Campus Network Best Practices: NREN Models

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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 Telephone Company is a losing game
- The pattern around the world is to build regional, national, and larger Research and Education Networks (RENs)

REN versus Campus Network

- The Campus Network is the foundation for all Research and Education activity
- Without a good campus network, the Research and Education Network can't work as well as it should
- The campus network is the foundation that the REN is built upon

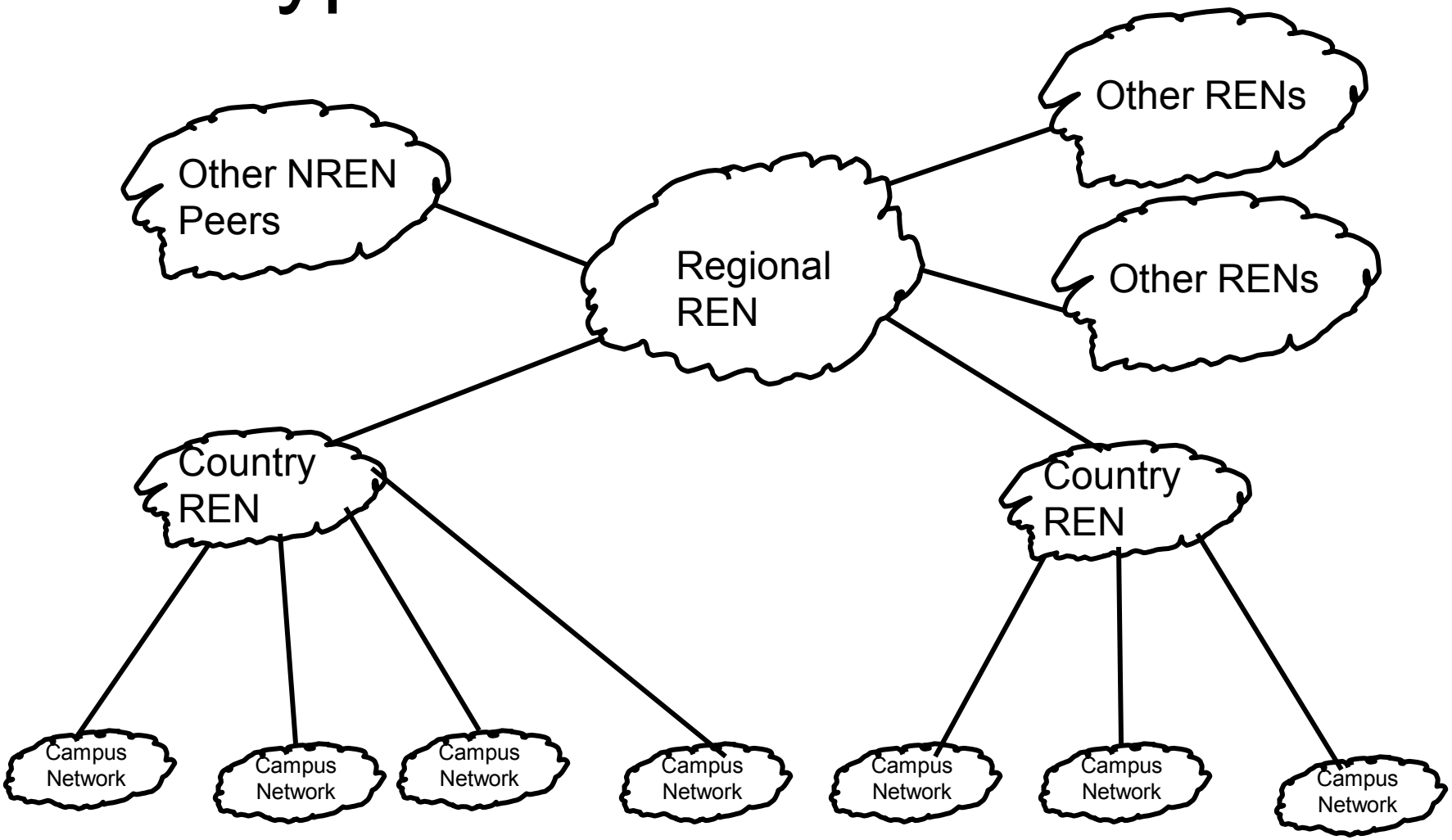
What are Our Goals?

- Network Design Goals
  - Reliability/Resiliency
  - Performance
  - Manageability
    - Must have this to find problems and viruses
  - Scalability
    - Need to be able to grow as needs grow
- Need this in the campus and the REN

REN Ecosystem

- A layered model
  - Global Connectivity
  - Regional RENs
  - National Research and Education Networks
  - All users are connected at the campus network level
    - No scientist is connected directly to a National Network. They are all connected to campus or enterprise networks

Typical REN Architecture



REN Topics

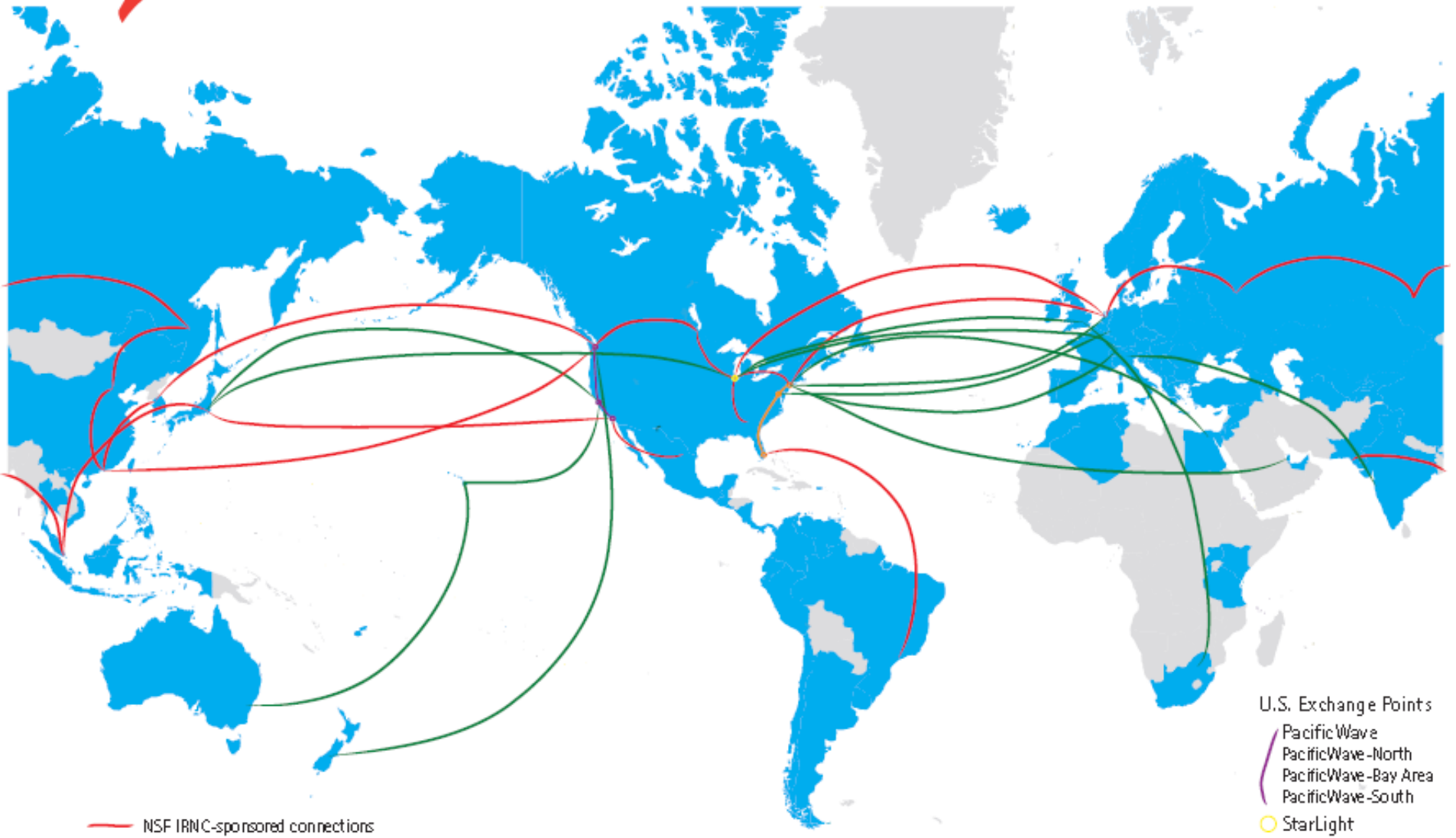
- A look at the Global and Regional REN environment
- A closer look at USA RENs
- How does this relate to South Asia
- NREN IP Transport Models
- Technical Requirements for campus networks and NRENs

Global REN Connections

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

INTERNET2® www.internet.edu

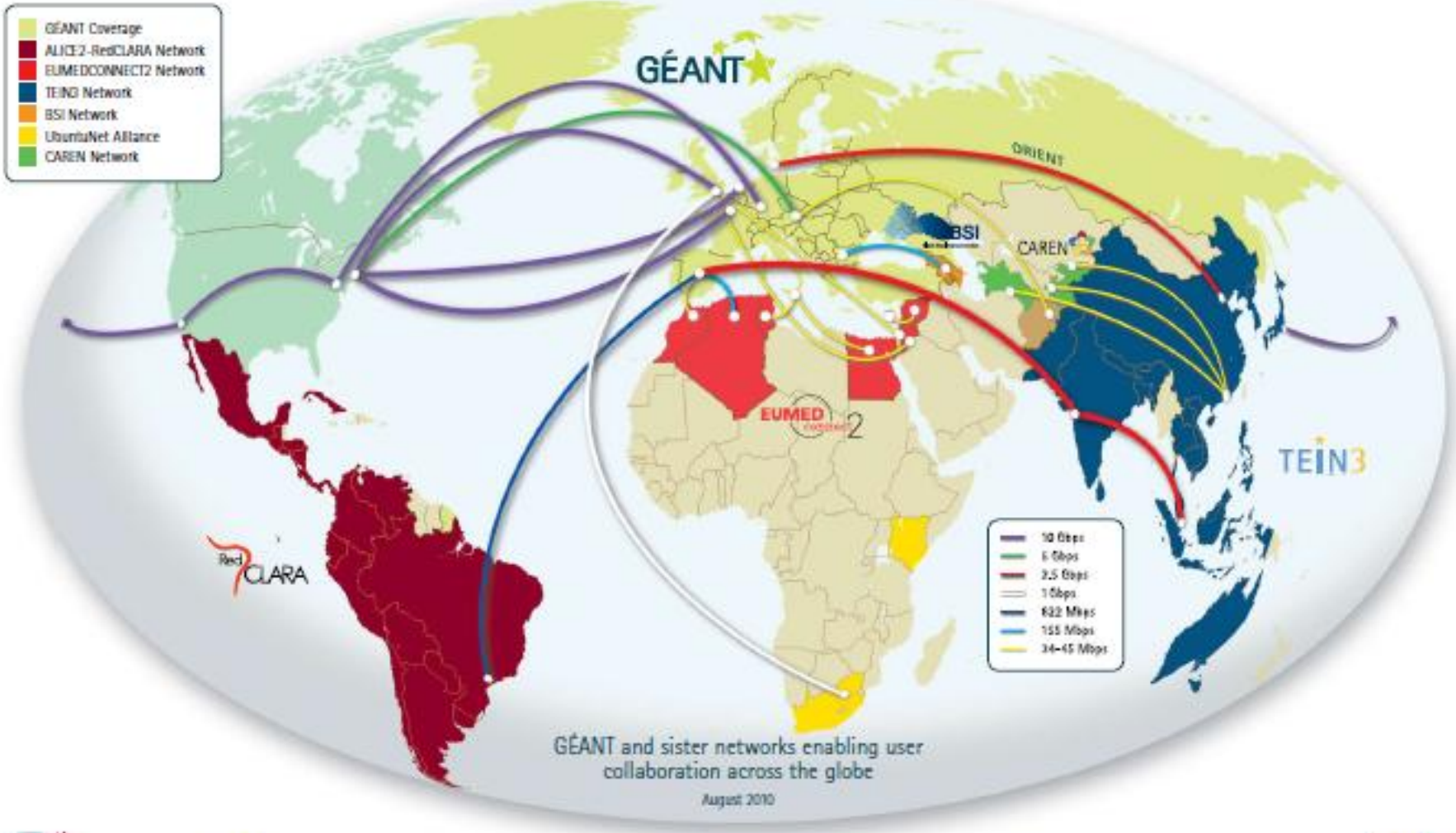
THE INTERNATIONAL REACH OF THE INTERNET2 NETWORK



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.

GÉANT At the Heart of Global Research Networking



DANTE www.dante.net GÉANT www.geant.net

connect • communicate • collaborate

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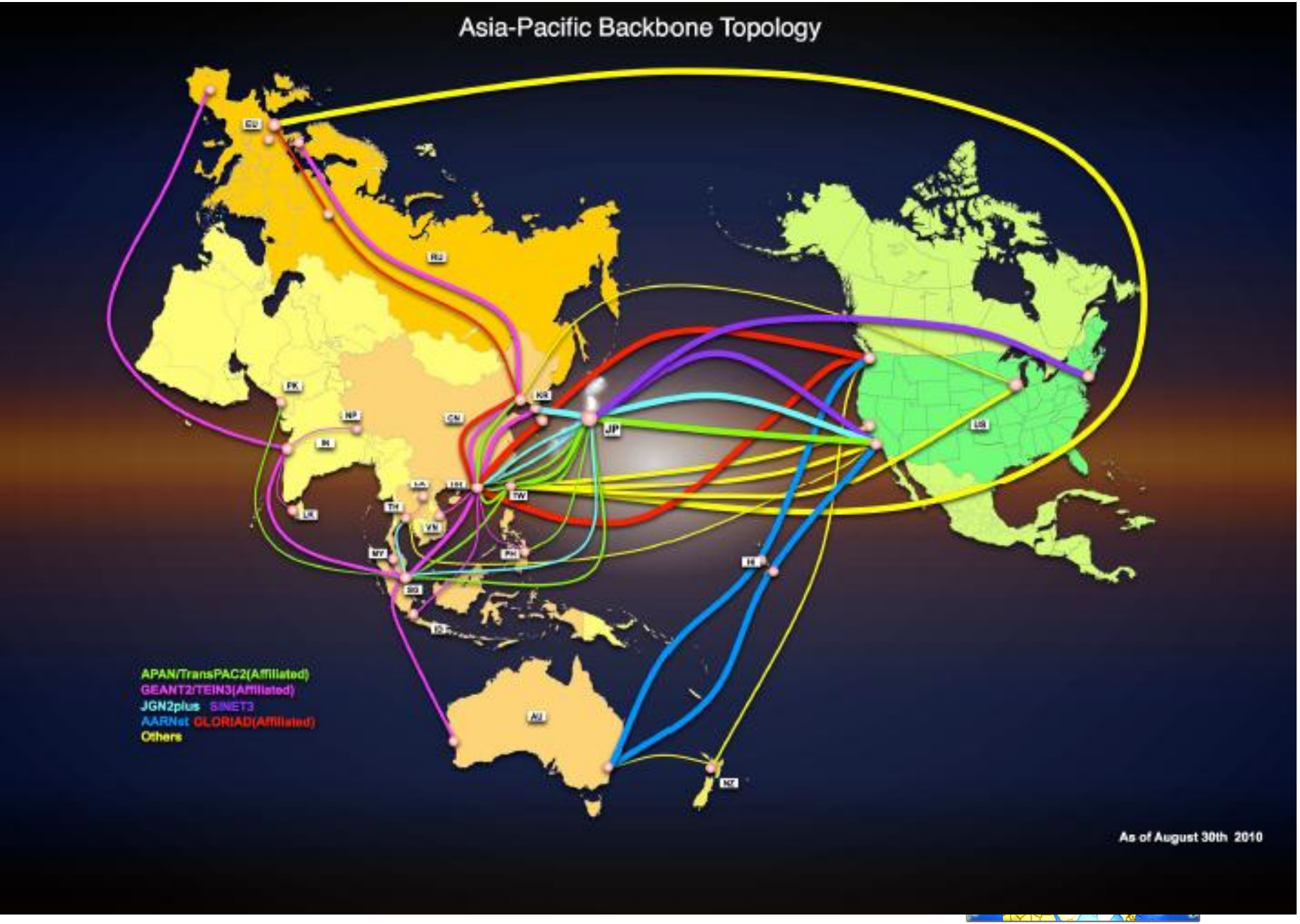
European Commission Information Society and Media


Asia-Pacific Backbone Topology
EU
RU
PK
NP
IN
CN
KR
JP
TW
TH
VN
MY
PH
SG
ID
AU
NZ
US
CA
MX
APAN/TransPAC2(Affiliated)
GEANT2/TEIN3(Affiliated)
JGN2plus SINET3
AARNet GLORIAD(Affiliated)
Others
As of August 30th 2010

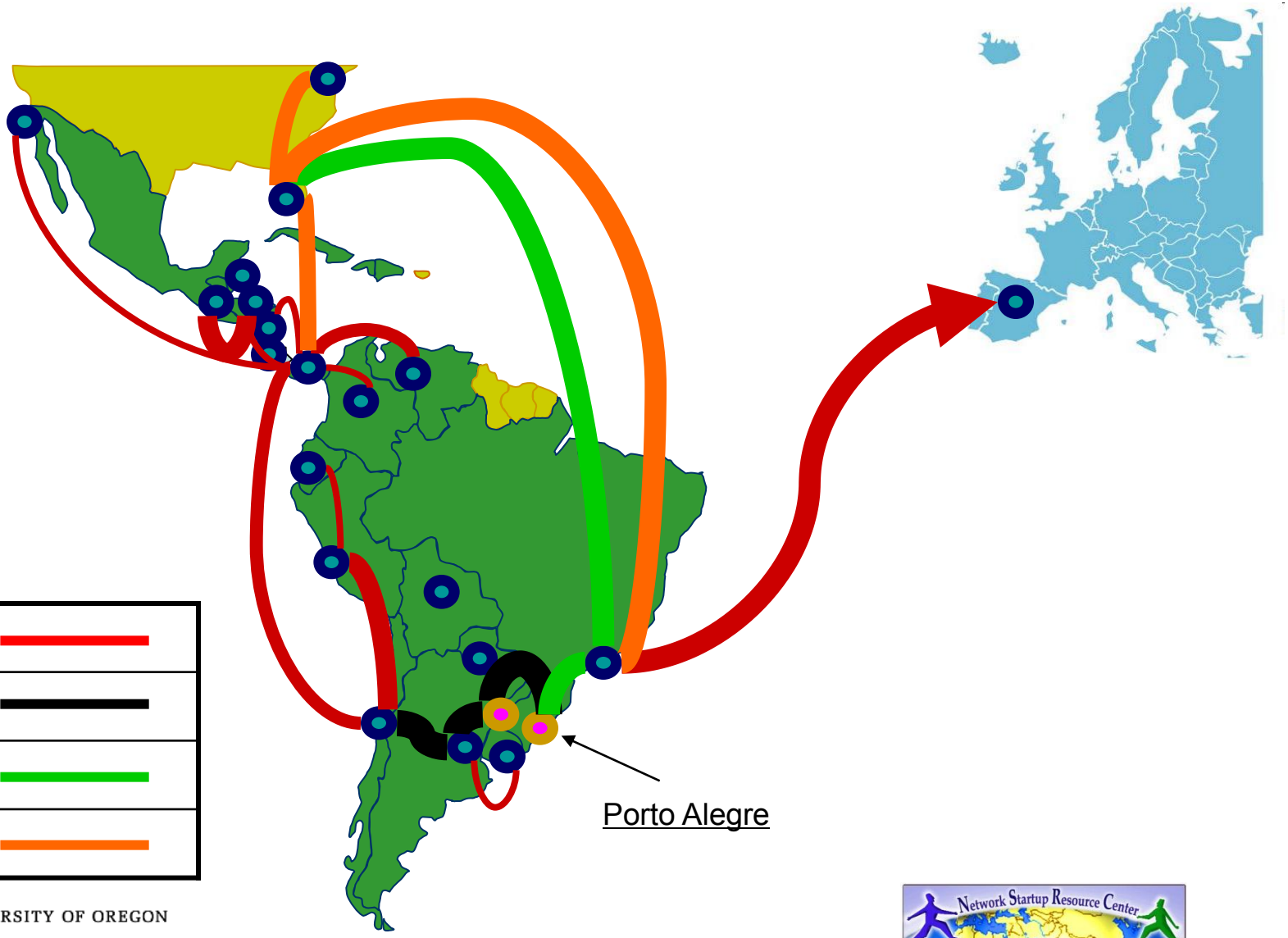
Regional REN Connections

- Connects RENs of individual countries within a geographic region
  - TEIN3 is a good example
- Some Regional RENs are also Global
  - APAN is a good example
- Almost all Regional RENs are peering only networks
    - AfricaConnect is likely to be the exception

Regional REN Connections

- Most regional networks have funding from European Union
  - EUMedConnect
  - TEIN/TEIN2/TEIN3
  - GEANT
  - ALICE/ALICE2 – RedCLARA
  - AfricaConnect

RedCLARA March 2011



ALICE2	
CLARA	
RNP	
AmLight	

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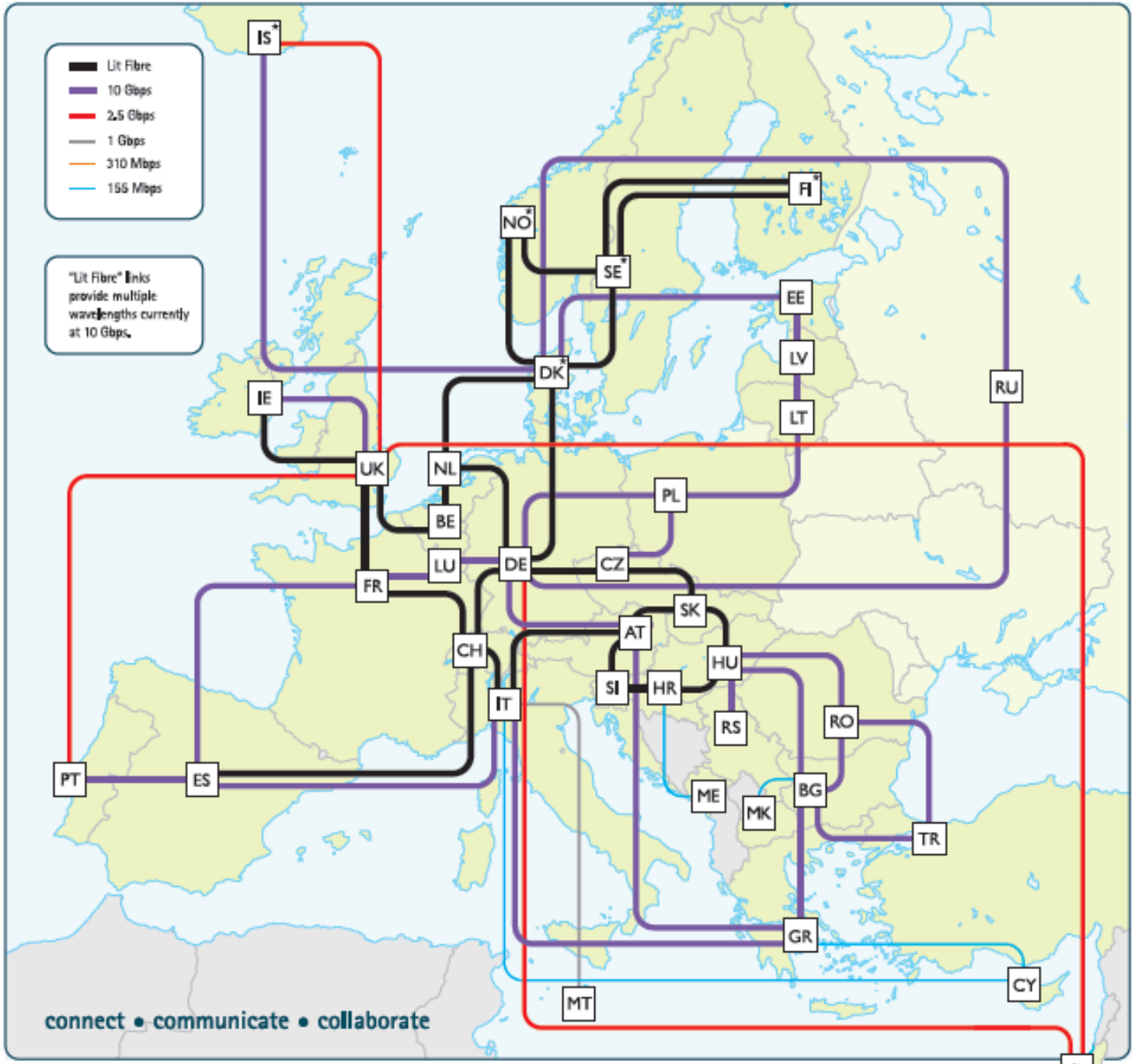
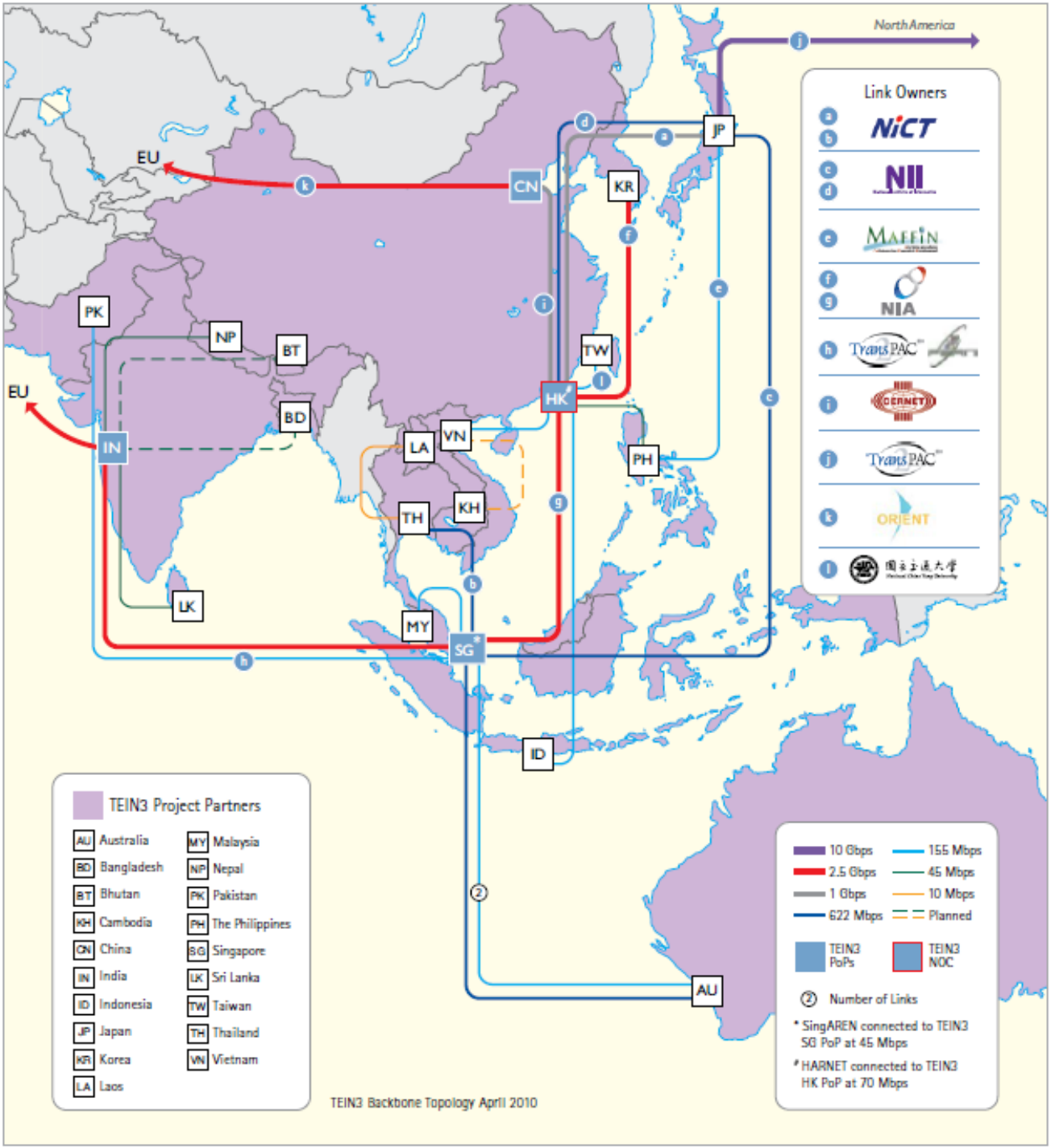
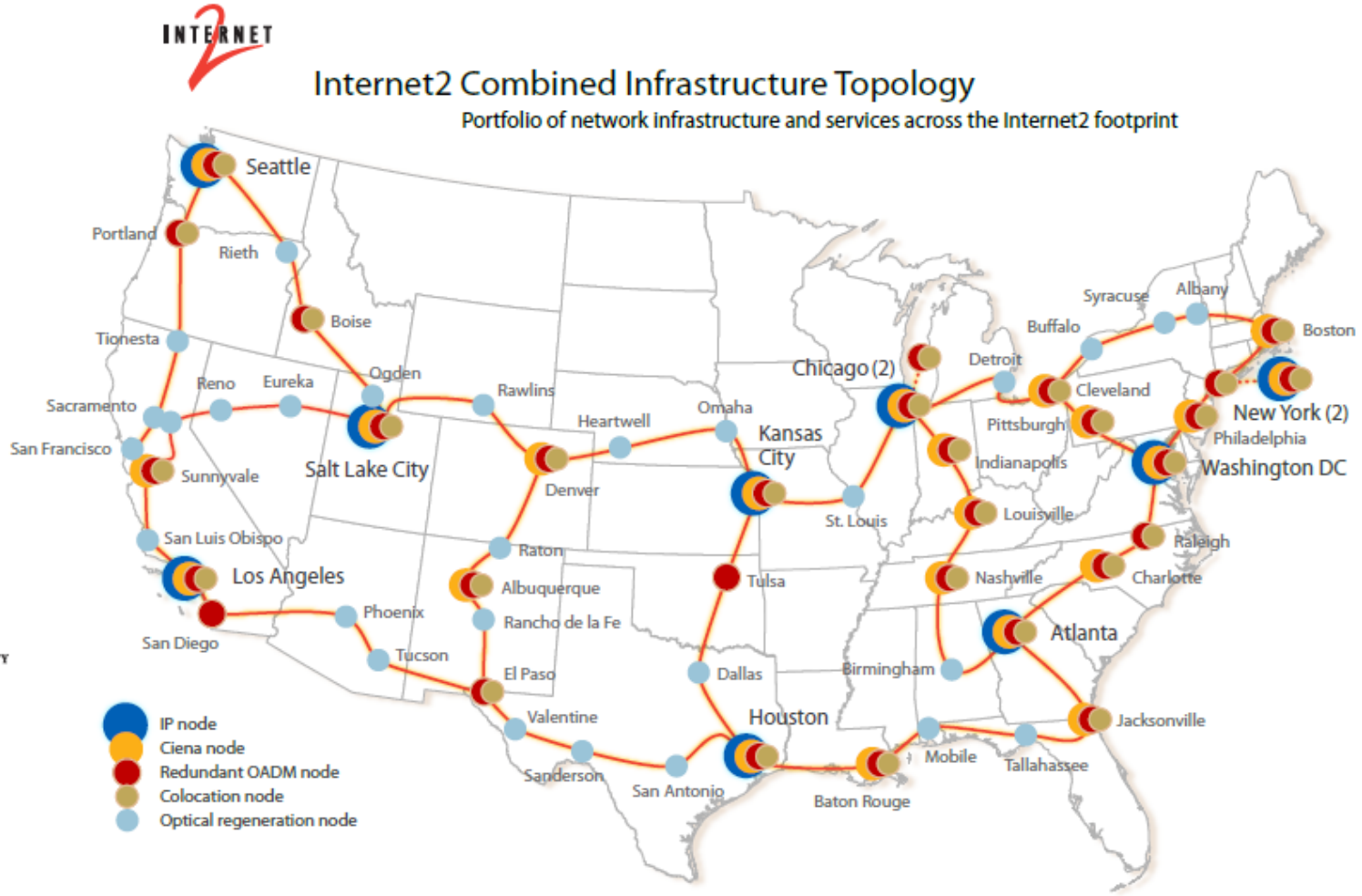
Network Startup Resource Center



Planned Backbone Topology by the end of 2010. GÉANT is operated by DANTE on behalf of Europe's NRENs.


North America
Link Owners
NiCT
NII
MAFFIN
NIA
TransPAC
CERNET
TransPAC
ORIENT
EU
EU
CN
JP
KR
TW
HK
PK
NP
BT
BD
IN
LA
VN
TH
KH
PH
LK
MY
SG
ID
AU
TEIN3 Project Partners
AU Australia
BD Bangladesh
BT Bhutan
KH Cambodia
CN China
IN India
ID Indonesia
JP Japan
KR Korea
LA Laos
MY Malaysia
NP Nepal
PK Pakistan
PH The Philippines
SG Singapore
LK Sri Lanka
TW Taiwan
TH Thailand
VN Vietnam
10 Gbps
2.5 Gbps
1 Gbps
622 Mbps
155 Mbps
45 Mbps
10 Mbps
Planned
TEIN3 PoPs
TEIN3 NOC
② Number of Links
* SingAREN connected to TEIN3 SG PoP at 45 Mbps
# HARNET connected to TEIN3 HK PoP at 70 Mbps
TEIN3 Backbone Topology April 2010

USA NREN: Internet2



NETWORK PARTNERS

ciena

INDIANA UNIVERSITY

infinera

Juniper NETWORKS

Level(3)

CONNECTORS

3ROX
CENIC
CIC OmniPoP
Drexel University
GPN
Indiana GigaPoP
KyRON
LEARN
LONI
MAGPI
MAX
MCNC
Merit Network
MREN
NOX
NYSERNet
Oregon Gigapop
Pacific Northwest GigaPoP
SoX
University of Memphis
University of New Mexico
USF/FLR
University of Utah/UEN

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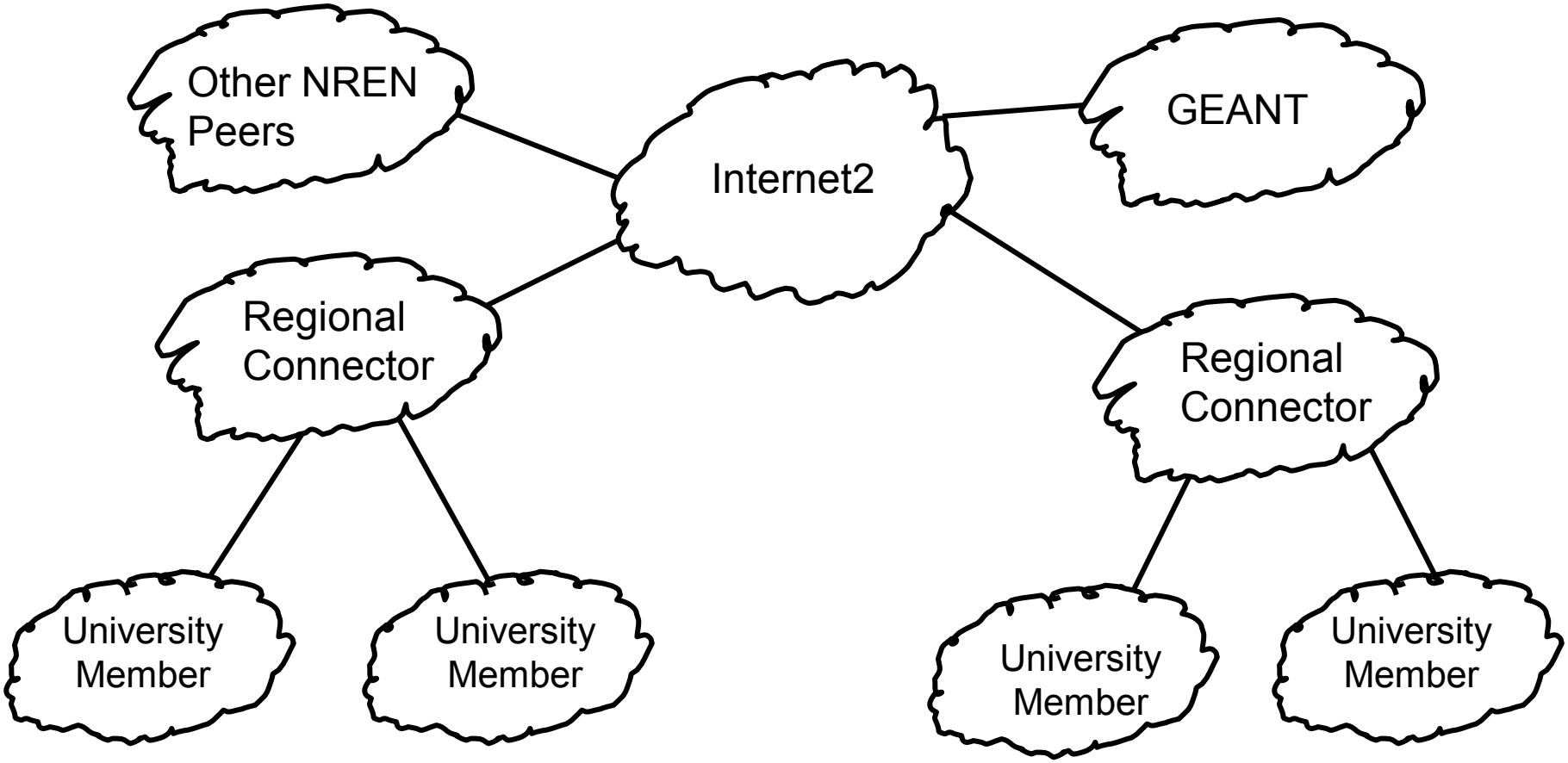
Network Startup Resource Center

Internet2 Logical Network



The Key to Internet2 is the Regional

- Internet2 doesn't connect individual campus networks
- Internet2 connects to Regional Networks
  - Regional RENs, in USA, we call them Regional Optical Networks or RONs
- The Regional Networks provide connections to campus networks

USA Regional Networks

- Often they cover a single state
- Regionals are similar, but different
  - Legal Status
    - Approx 50% are legal non profit
    - Approx 40% are housed at a University
  - Startup Funding
    - Most obtained funding from State Government

USA Regional Networks

- Staffing
  - Range in size from 1 to 110 employees
  - RONs associated with Universities frequently used University back-office functions
- Network Operations
  - All provided 24x7 monitoring
  - Only half provided staffed 24x7 NOC
  - Over 40% outsource NOC functions
    - ¾ of those who outsourced used University member

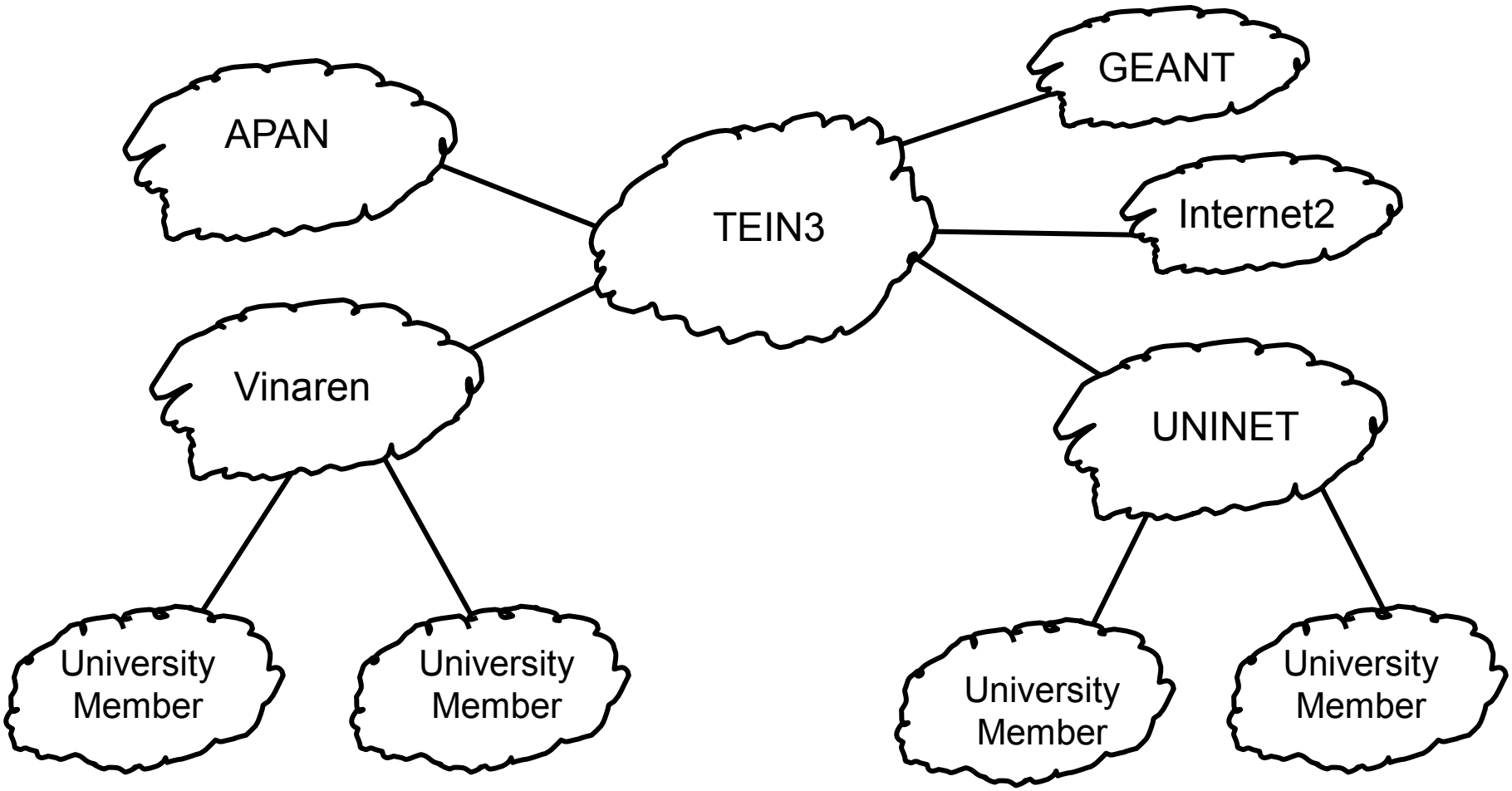
USA Regional Networks

- Services
  - All provided IP transport to Internet2
  - Not all provide commodity Internet access
  - Many provide other services
    - Video Conferencing
    - VoIP
    - Business Continuity/disaster recovery services
    - Email hosting
    - Web hosting
    - Data center space

USA Regional Networks

- Pricing/Cost Recovery
  - State Government funded
  - Member funded
    - Some split costs evenly among members
    - Others had tiered pricing
  - Most who provided “other” services charged specifically for that service
- Customer base
  - Most serve more than Universities

The South Asia Picture



NREN IP Network

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

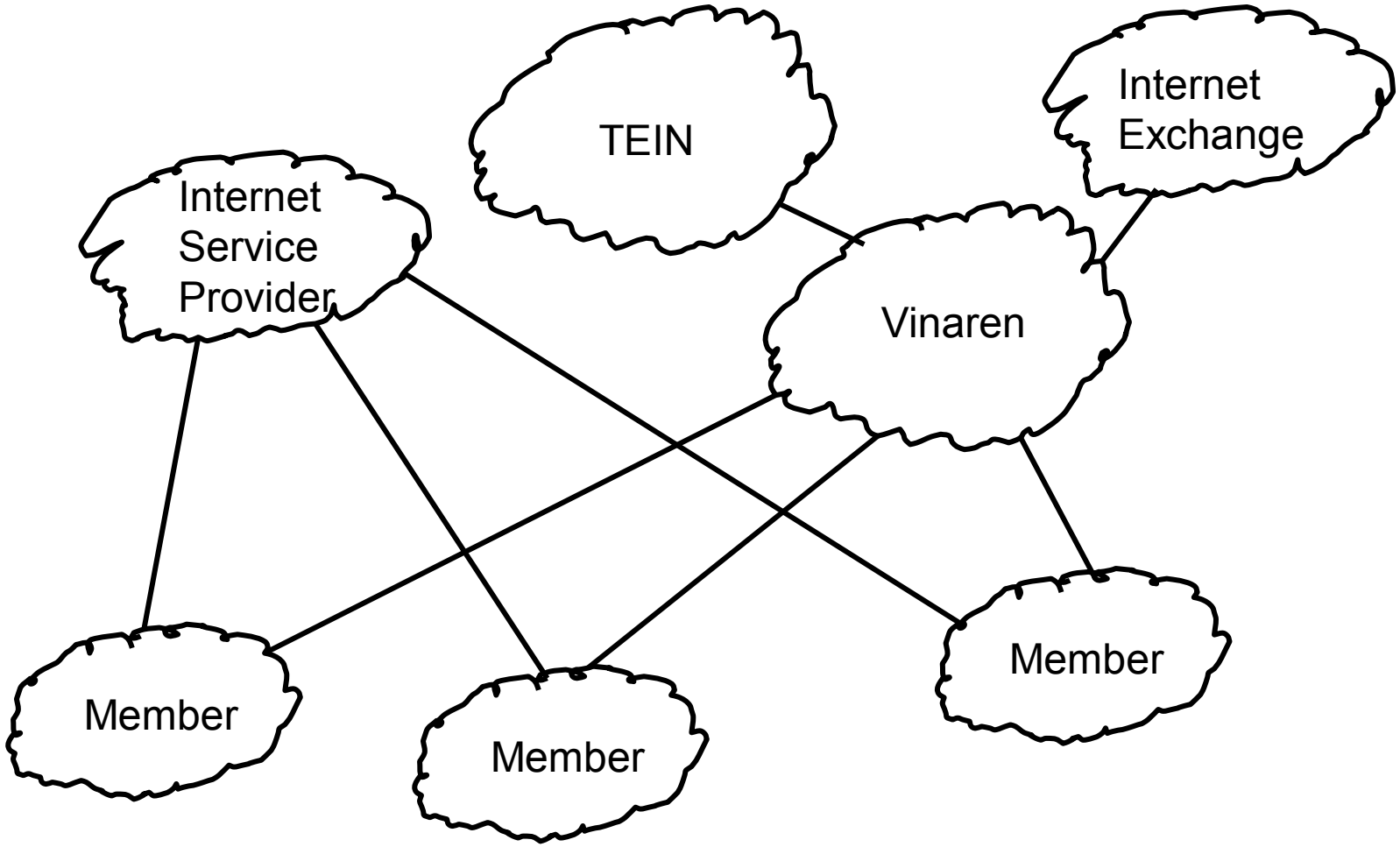
Requirements of Members

- REN is Peering Network
  - Each member still has their own ISP
  - Each member must have ASN and run BGP
- REN provides all Internet connectivity
  - Simplest for campus members
  - No ASN or BGP required at campus level

Introduction to Peering

- Exchange of Customer traffic (not transit)
- Peering requires sophisticated route selection techniques
- This is done with Border Gateway Protocol (BGP is the acronym)
- Every BGP speaker must have a unique Autonomous System Number (ASN)
  - An ASN is typically assigned per network

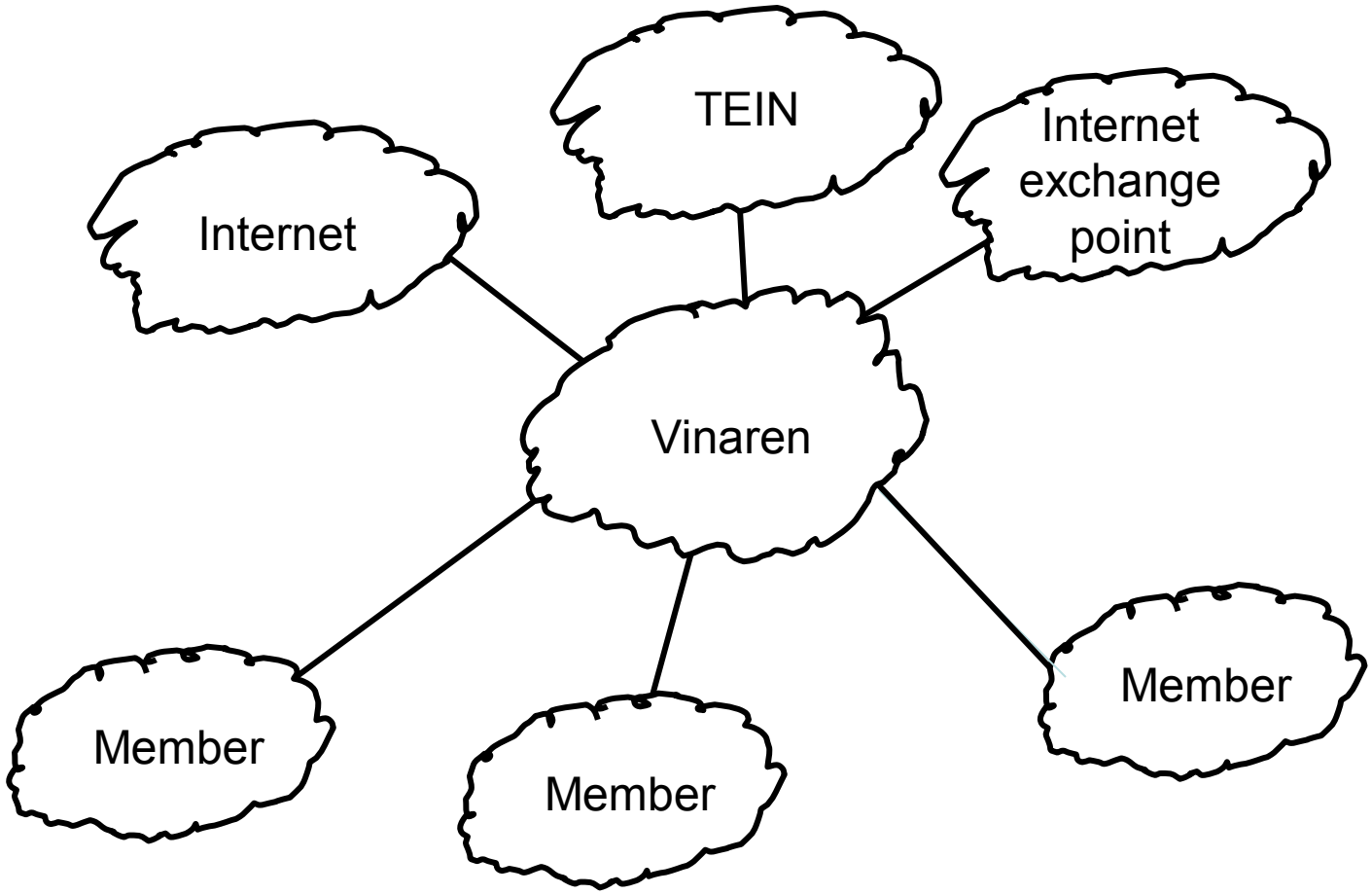
REN as Peering Network



REN as Peering Network

- To make this really work right:
  - Each member still has their own ISP
  - Each member must have Provider Independent IP Address Space
  - Each Member much has their own ASN
  - Each Member must run BGP and peer with both their REN and their ISP
- You can try to play tricks with NAT and IP addressing, but you will fail in the end.

REN as ISP


TEIN
Internet
Internet exchange point
Vinaren
Member
Member
Member

REN as ISP

- When the REN provides all Internet connectivity to campus members:
  - Simplest for campus members
  - Campuses don't need Provider Independent IP address space
  - No ASN or BGP required at campus level
- This strategy is the easiest for the members, but the most difficult from a regulatory perspective

Requirements of NRENs

- All NRENs must have provider independent IP address space
- All NRENs must have their own ASN
- All NRENs must run BGP to external peers

Questions/Discussion?