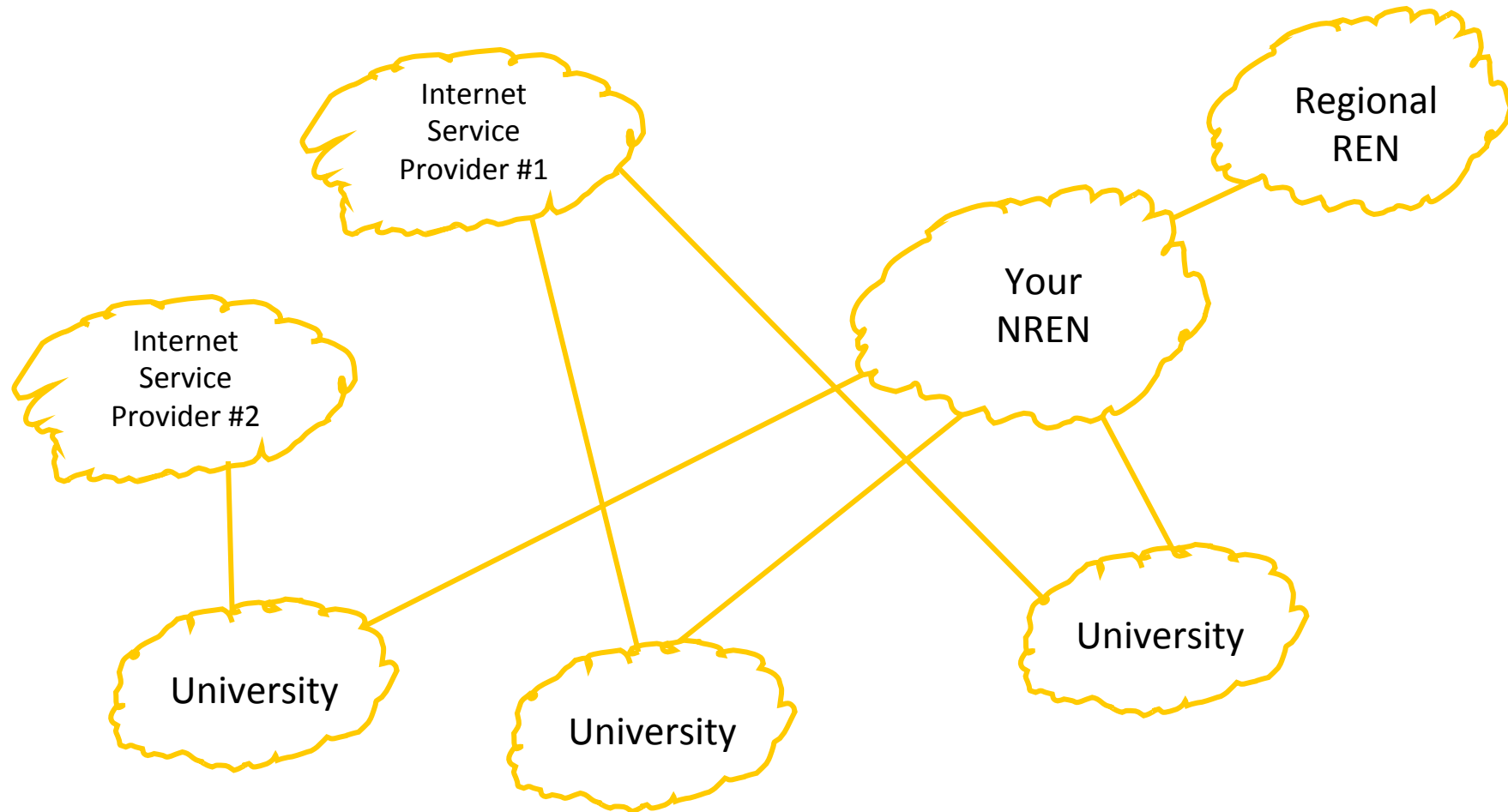
NREN as ISP

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

REN EcoSystem
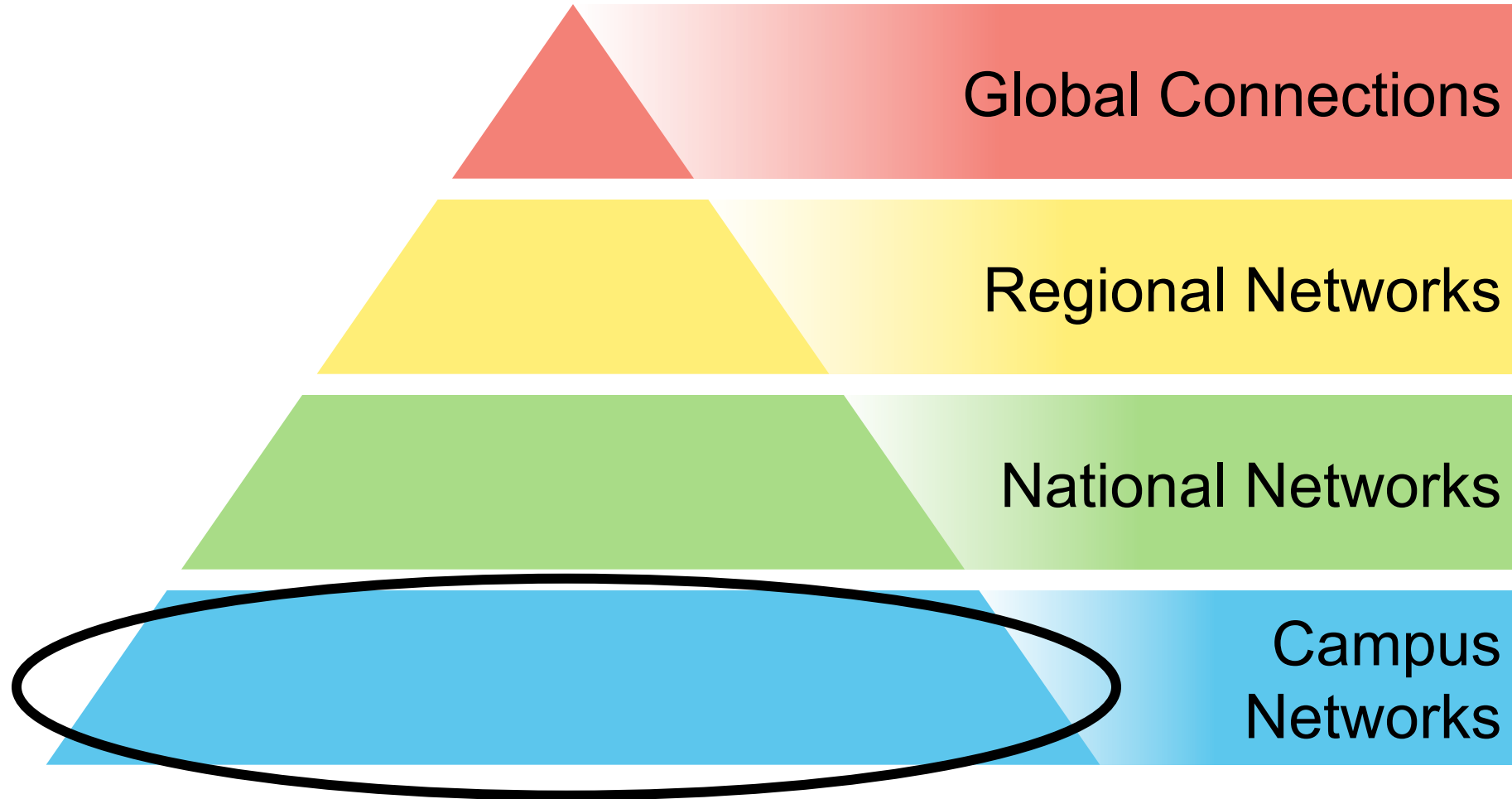
Campus Network Role

- 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 National Network with a 100-gigabit to the regional 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

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

Challenges

- Emerging regions need to develop National Networks
  - Some countries have problems getting funding and the political will to build an NREN

- Campus networks often perform poorly
  - Local expertise is often lacking

Questions?