Research and Education Networking EcoSystem

Campus Network Design & Operations Workshop

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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 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

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
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.
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.

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- National Supercomputing Centre, Singapore
- Internet2, USA

**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/EGIANT and US/Internet2.**

**e-learning, e-Culture, Advanced ICT Technology, Capacity Building Programs**

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NREN EcoSystem

- Global Connections
- Regional Networks
- National Networks
- Campus Networks
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

- Other REN
- Country NREN
  - University Member
  - University Member
- Regional REN
- REN
- Another Country NREN
  - University Member
  - University Member
- University Member
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

Your REN

Internet Service Provider #1

Internet Service Provider #2

Regional 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

Global Connections

Regional Networks

National Networks

Campus Networks
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

Commodity Internet

University Network

Internet Service Provider

Internet Service Provider

Your REN

Regional REN

R&E Internet

BGP configured with University or NREN provided ASN to exchange routes with ISP and your REN

University or NREN Provider Independent IP Addresses on both router Interfaces
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?