Campus Network Best Practices: RENs Around the World

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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

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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

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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

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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)

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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
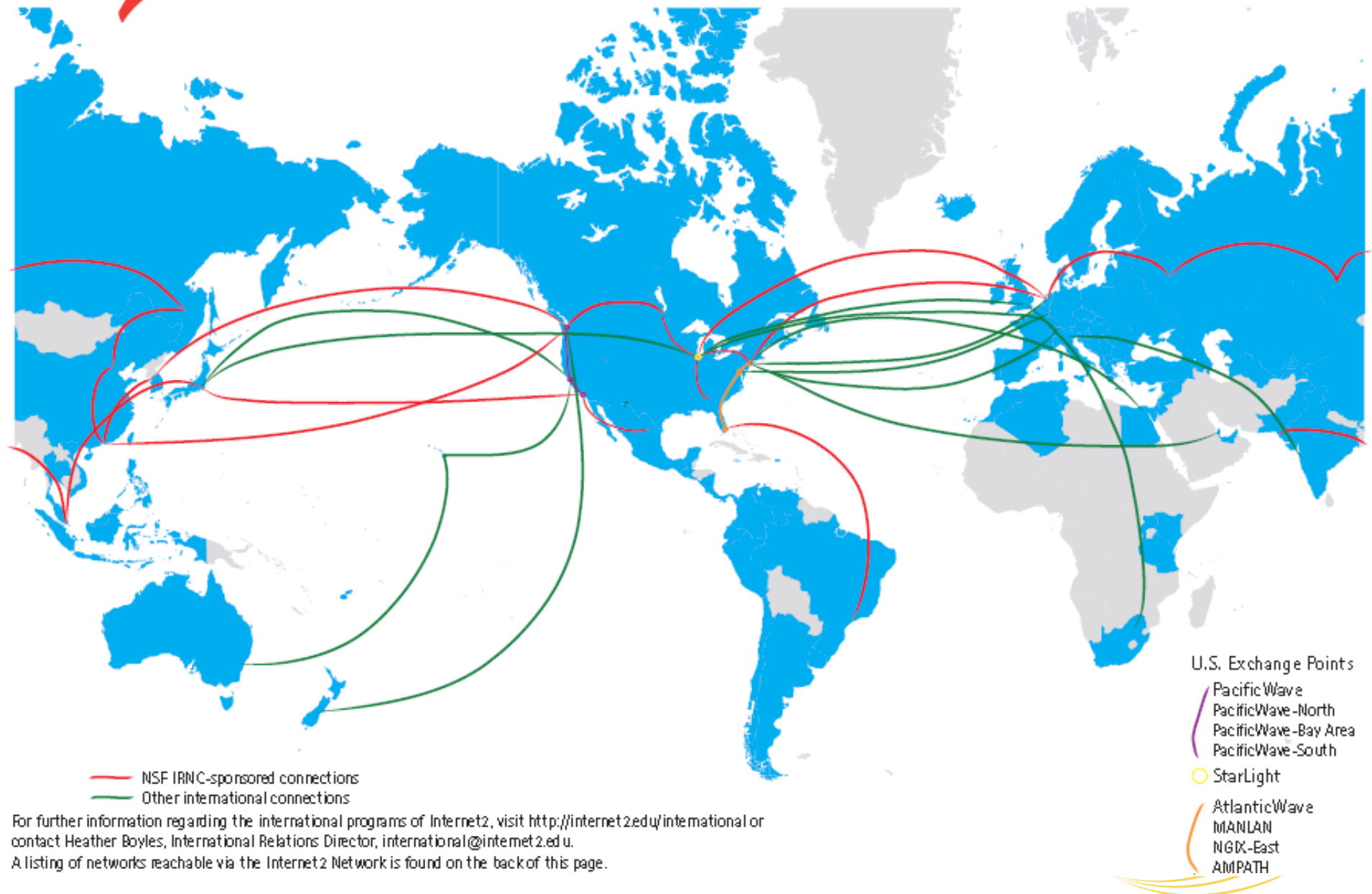
REN Ecosystem

- 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

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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 your REN
- NREN IP Transport Models
- Technical Requirements for campus networks and NRENs

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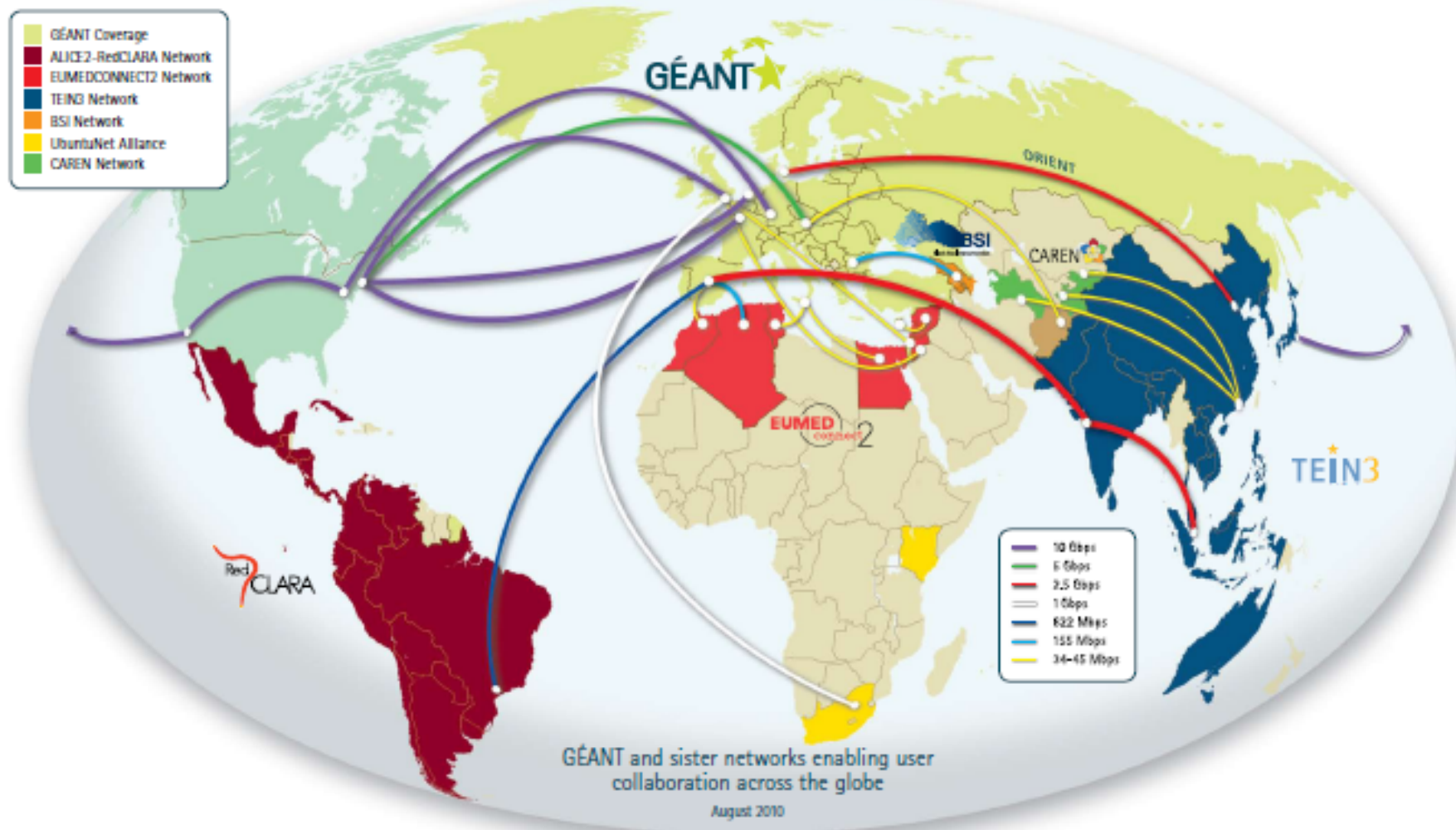
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Global REN Connections

- 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

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INTERNET2® www.internet.edu

THE INTERNATIONAL REACH OF THE INTERNET2 NETWORK

U.S. Exchange Points

PacificWave
PacificWave-North
PacificWave-Bay Area
PacificWave-South

○ StarLight

AtlanticWave
MANLAN
NGIX-East
AMPATH

—— NSF IRNC-sponsored connections
—— Other international connections

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

GÉANT Coverage
ALICE2-RedCLARA Network
EUMEDCONNECT2 Network
TEIN3 Network
BSI Network
UbuntuNet Alliance
CAREN Network

GÉANT

ORIENT

BSI

CAREN

EUMED connect 2

Red CLARA

TEIN3

10 Gbps
5 Gbps
2.5 Gbps
1 Gbps
622 Mbps
155 Mbps
34–45 Mbps

GÉANT and sister networks enabling user
collaboration across the globe

August 2010

DANTE
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GÉANT
www.geant.net

connect • communicate • collaborate

GÉANT is co-funded by the European Commission within its 7th R&D Framework Programme.
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European Commission
Information Society
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Asia-Pacific Backbone Topology

APAN/TransPAC2(Affiliated)
GEANT2/TEIN3(Affiliated)
JGN2plus SINET3
AARNet GLORIAD(Affiliated)
Others

As of August 30th 2010

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Regional REN Connections

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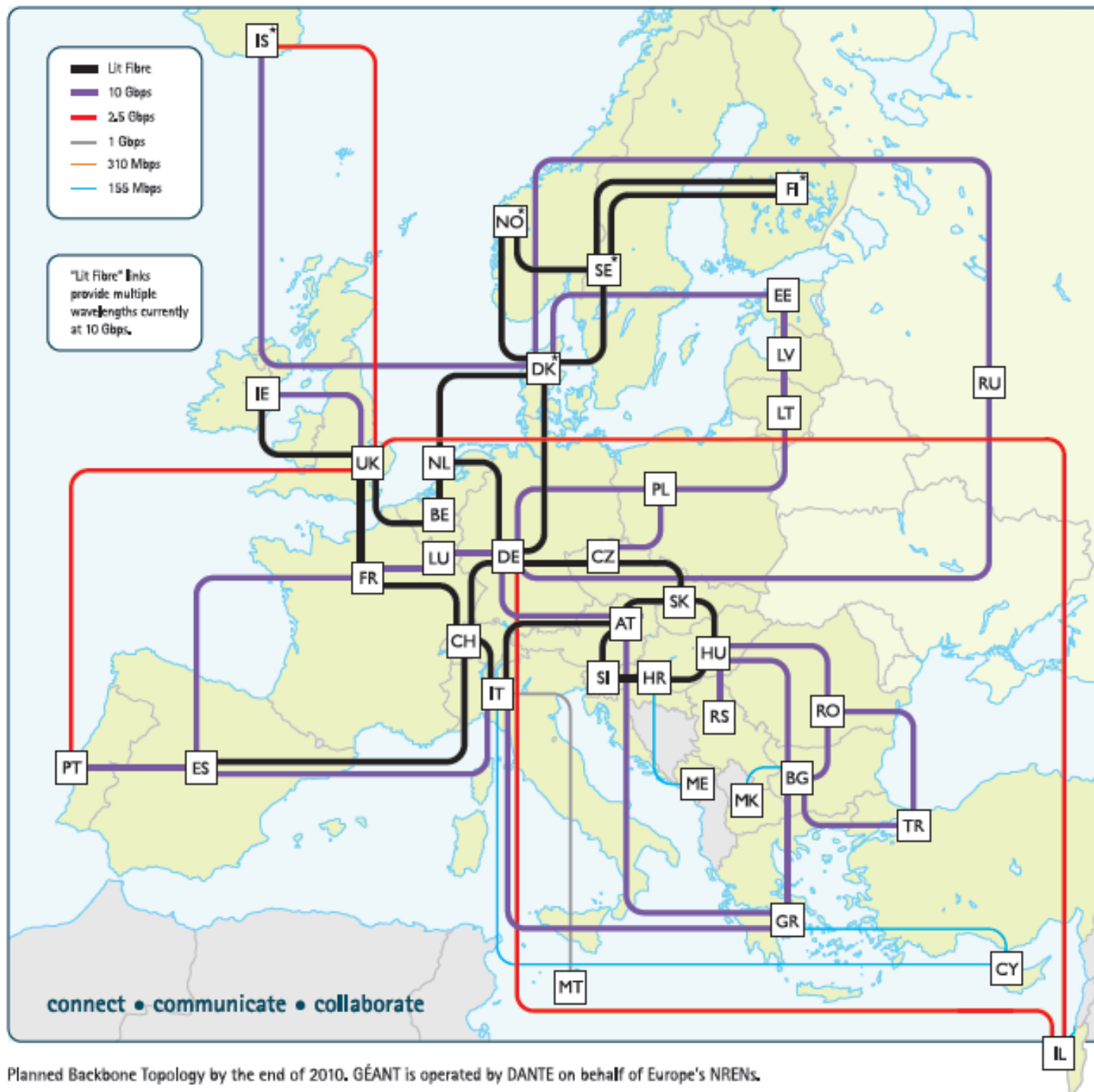
Regional REN Connections

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

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RedCLARA March 2011

ALICE2	——
CLARA	——
RNP	——
AmLight	——

Porto Alegre

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

TEIN3 Backbone Topology April 2010

Link Owners

- a, b: NiCT
- c, d: NII
- e: MAFFIN
- f, g: NIA
- h: TransPAC
- i: CERNET
- j: TransPAC
- k: ORIENT
- l: 國立交通大學

TEIN3 Project Partners

AU	Australia	MY	Malaysia
BD	Bangladesh	NP	Nepal
BT	Bhutan	PK	Pakistan
KH	Cambodia	PH	The Philippines
CN	China	SG	Singapore
IN	India	LK	Sri Lanka
ID	Indonesia	TW	Taiwan
JP	Japan	TH	Thailand
KR	Korea	VN	Vietnam
LA	Laos		

Legend:
- 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

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USA NREN: Internet2
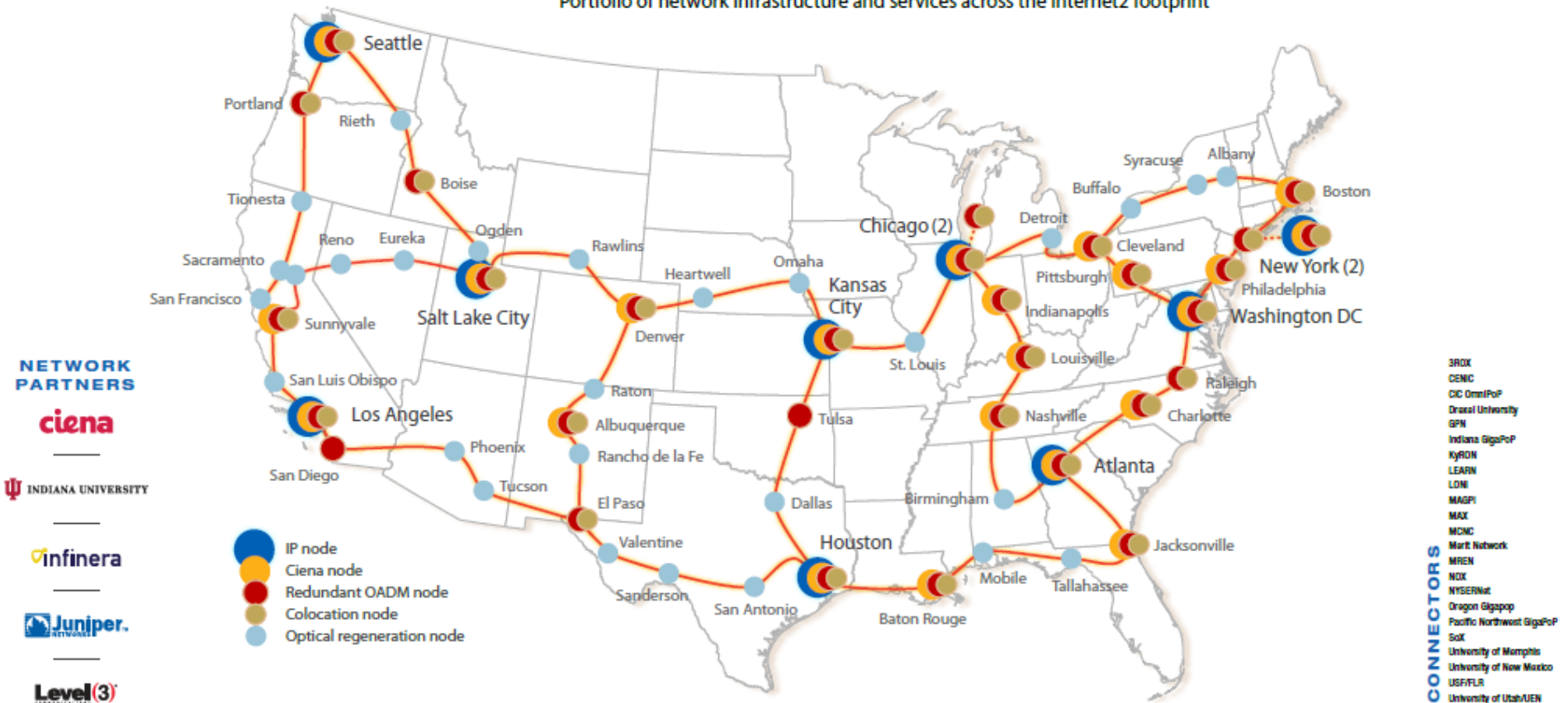
Internet2 Logical Network
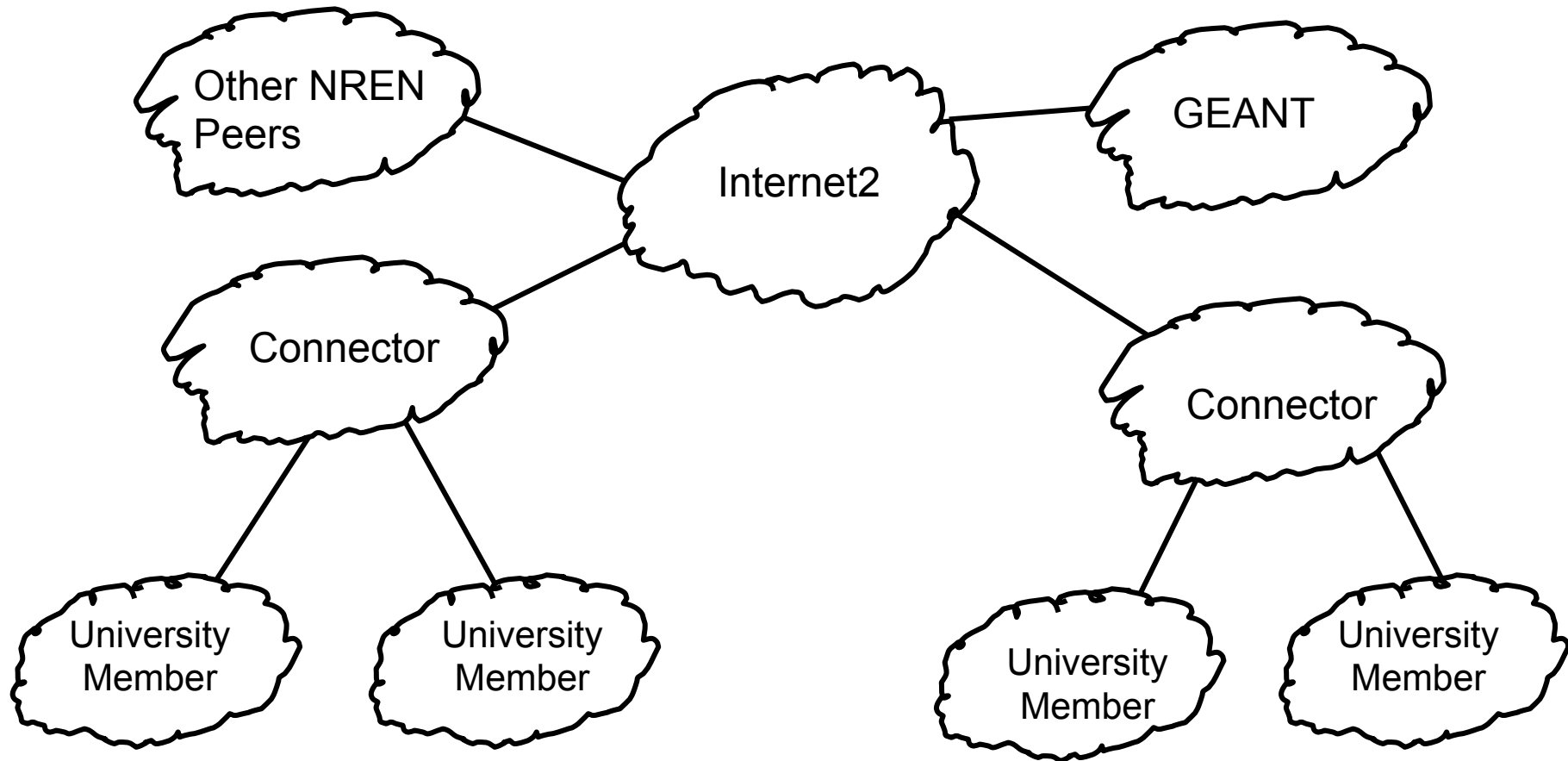
The Key to Internet2 is the Connector

- 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 Connector Networks provide connections to campus networks

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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
  - Connectors 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 Connector 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

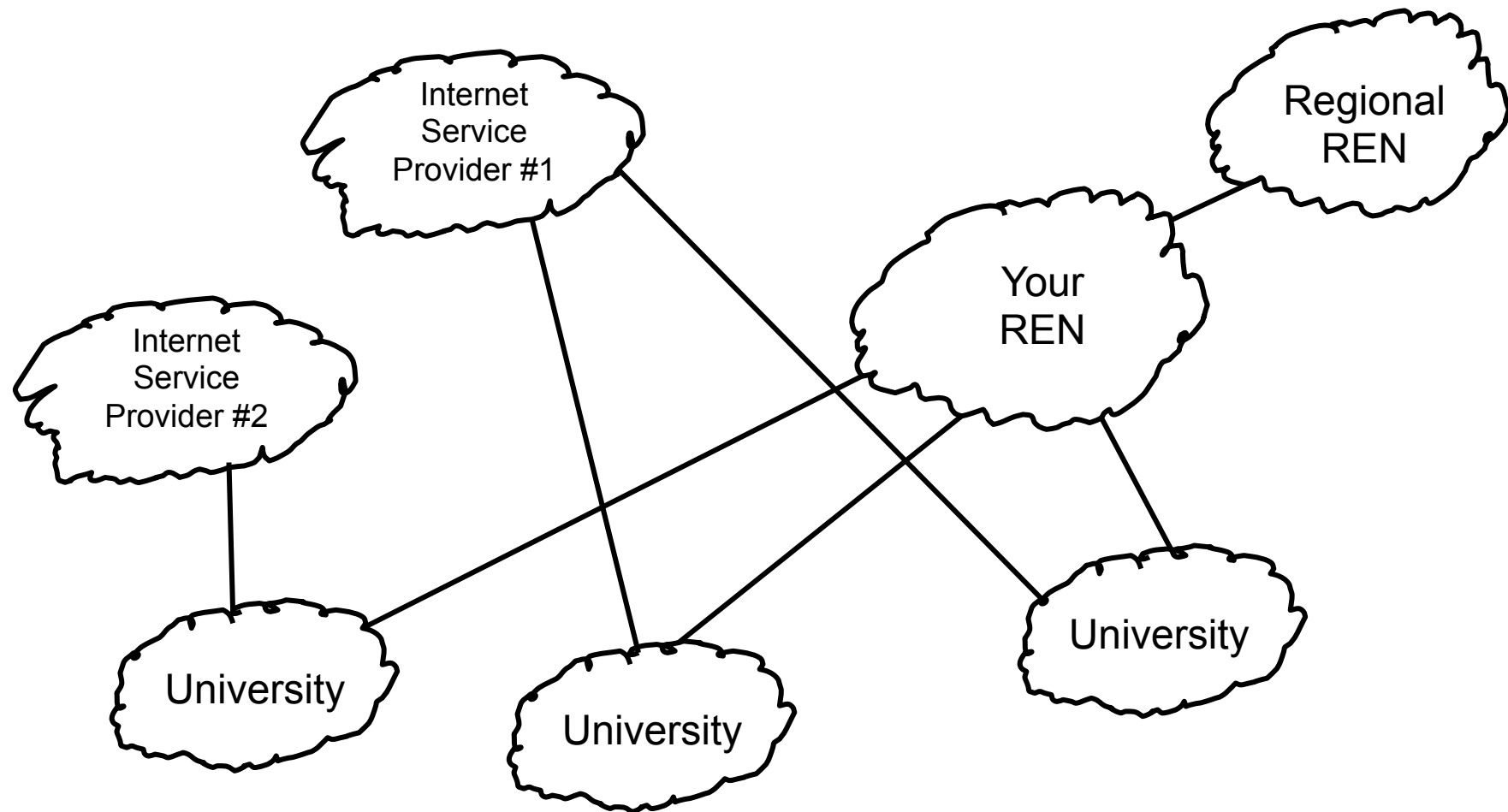UNIVERSITY OF OREGON

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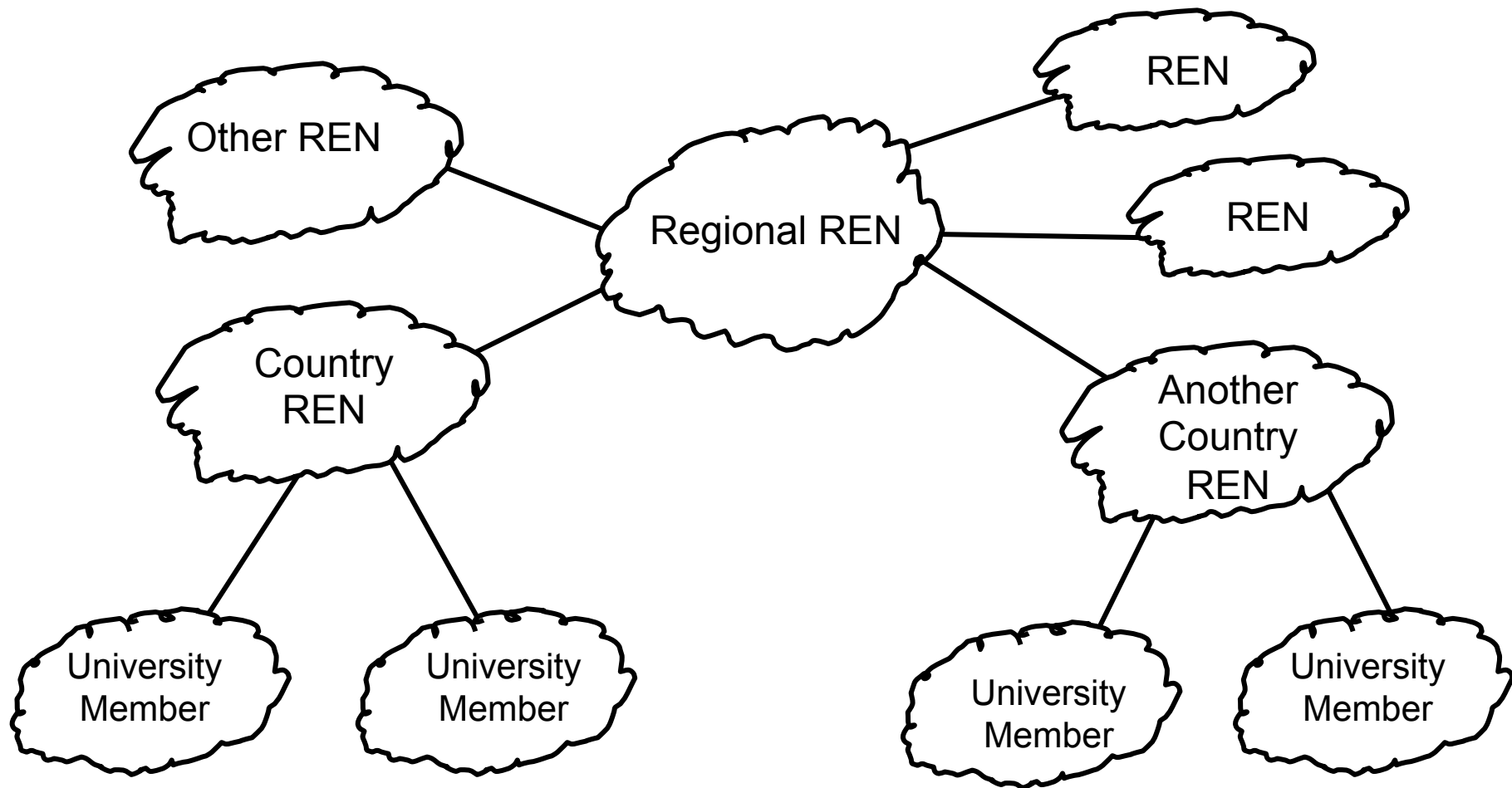
Typical NREN

NREN 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
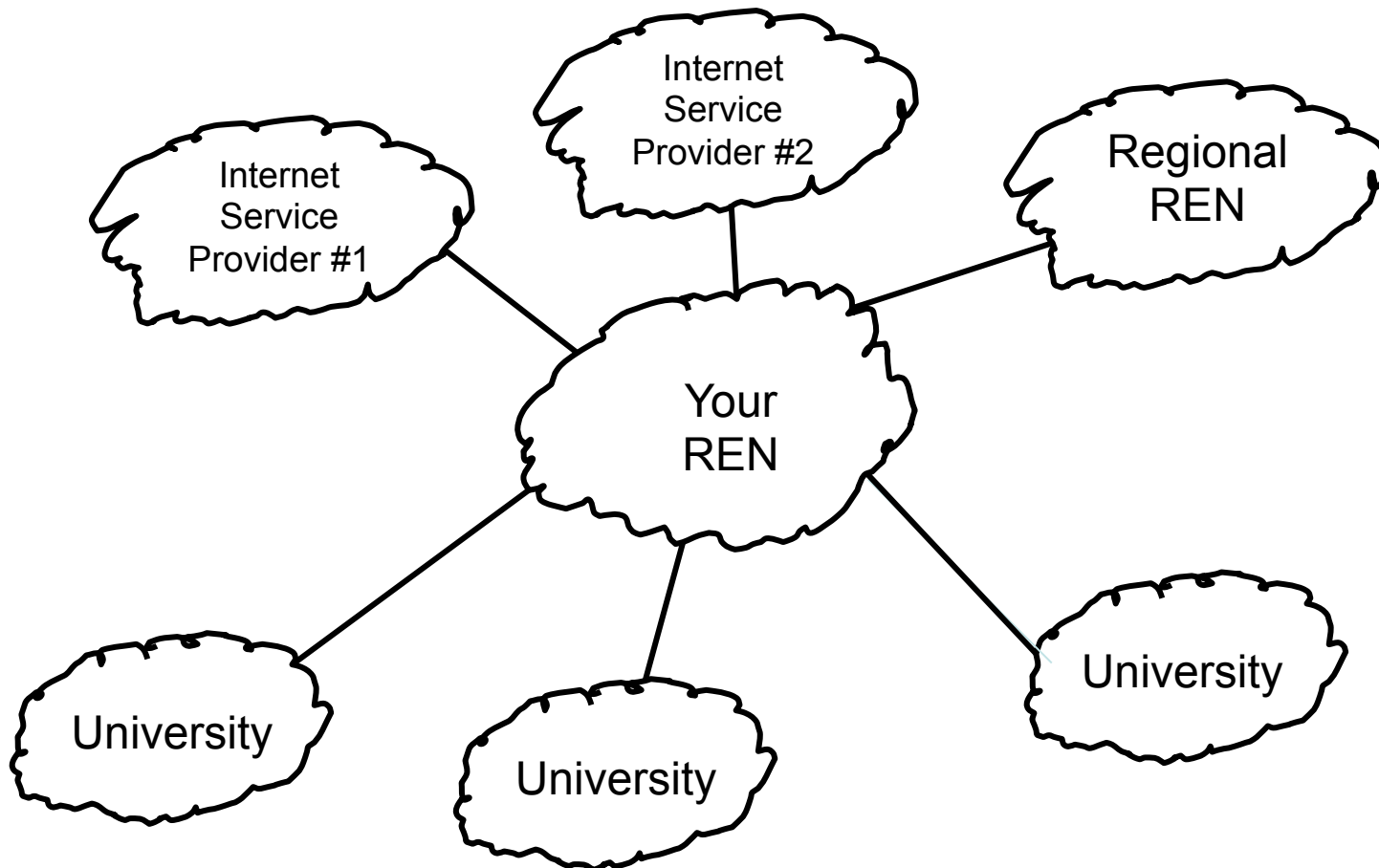   - In this case, REN also provides peering network

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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
  - 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

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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

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NREN as a Peering Network

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

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Dual Homed Campus Networks

- Three approaches:
    1. Get provider independent IP address, autonomous system number (ASN), and run BGP (can get IPs and ASN from NREN)
    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?

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NRENs Around the World

- Most NRENs act as the Internet Service Provider, so dual homing is not an issue

- 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 network into two parts: the Internet the NREN (many places turn the NREN into a video conferencing network).
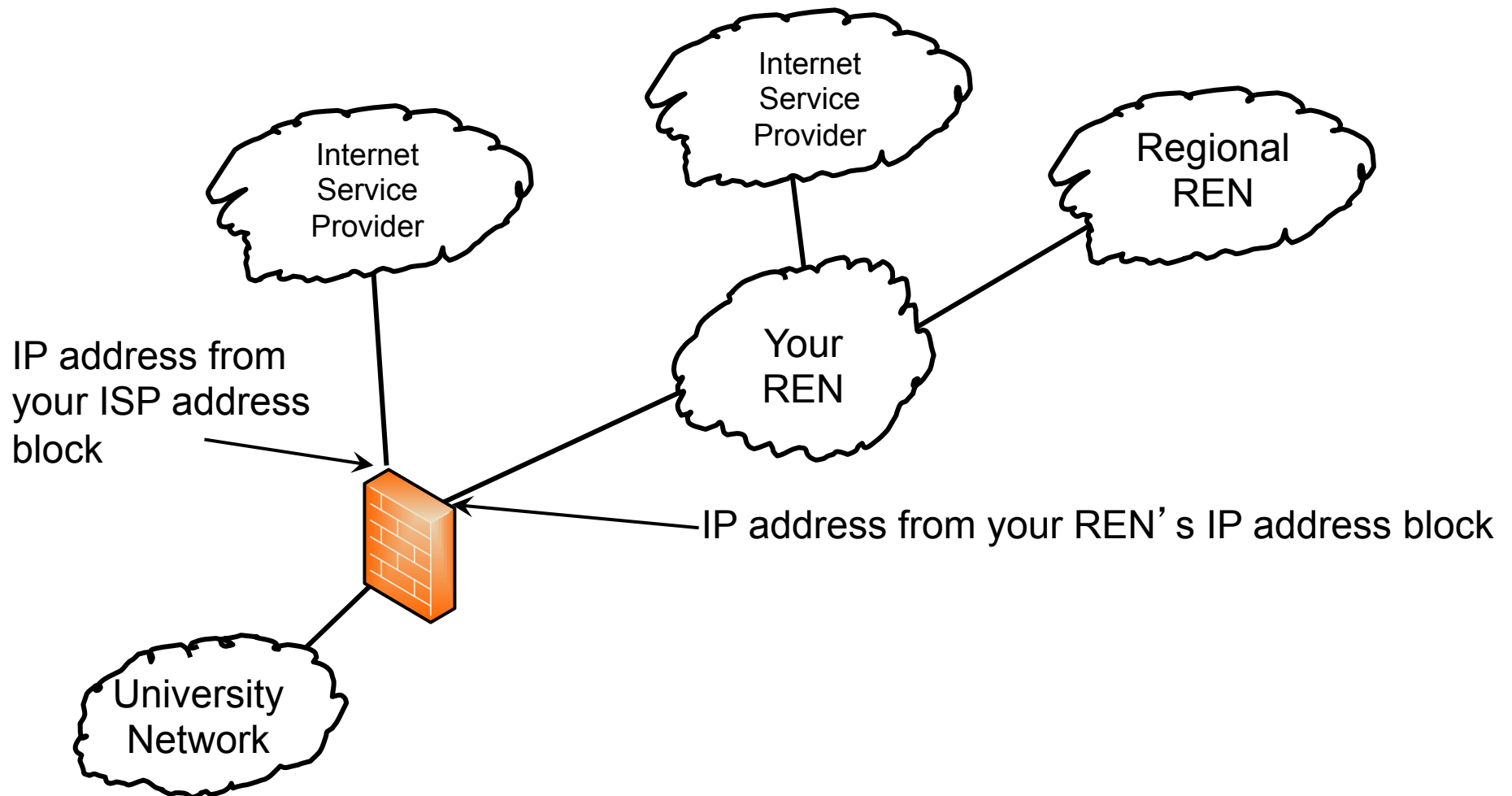
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The "Right" way to Dual Home
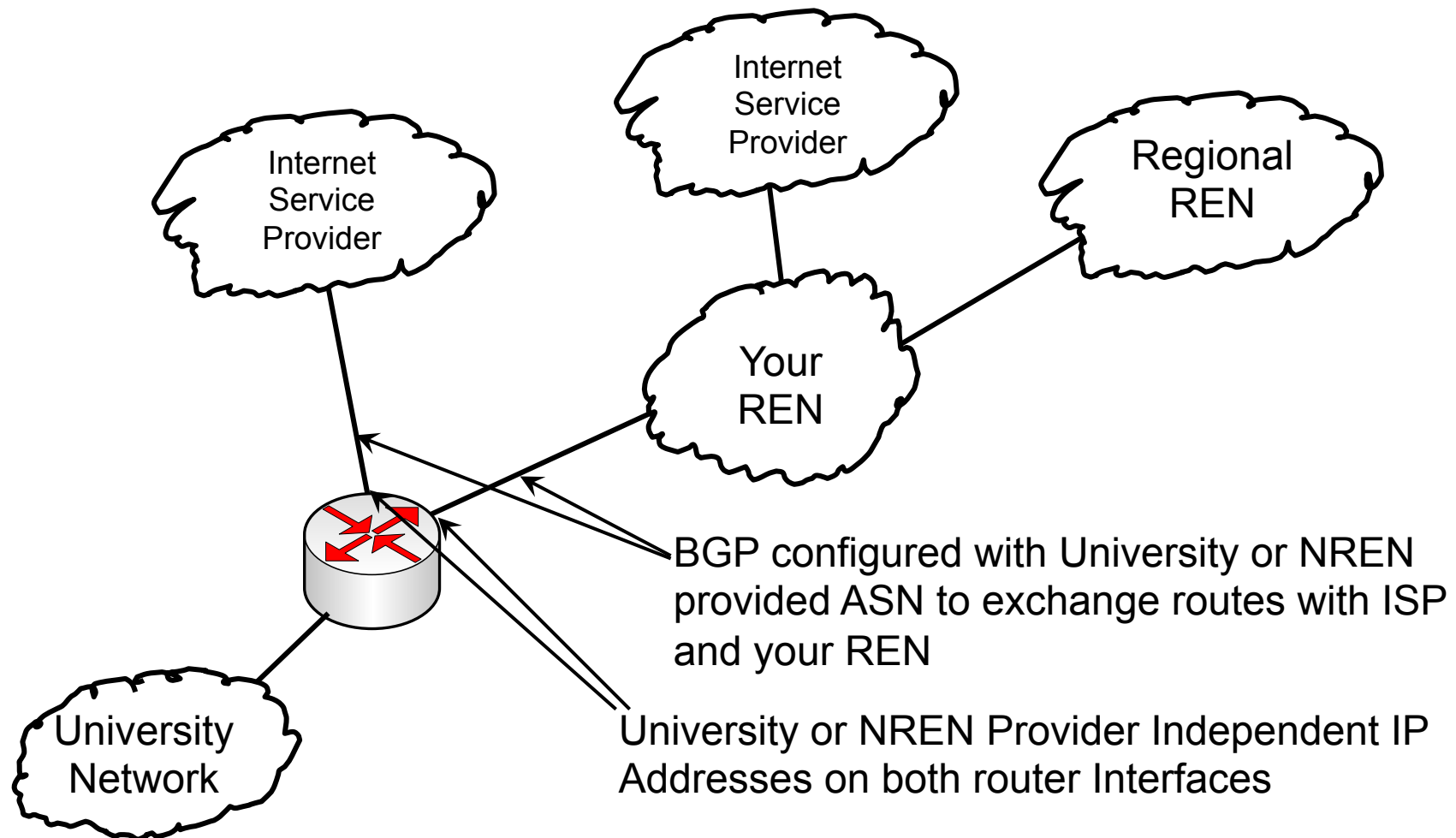
Dual Homing with NAT

- Typical configuration
  - Address block from ISP
  - Address block from NREN
- Can't make this work with BGP
  - To use BGP, you must get Provider Independent IP addresses and ASN
- Can use NAT Tricks for load balancing and/or link failover

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Typical NAT Dual Home Config

Internet Service Provider

Internet Service Provider

Regional REN

Your REN

IP address from your ISP address block

IP address from your REN's IP address block

University Network

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Using NAT to Dual Home

- The NAT translation rules control where traffic exits and also controls where traffic returns to your network
    - If you do a NAT translation to the ISP external address, then the traffic exits to the ISP and will come back via the ISP
- Now, the trick is to convince your NAT box to do this intelligently. Different vendors and software products have different tools

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General NAT Comments

- NAT makes SIP and H.323 (video conferencing) difficult
- NAT makes it hard to track down viruses, botnets, and hackers
- NAT hurts performance
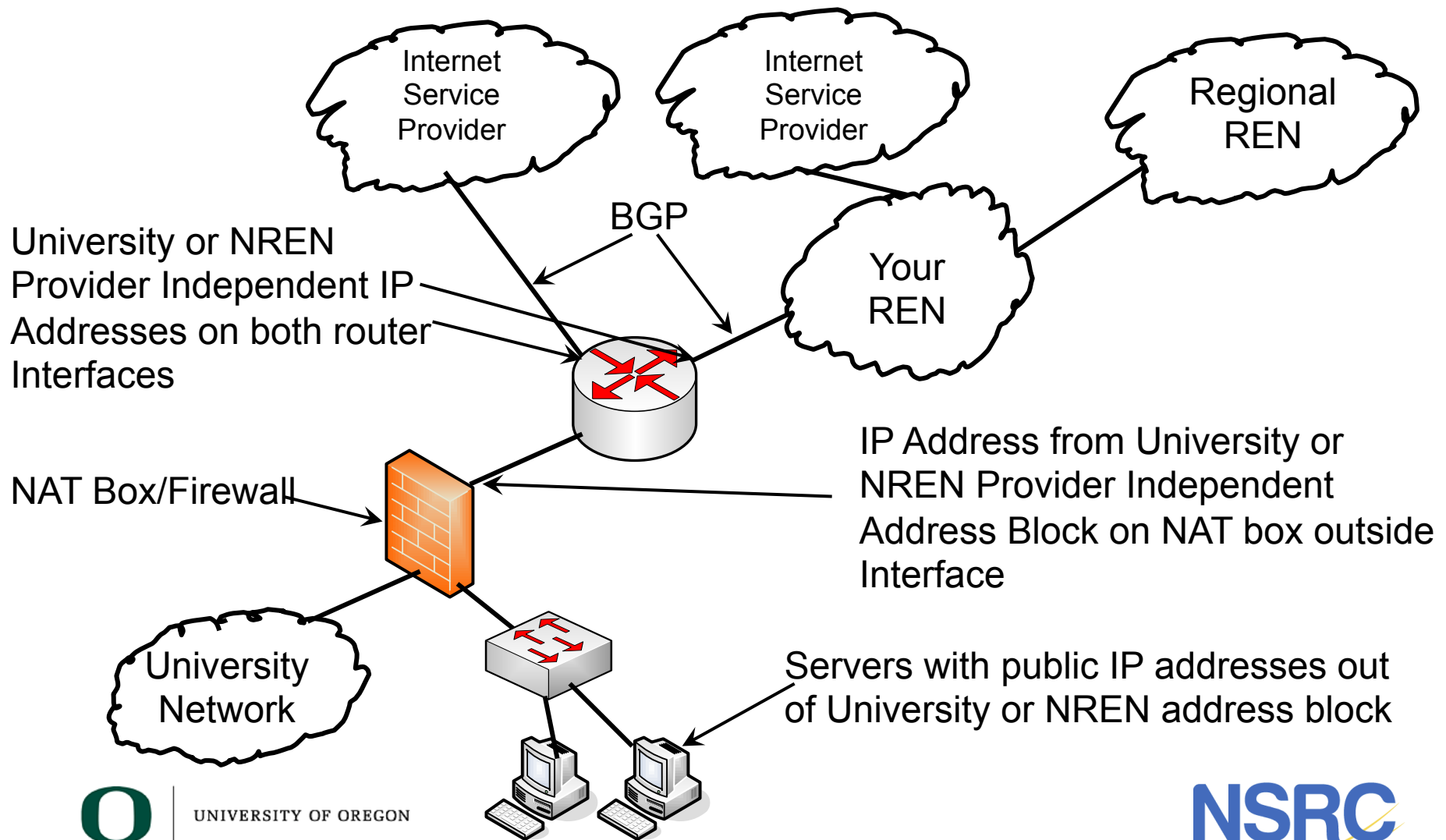- NAT makes it hard for researchers and educators to do innovative things

More NAT Comments

- NAT does not provide more security than a firewall

- NAT makes it hard to provide robust services on your campus

  – If you have typical NAT configuration and you place a NAT translation for a server on the ISP address and the ISP goes down, you lose your service to the outside world

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More NAT Comments

- No reason you can't get more addresses from your NREN, run BGP and do NAT internally if you still don't have enough addresses.

- See following slide for how this could work

NAT plus BGP (Better)

Questions/Discussion?

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