

Research and Education Networks

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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, services, or activities that could not be otherwise accomplished**
- 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 you 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 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



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Problems with Campus Networks

- Many are not structured properly and can't effectively utilize high bandwidth REN 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
- Many don't have sufficiently trained staff



What are Our Goals?

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

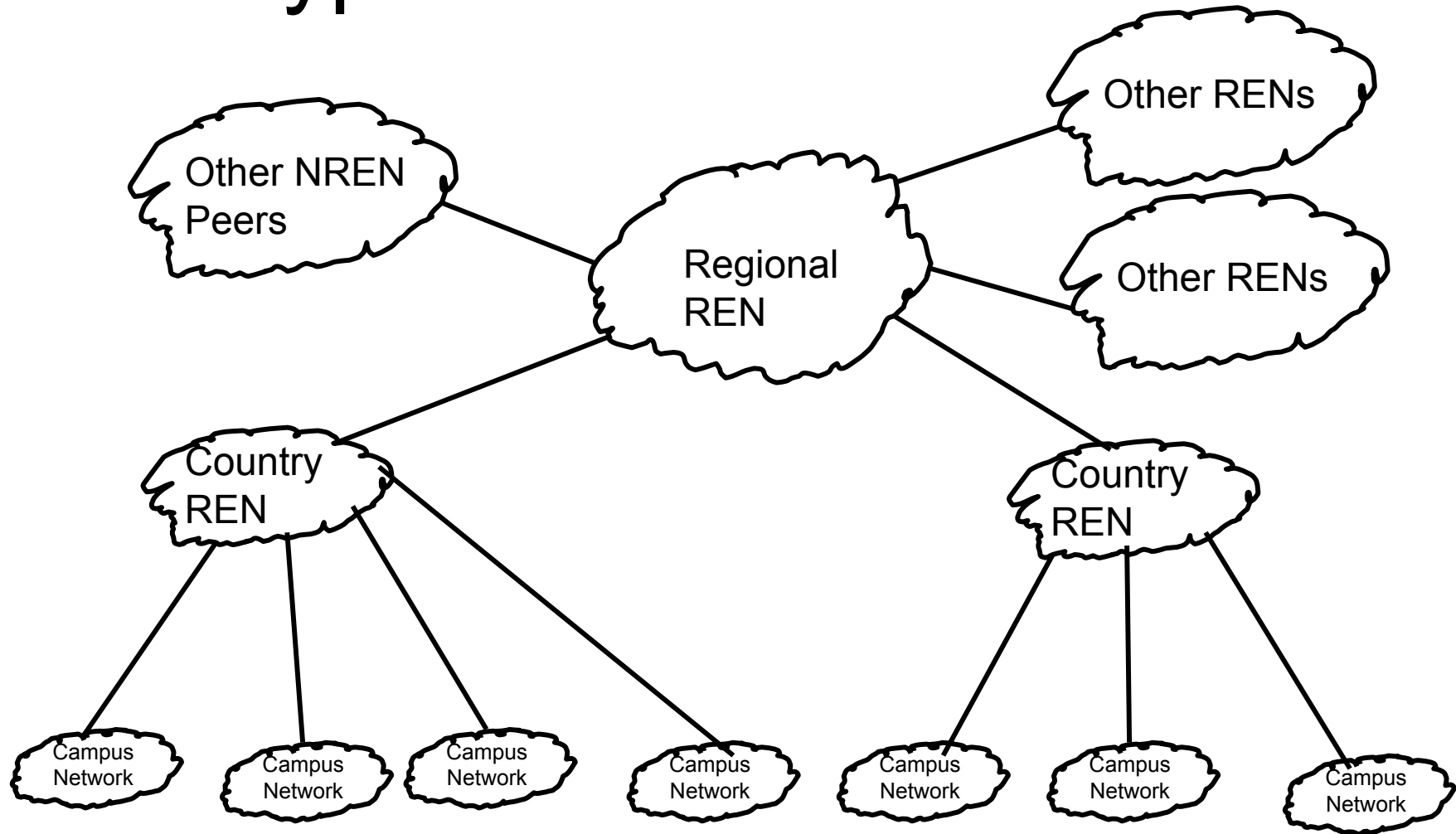


REN Ecosystem

- 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



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REN Topics

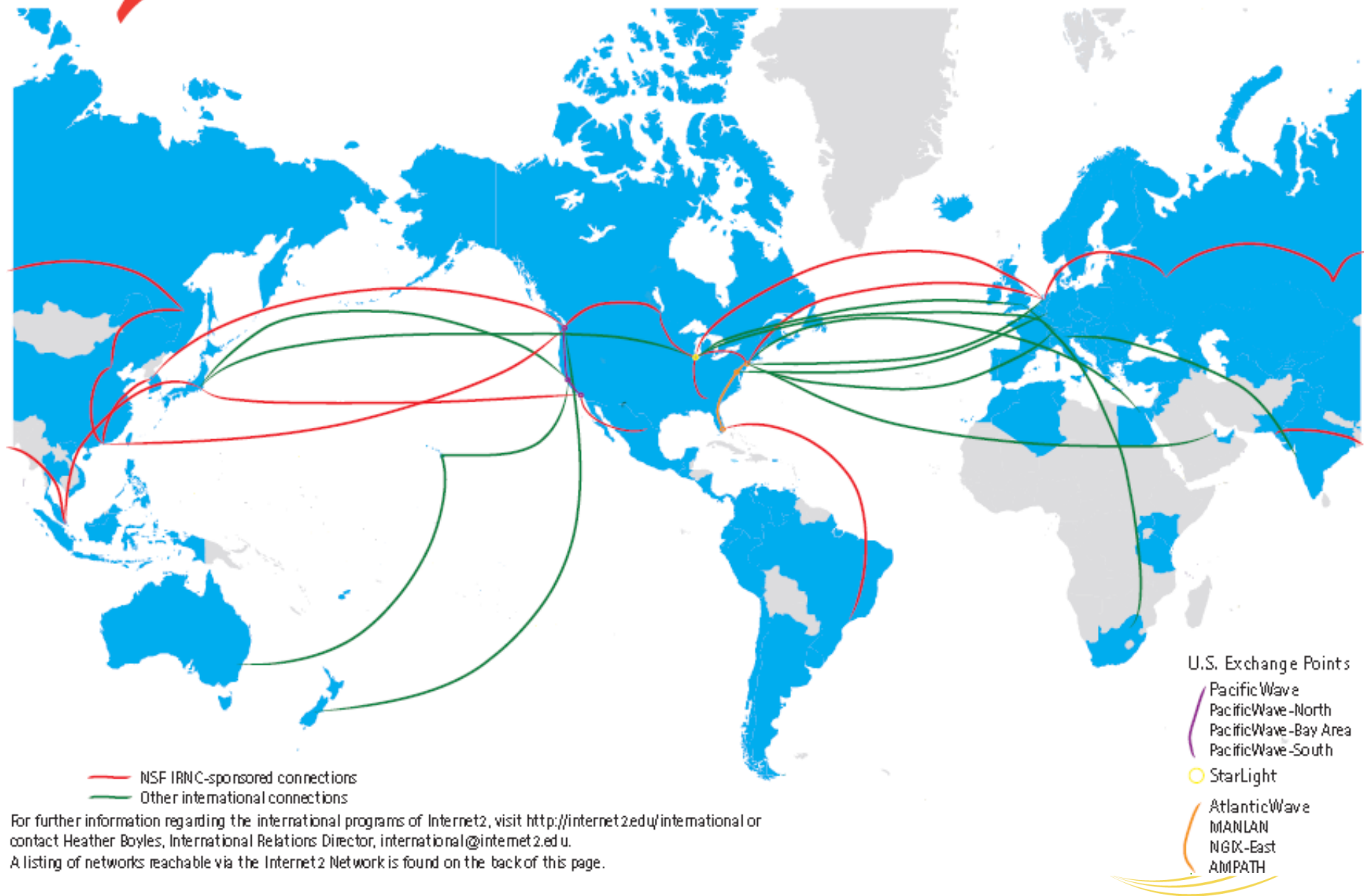
- A look at the Global and Regional REN environment
- A closer look at USA RENs
- How does this relate to South Asia
- NREN IP Transport Models
- Technical Requirements for campus networks and NRENs



Global REN Connections

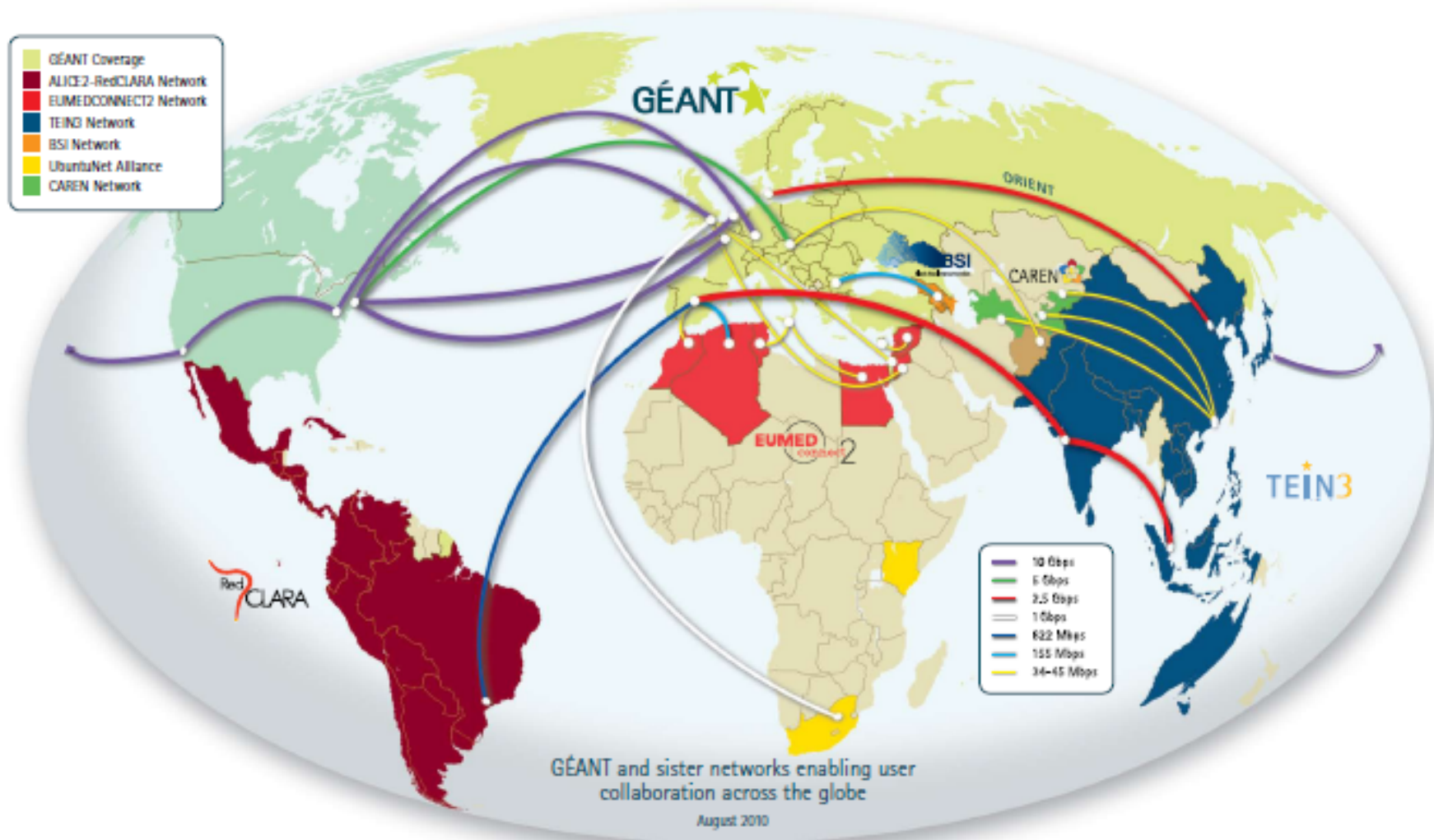
- Connect Regional or National networks together
- Tend to be longer, more expensive circuits
- Not always well coordinated
- Routing policies often inconsistent
- Always are peering networks





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



Asia-Pacific Backbone Topology



As of August 30th 2010

Regional REN Connections

- Connects RENs of individual countries within a geographic region
 - TEIN is a good example
- Some Regional RENs are also Global
 - APAN is a good example



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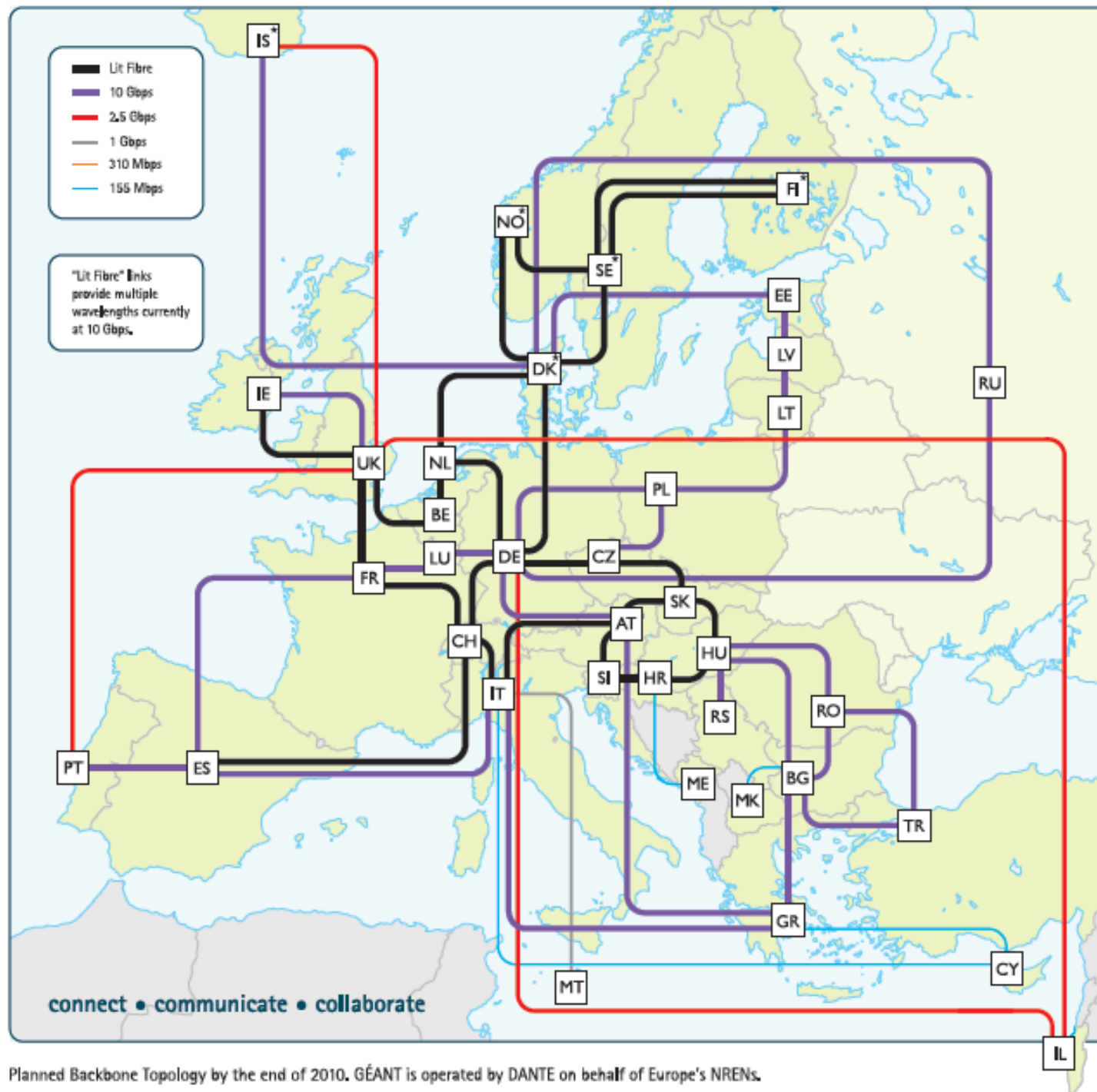
Regional REN Connections

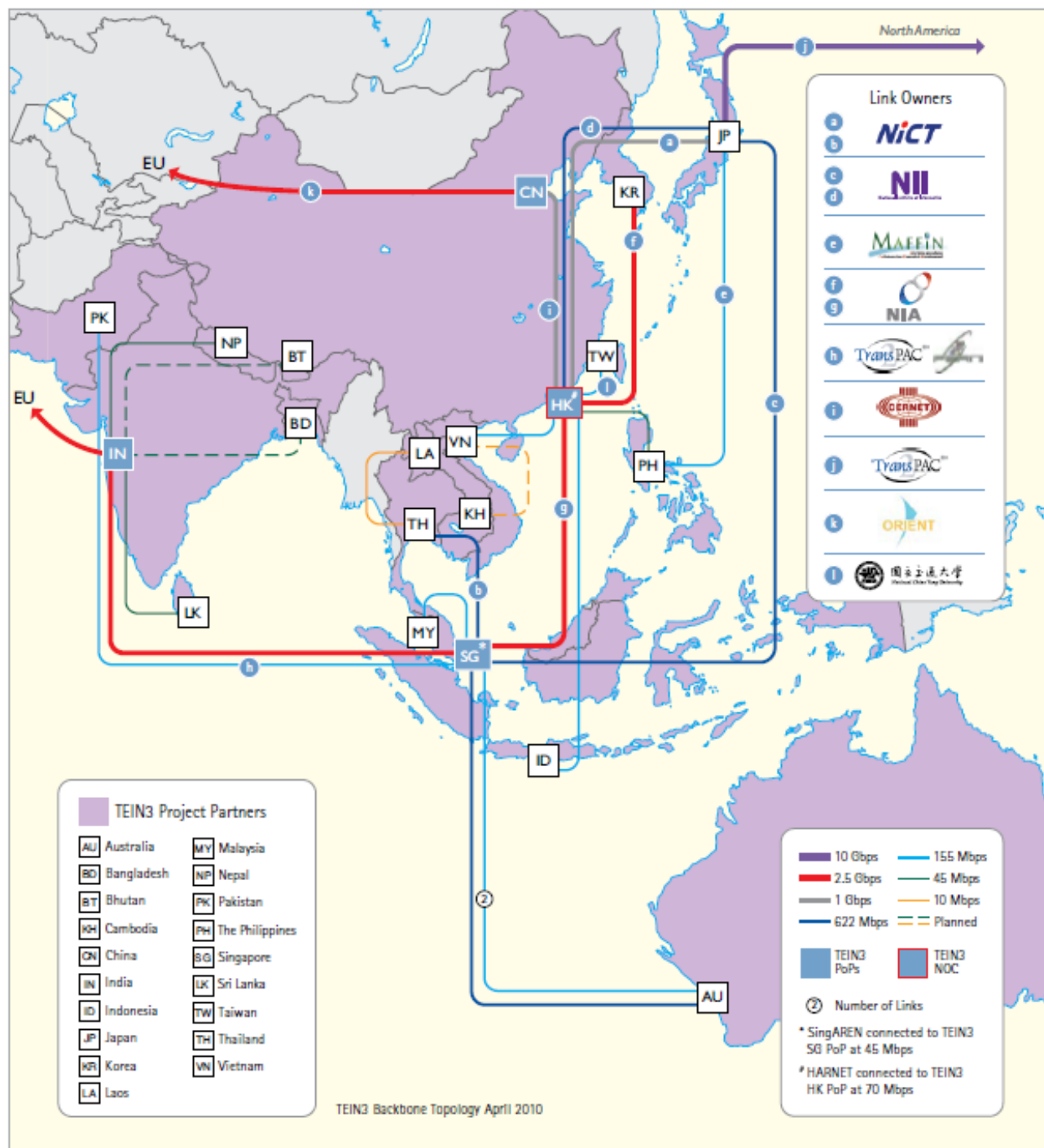
- Most regional networks have funding from European Union
 - EUMedConnect
 - TEIN/TEIN2/TEIN3
 - GEANT
 - ALICE/ALICE2 – RedCLARA
 - AfricaConnect/Ubuntunet



RedCLARA March 2011







USA NREN: Internet2



Internet2 Combined Infrastructure Topology

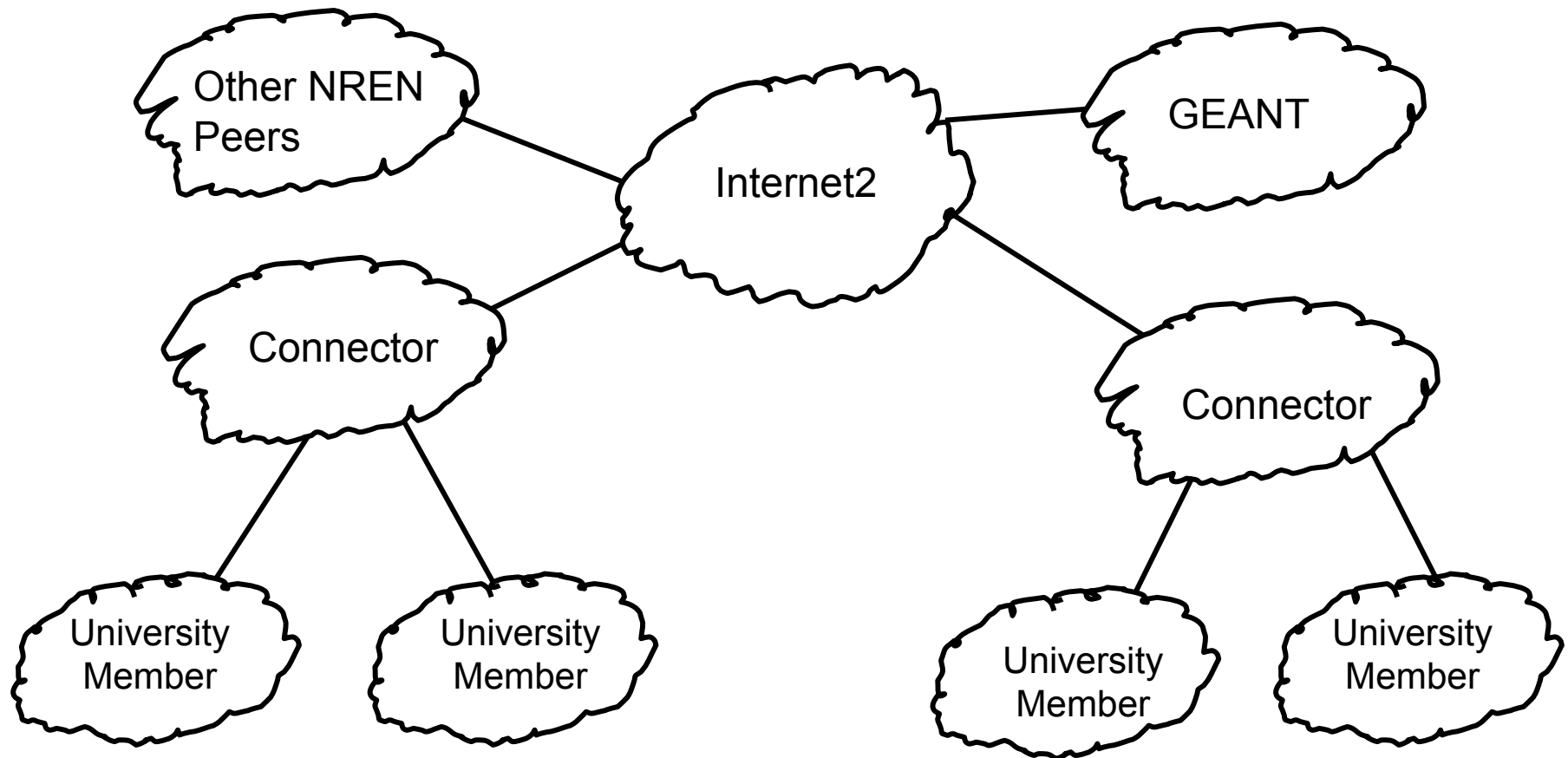
Portfolio of network infrastructure and services across the Internet2 footprint



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Internet2 Logical Network



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The Key to Internet2 is the Connector

- Internet2 doesn't connect individual campus networks
- Internet2 connects to Connector Networks
 - These connector networks provide service typically in one state, some provide connections to multiple states
- The Regional Networks provide connections to campus networks



USA Connector Networks

- Often they cover a single state
- Each Connector is 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



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USA Connector 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
 - $\frac{3}{4}$ of those who outsourced used University member



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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



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USA Connector Networks

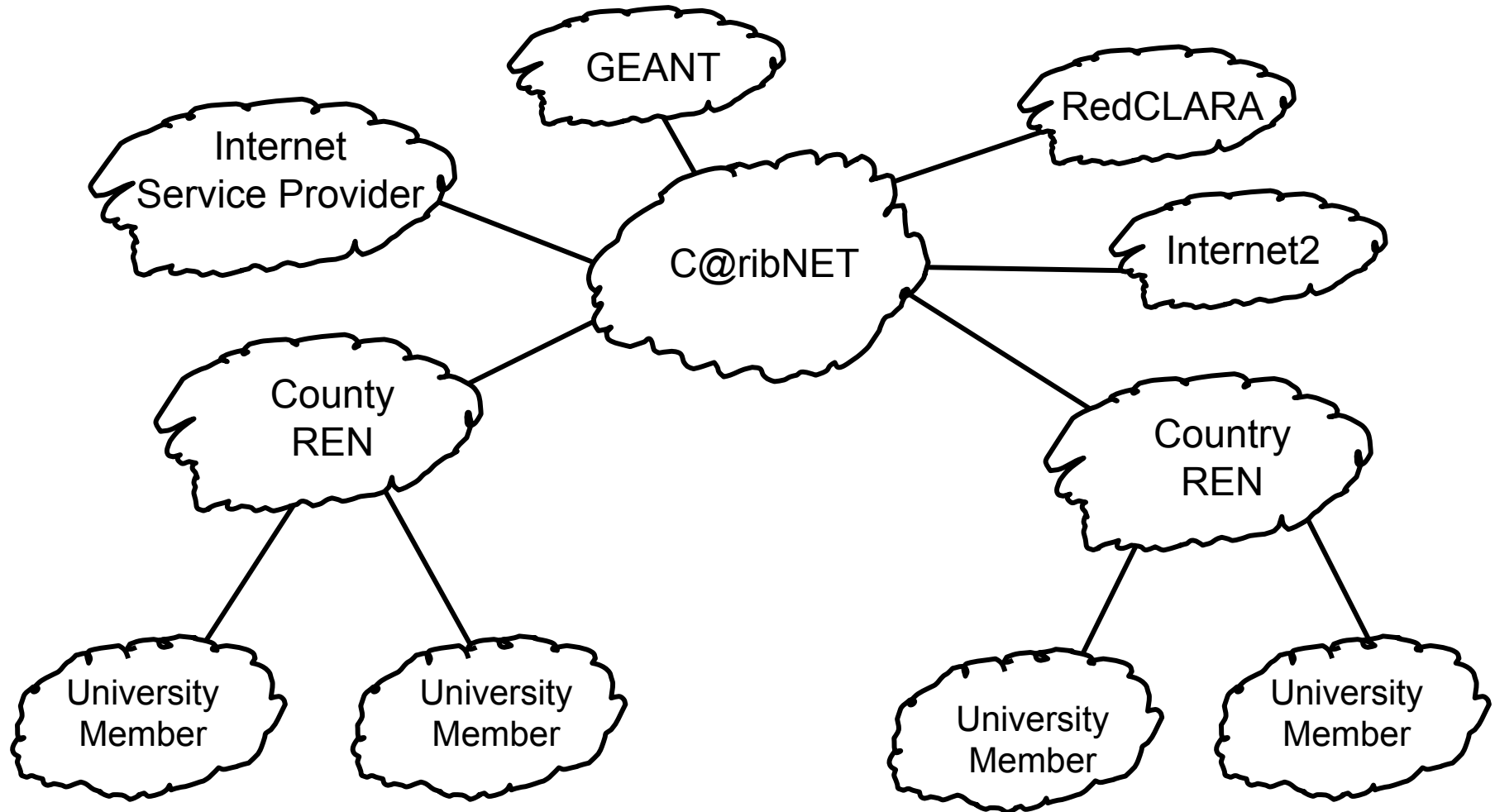
- Pricing/Cost Recovery
 - State Government funded
 - Member funded
 - Some split costs evenly among members
 - Others had tiered pricing
 - Most who provided “other” services charged specifically for that service
- Customer base
 - Most serve more than Universities



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The Caribbean Picture (incomplete)



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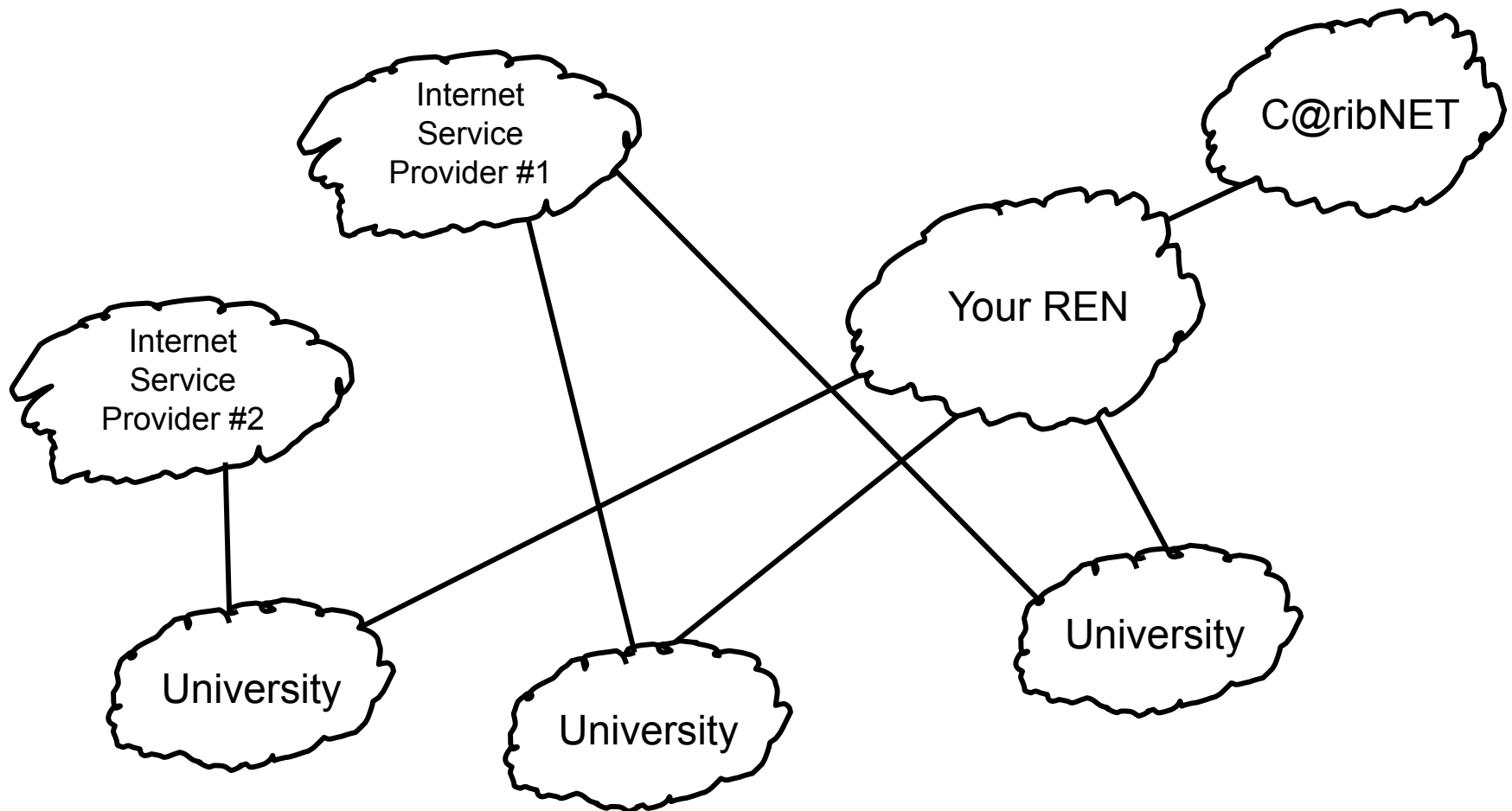


NREN Models of Service

- Two basic models:
 - Peering network
 - Exchange traffic between members
 - Provide international connections (Internet2, 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



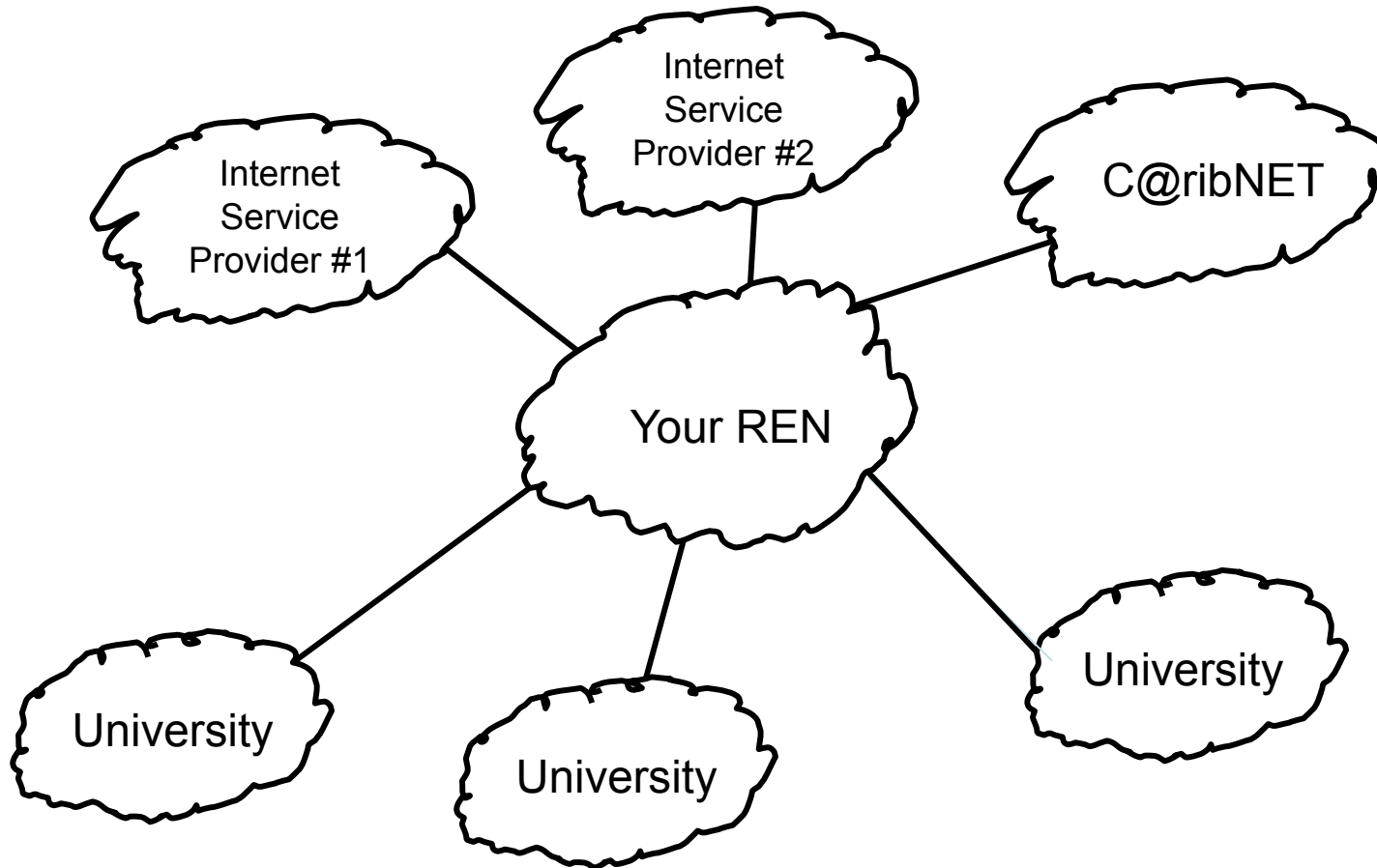
NREN as Peering Network



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NREN as ISP



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Implications for Universities

- If NREN is a Peering Network
 - Each University still has their own ISP
 - Each University connects to NREN
 - 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 many customers
 - Often the legal and regulatory environment allows this use without licensing and/or the license is easier to get
- However, there are problems with this approach



NREN as a Peering Network

- Universities now have two connections
 - How do they decide which one to use?
- Three approaches:
 1. Get provider independent IP address, autonomous system number, and run BGP
 2. Get routes from NREN and run special software and configuration on a NAT box
 3. Split 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
- For those that do Peering Only
 - Advanced regions: they do the right thing and have Provider Independent IP addresses, ASN, and run BGP. This works fine.
 - Less advanced regions: they split their campus and the NREN becomes a video conferencing network.
- What kind of network will you build here?



Your REN as Peering Only

- How will each campus manage two connections?
 - Split the campus network into two sections?
 - Get routes from the REN to your NAT box and use NAT translations?
 - Get Autonomous System Number (ASN), Provider Independent IP addresses, and run BGP?



Your REN as an ISP

- This is simple for campuses. The campus just has a default route to your REN.
- What the REN do about a backup connection to improve reliability?
 - If link to the ISP goes down, the campus will lose Internet – Maybe two ISPs?
- What are the politics of having your REN be an ISP?



Questions/Discussion?

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