# Campus Network Best Practices: Introduction and NREN Models

Dale Smith

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# Instructor Team

| Name | Organization (country) |
|---|---|
| Alain Aina | NSRC/AfriNIC (Togo) |
| Hervey Allen | NSRC (Chile) |
| Brian Candler | NSRC (England) |
| Steve Huter | NSRC (USA) |
| Ron Milford | Indiana University/GlobalNOC (USA) |
| Dale Smith | NSRC (USA) |

# Logistics

- Local Workshop Server
  - http://noc.ws.nsrc.org
- Final workshop documentation
  - http://nsrc.org/workshops/2011
- Wireless Network
  - SSID is ngREN-Workshop
  - WPA-PSK is “8888888888” (ten of the digit 8)

# Week Schedule

| Day | Topic |
|---|---|
| Monday | Introduction, cabling standards, fiber |
| Tuesday | In-building layer 2 networks |
| Wednesday | Campus routing - OSPF |
| Thursday | BGP |
| Friday | BGP and wrap-up |

# Day Schedule

| Time | Activity |
|---|---|
| 0830-1030 | Morning Session 1 |
| 1030-1100 | Tea Break |
| 1100-1300 | Morning Session 2 |
| 1300-1400 | Lunch |
| 1400-1600 | Afternoon Session 1 |
| 1600-1630 | Tea Break |
| 1630-1800 | Afternoon Session 2 |

# Why Are We Doing This?

- Our goal is to build networking capacity to support Research and Education
  - Remember: University = Research & Education
- The end game is regional, national, and larger Research and Education Networks (RENs)
- All RENs start with campus networks – they are the foundation of the REN

# Why Focus on Campus Networks?

- 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
- Ad-hoc campus networks work OK with VSAT uplinks, but moving to high speed external links, they start to fail.

# Why Focus on Campus Networks?

- Your campus network is the foundation that all services are provisioned on
- Ad hoc networks just don't work well. They are unreliable and hard to maintain.
- If you don't have a plan, how will you know where are going?

# 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

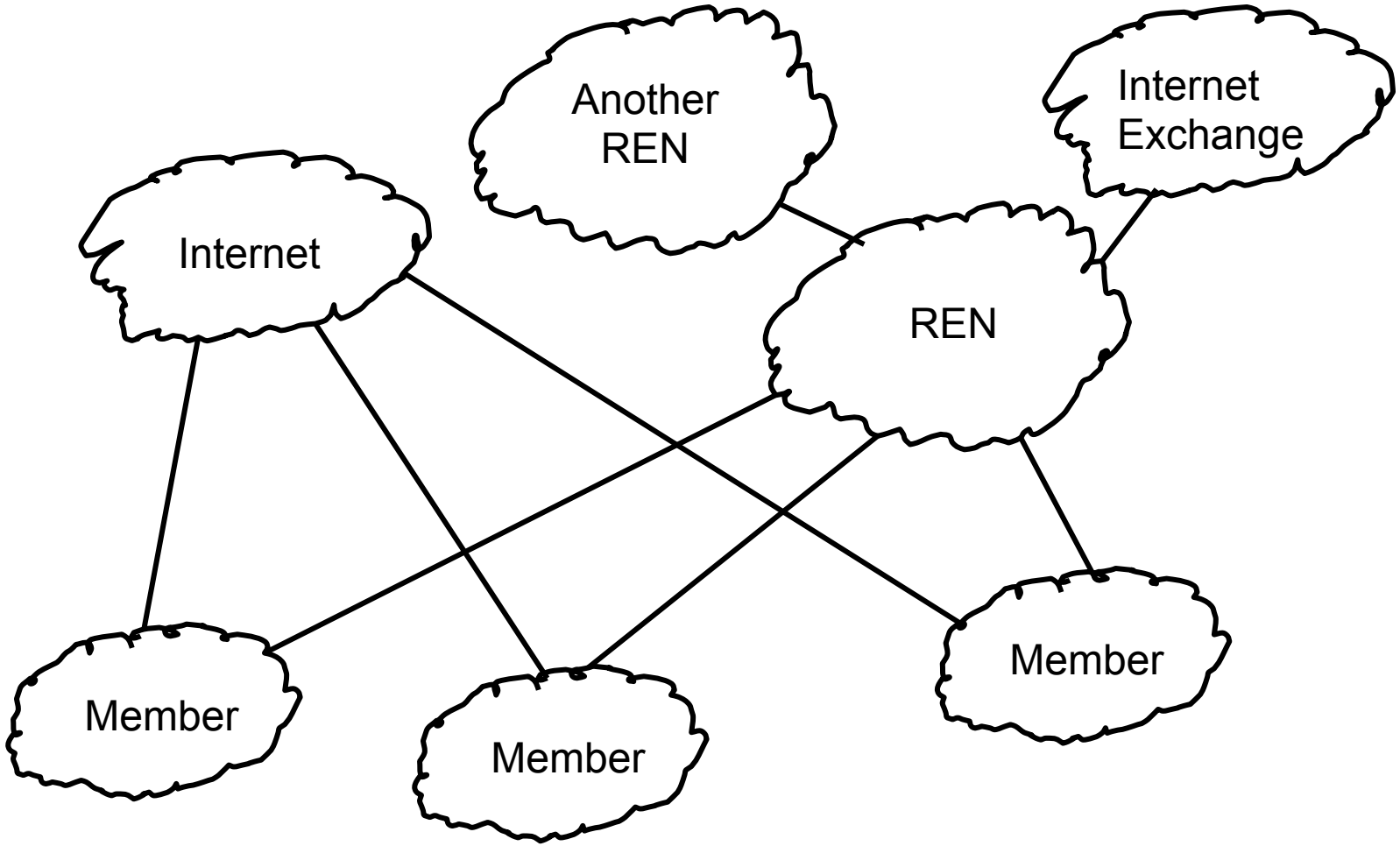
# REN Topics

- NREN IP Transport Models
- Technical Requirements for campus networks and NRENs
- A look at USA NRENs
- How might this relate to Africa in general and Nigeria specifically

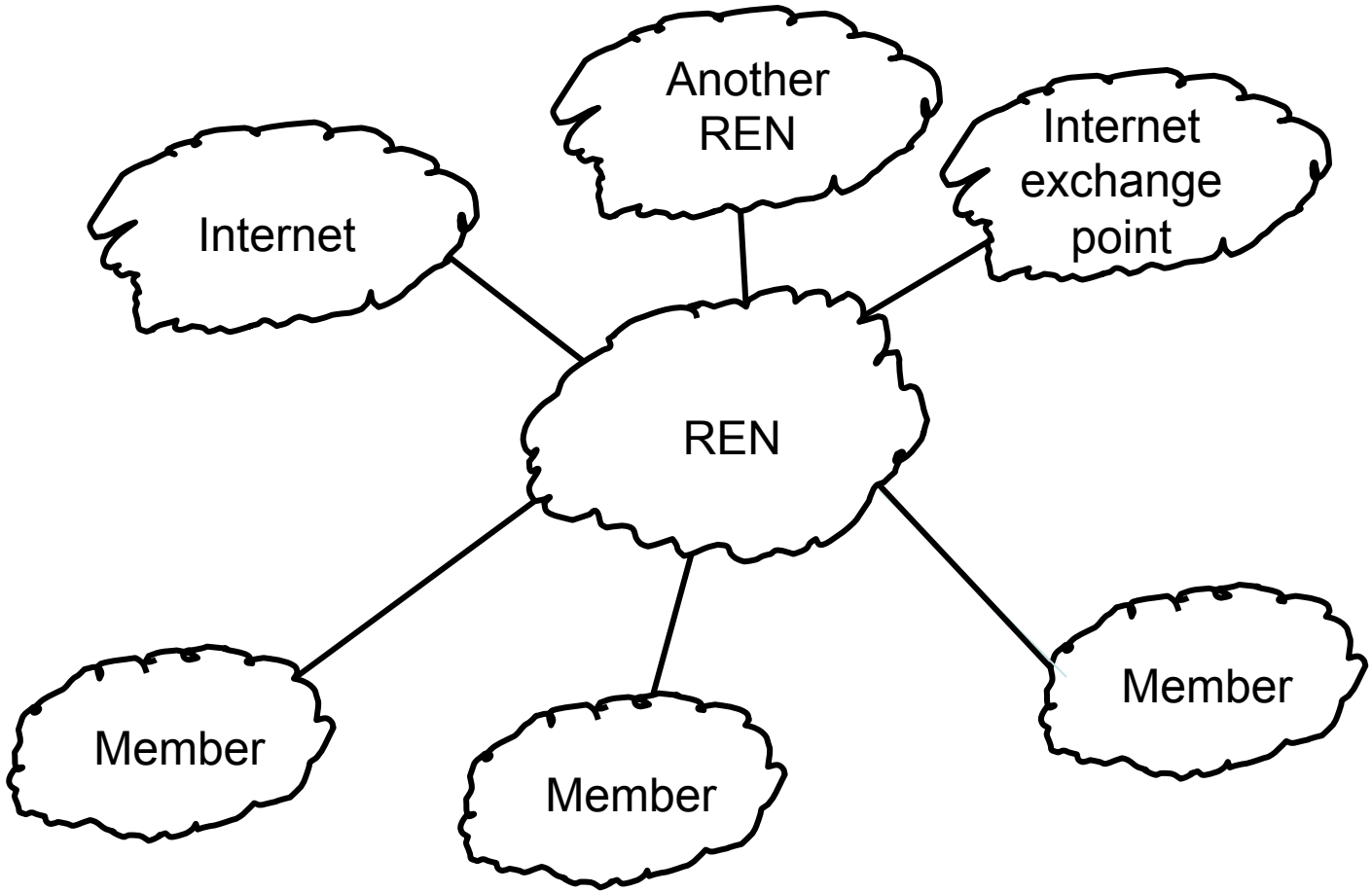
# NREN IP Network

- 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

# REN as Peering Network



# REN as Internet Service Provider



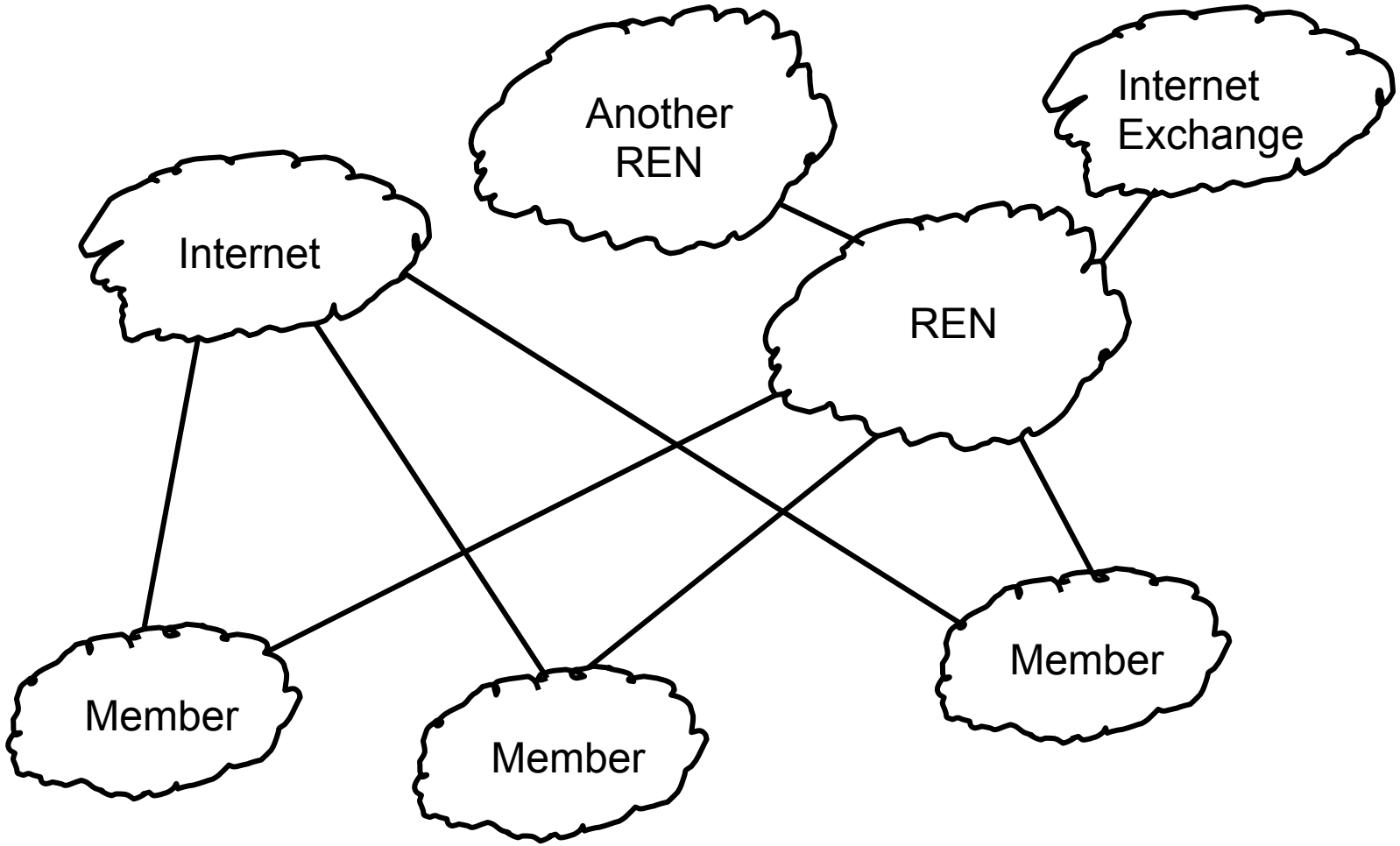
# Introduction to Peering

- 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

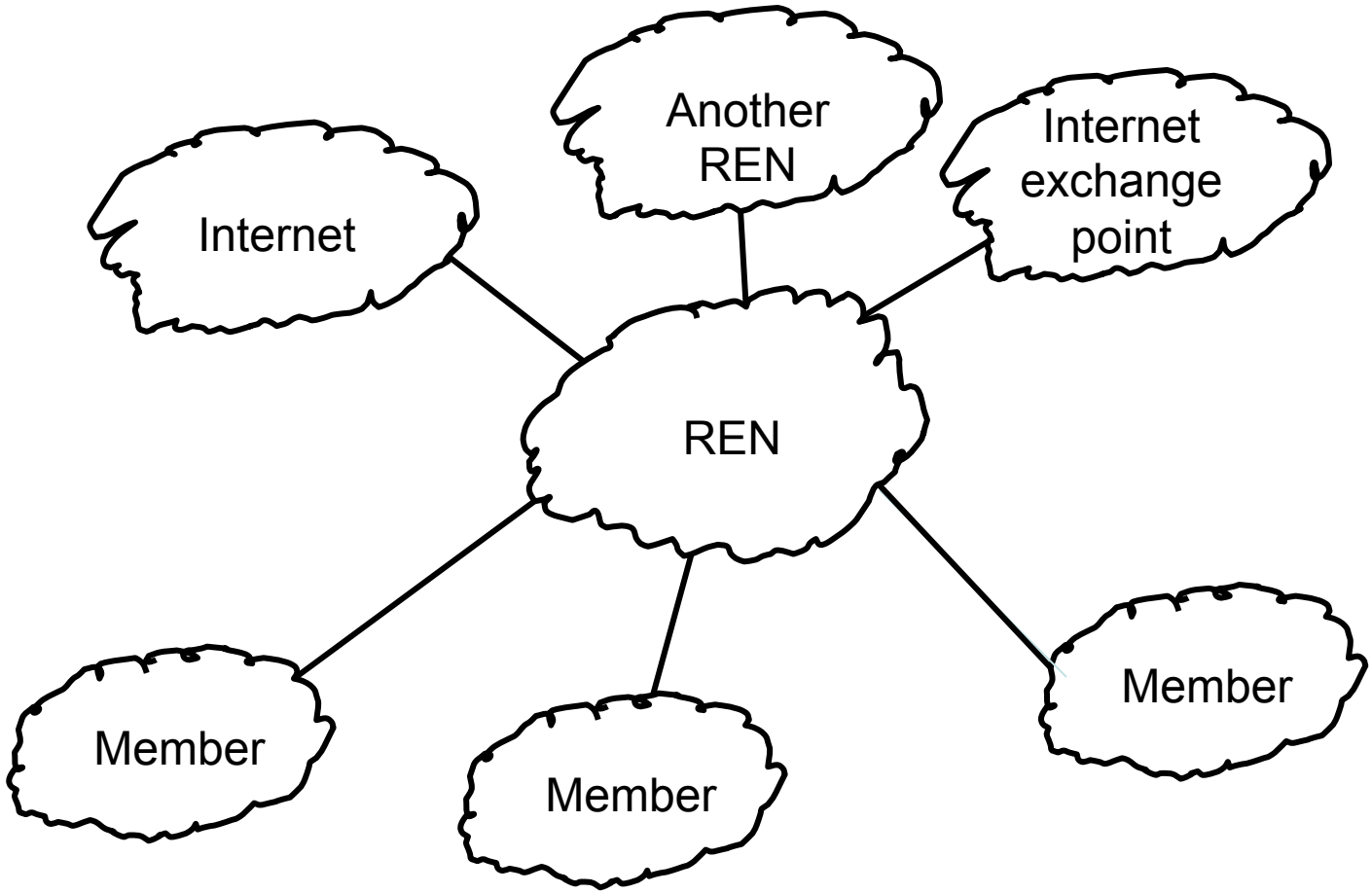
# Requirements of Members

- 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

# Peering Network Requirements



# REN as ISP Requirements



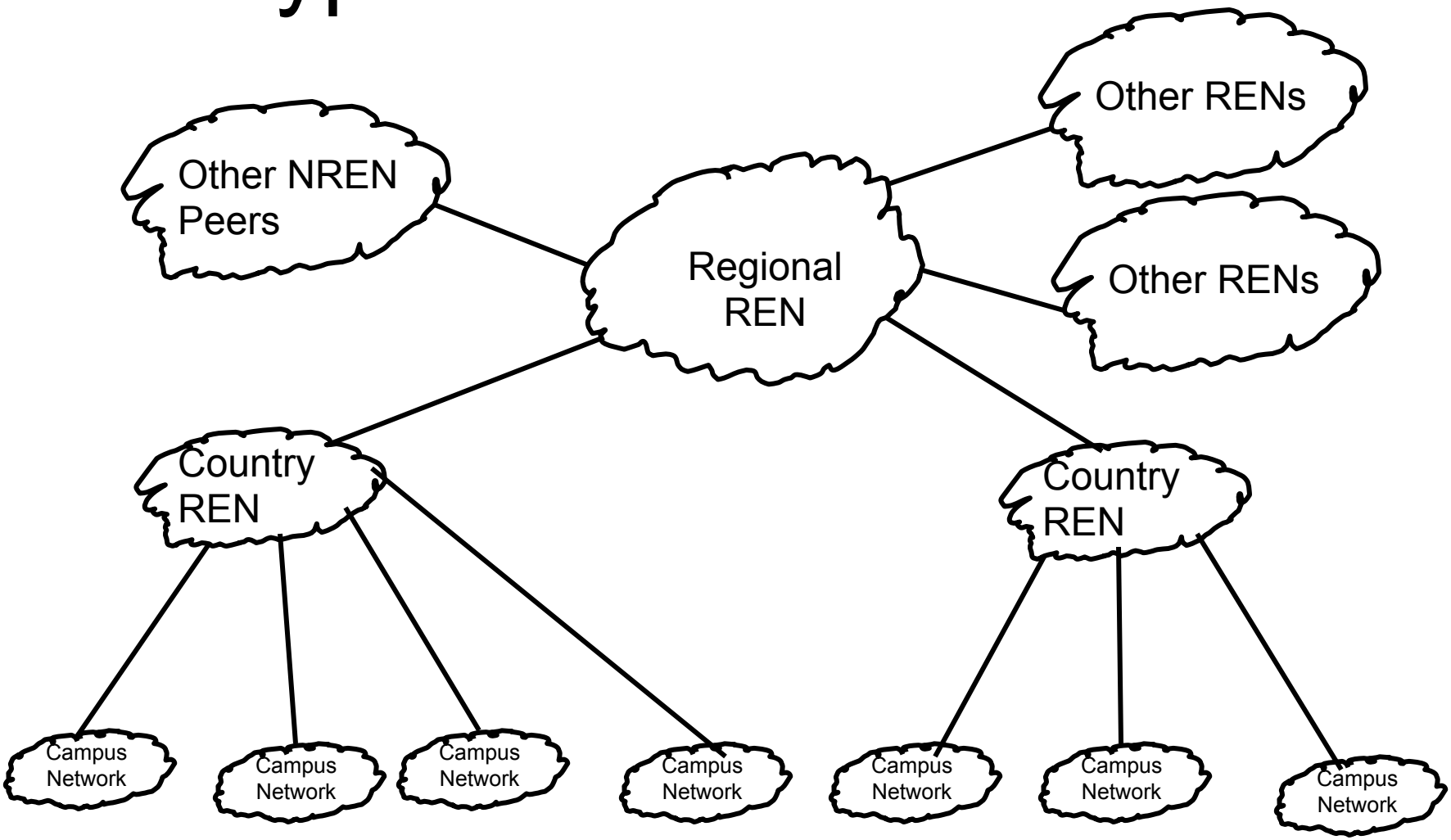
# Requirements of NRENs

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

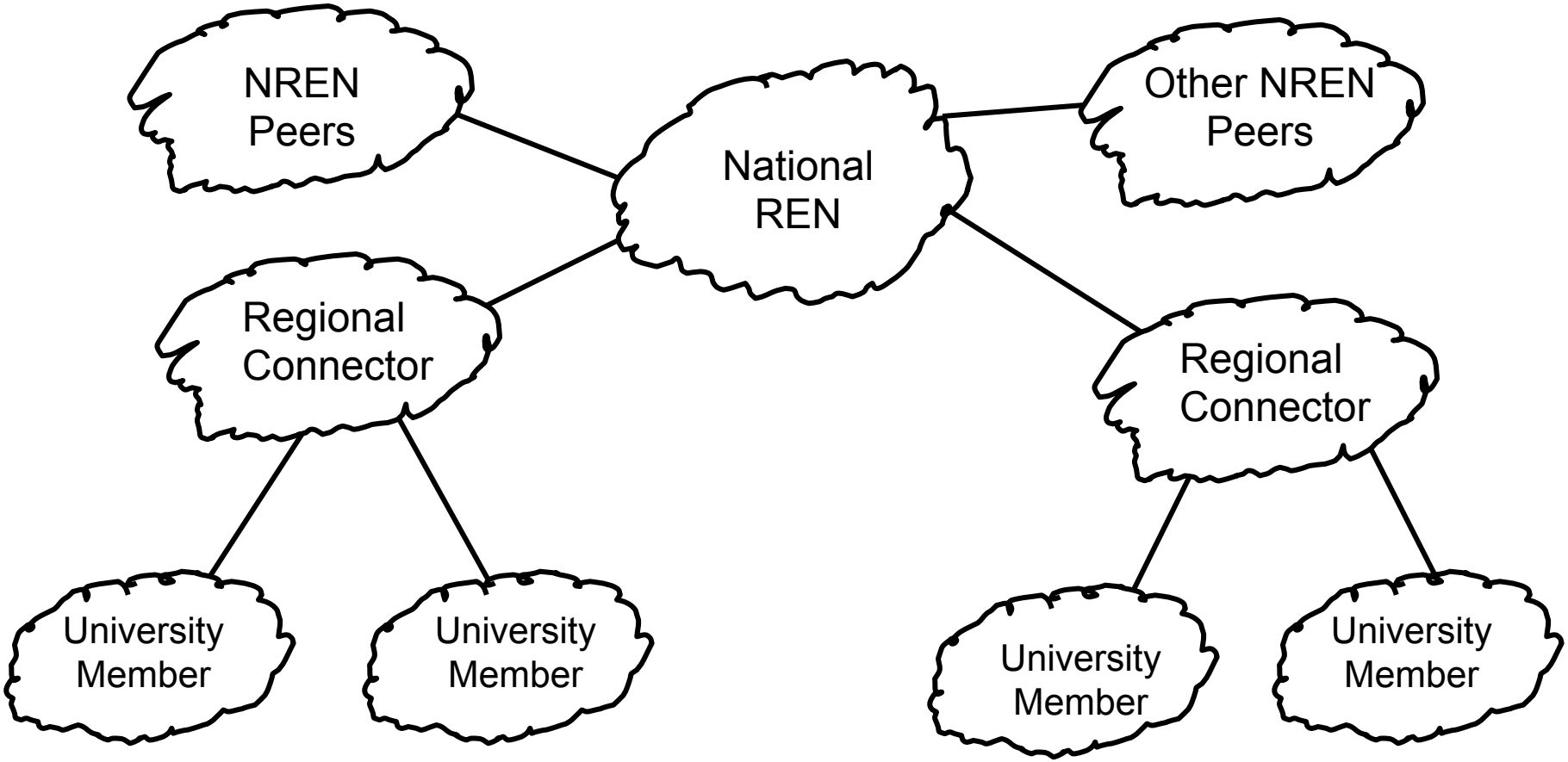
# Why a REN?

- 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

# Typical REN Architecture



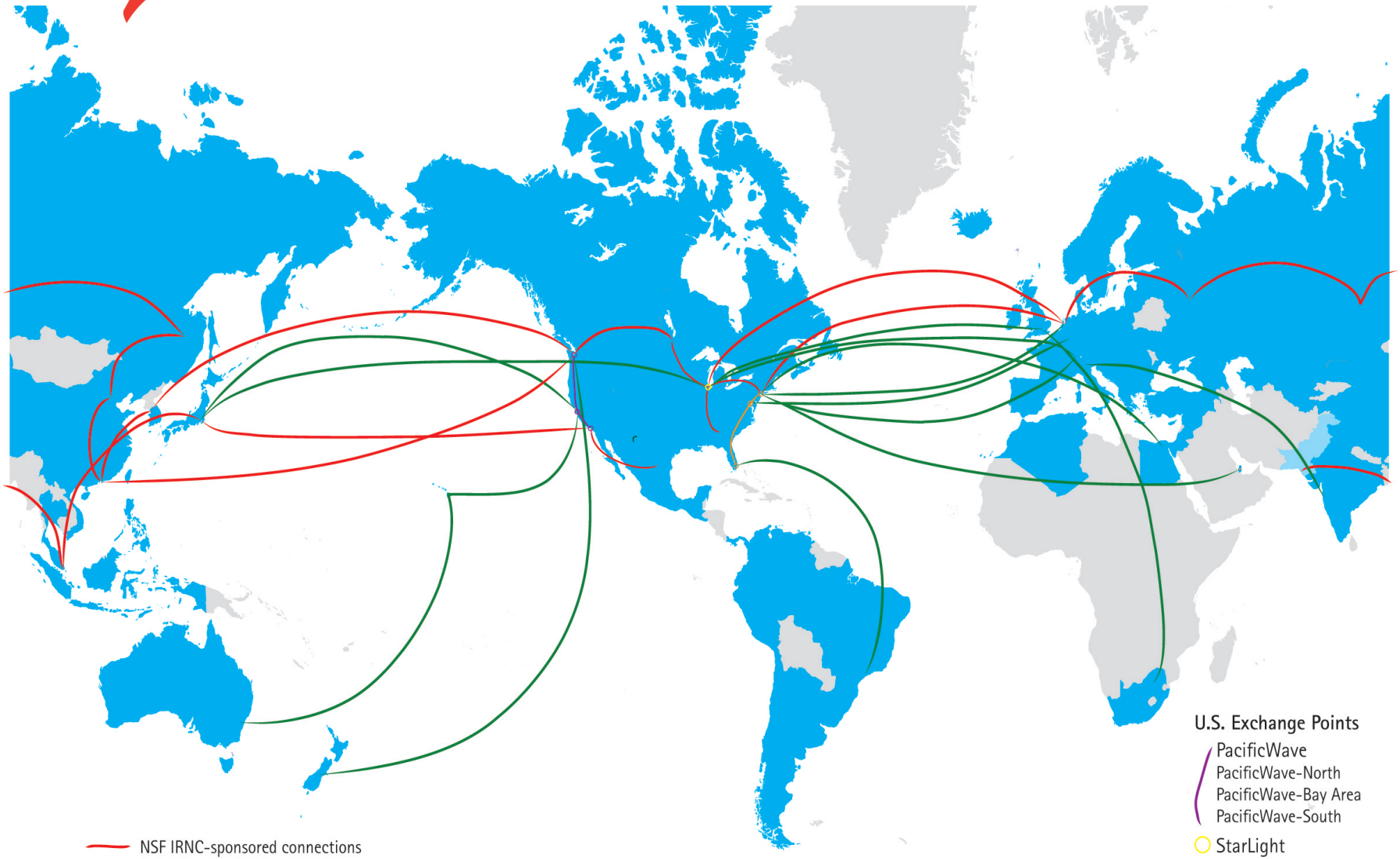
# An Alternative NREN Design



# Global NREN Picture

INTERNET2® www.internet.edu

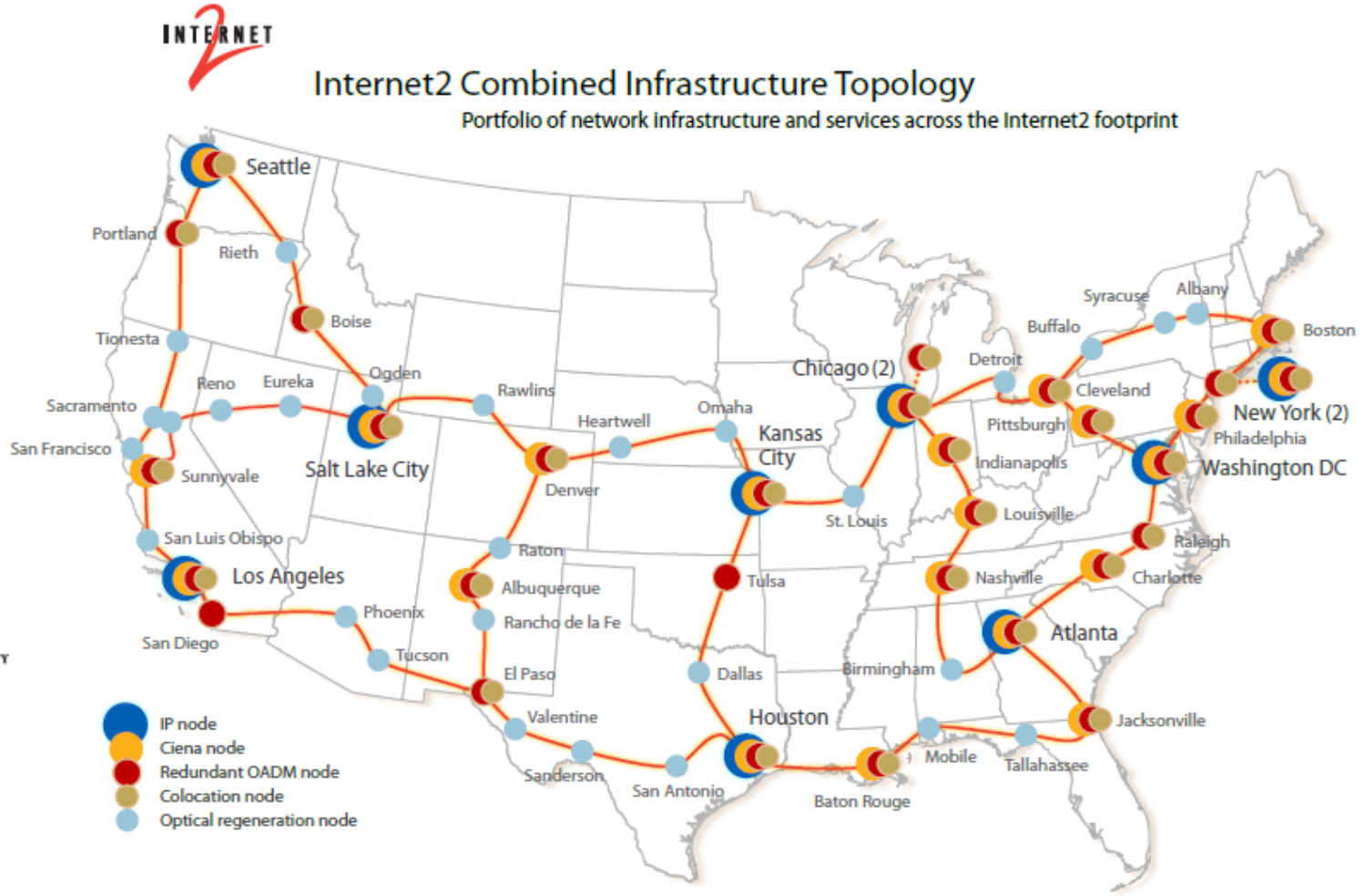
THE INTERNATIONAL REACH OF THE INTERNET2 NETWORK




For further information regarding the international programs of Internet2, visit http://international.internet2.edu/ or contact Heather Boyles, International Relations Director, heather@internet2.edu.

A listing of networks reachable via the Internet2 Network is found on the back of this page.

# USA NREN: Internet2

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Oregon Gigapop
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SoX
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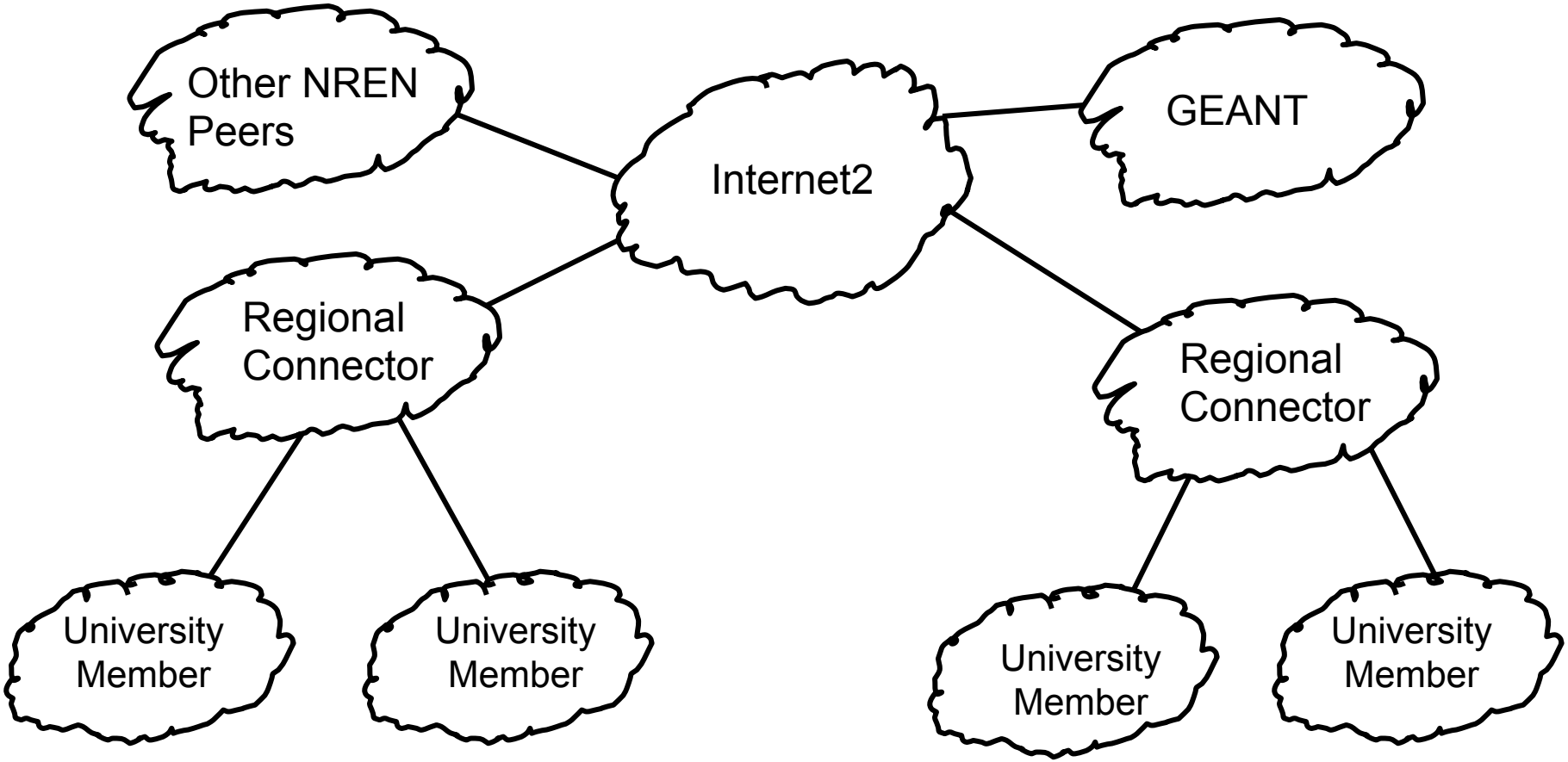
# Internet2 Logical Network



# The Key to Internet2 is the Regional

- Internet2 doesn't connect to even one individual campus network
- 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 and use the University legal status
  - Startup Funding
    - Most obtained some funding from Government

# USA Regional Networks

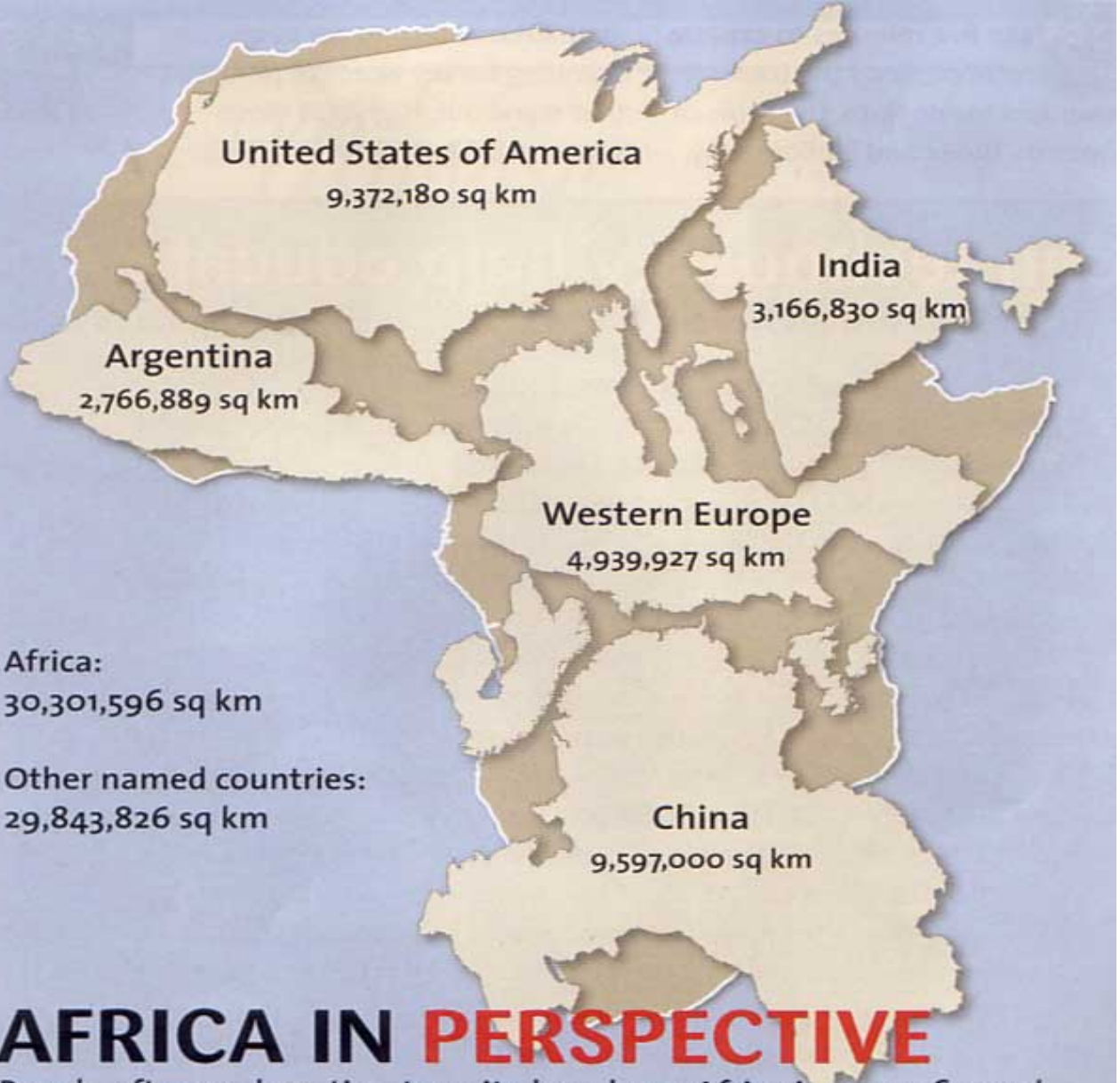
- Staffing
  - Range in size from 1 to 110 employees
  - RONs associated with Universities frequently used University back-office functions
- Network Operations
  - All provided 24x7 monitoring
  - Only half provided staffed 24x7 NOC
  - Over 40% outsource NOC functions
    - ¾ of those who outsourced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

# USA Regional Networks

- Services
  - All provide IP transport to Internet2
  - Not all provide ISP services
  - 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 with direct budget
  - 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




Africa:
30,301,596 sq km

Other named countries:
29,843,826 sq km

# AFRICA IN PERSPECTIVE

People often underestimate quite how large Africa is, so we figured we'd put it in perspective by transposing as many of the world's other countries over it as we could. As you can see, Africa is larger than China, the USA, Western Europe, India, Argentina and the British Isles... combined!

*Source: The Times Atlas*

# Fiber Capacity History Lesson

- International Fiber capacity has come very late to Africa
  - Until 2 years ago, only one cable served Sub Saharan Africa
  - Until 1 year ago, only one cable served West Africa
- Next year, five cables will serve West Africa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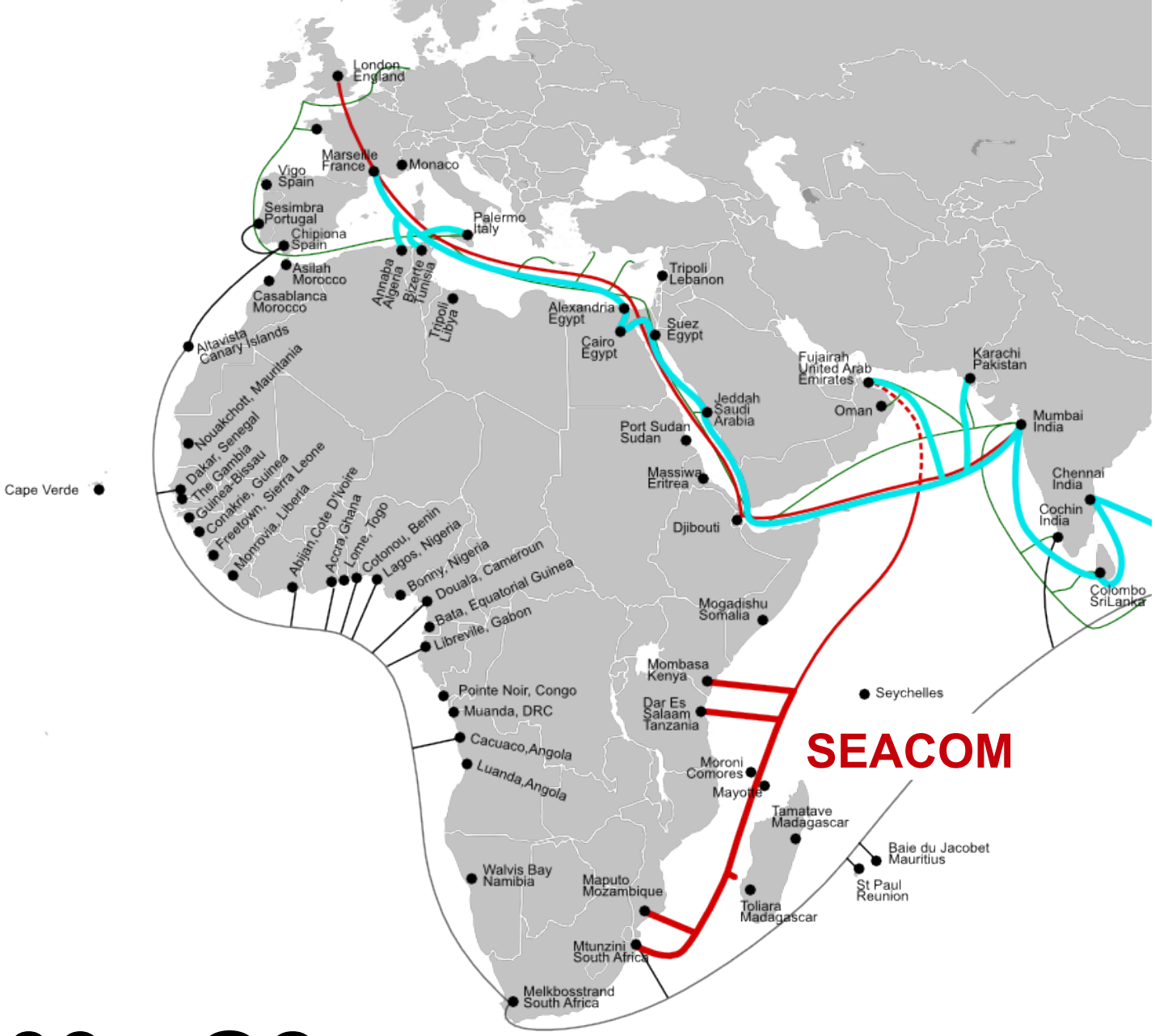
SAT3

# 2001 - Q2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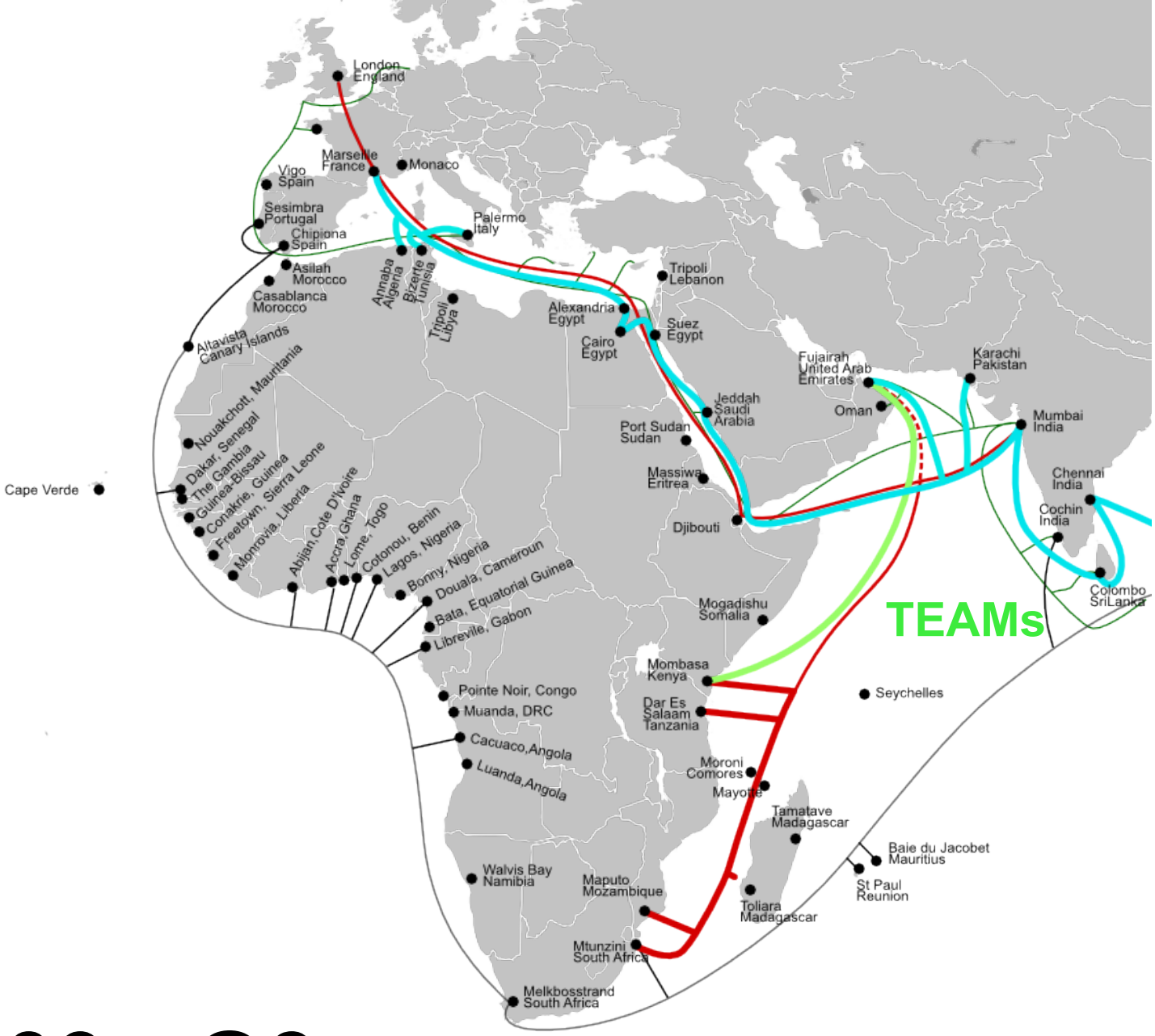
# 2009 - Q2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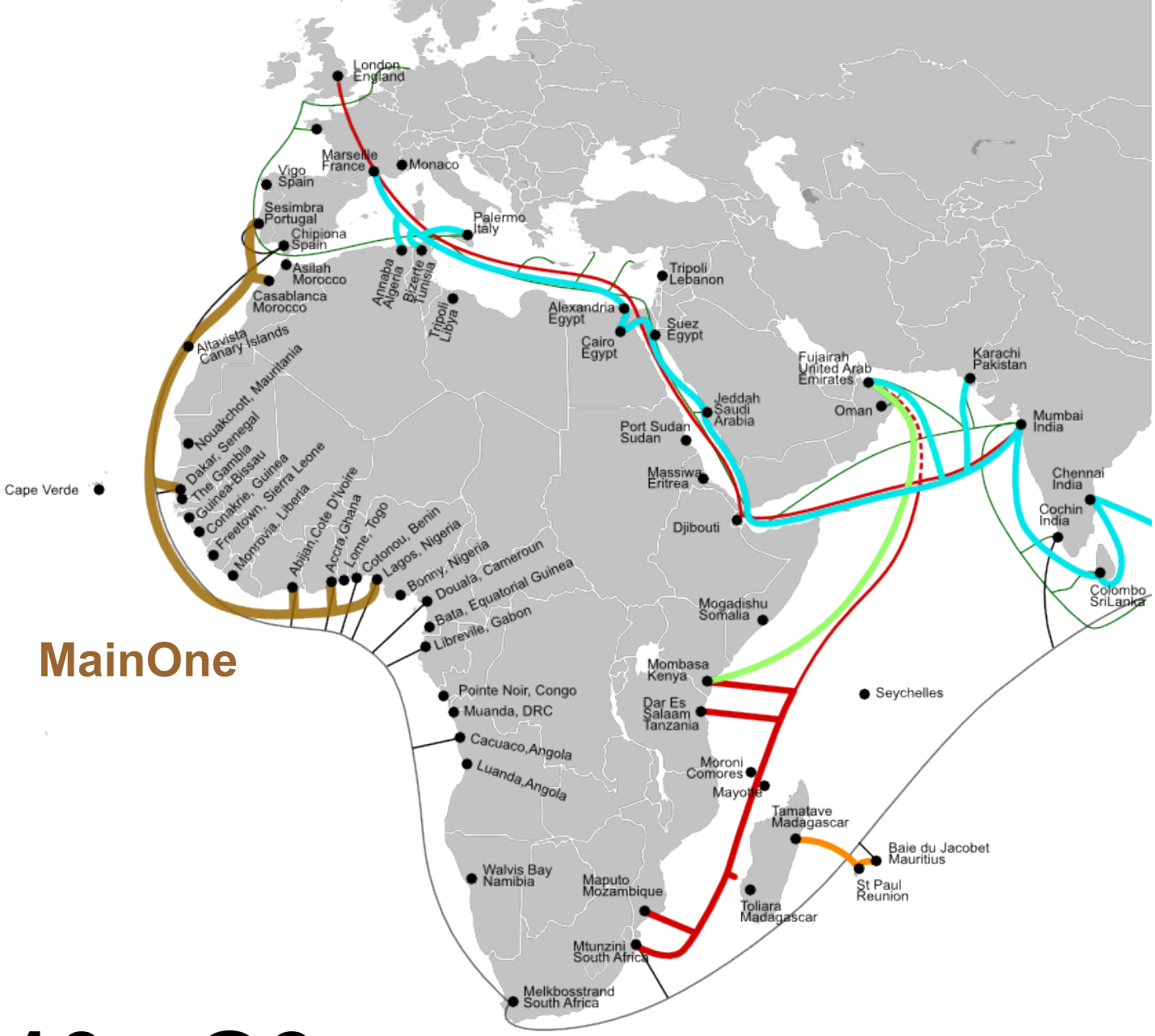
# 2009 - Q3

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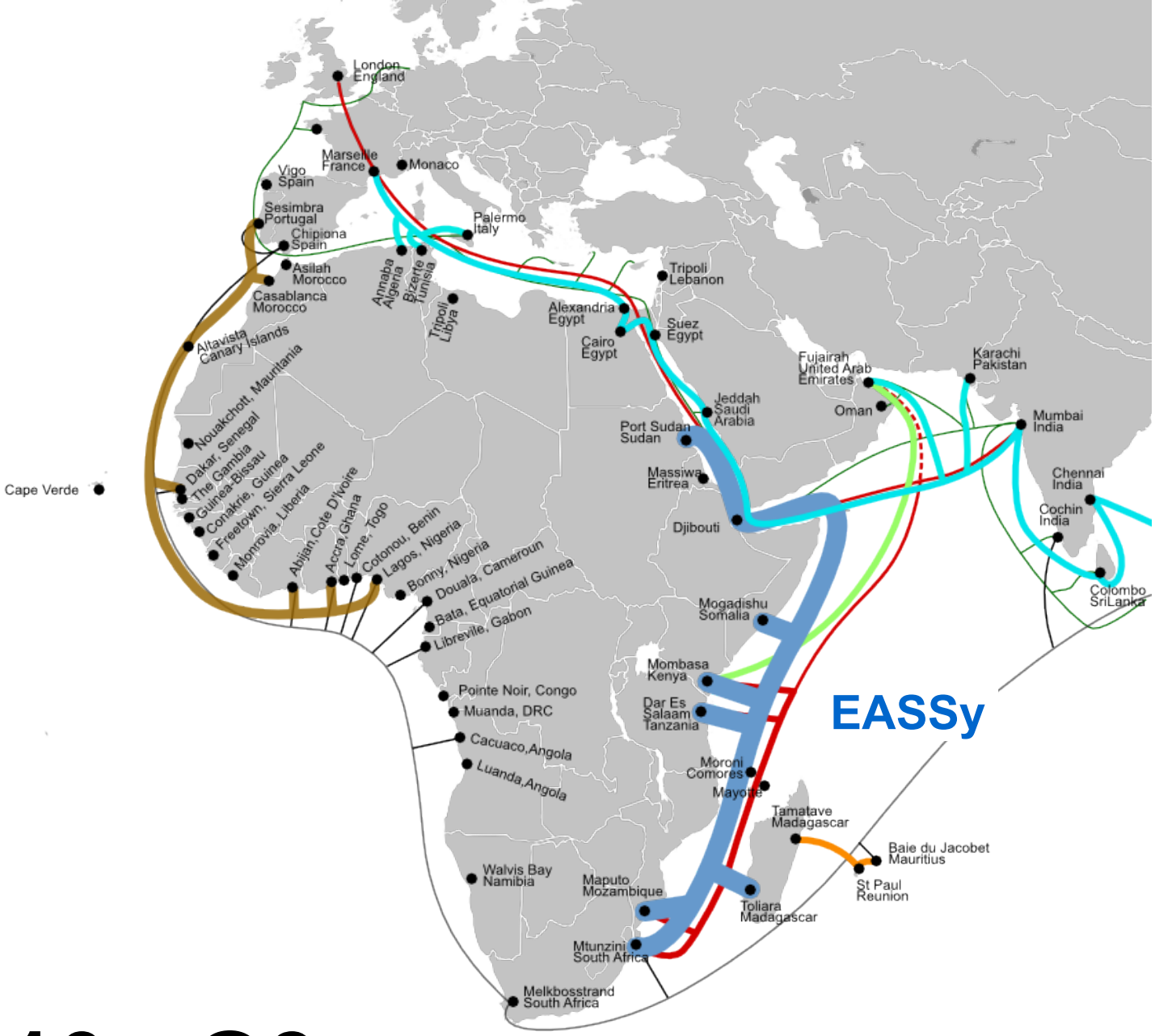
# 2010 - Q3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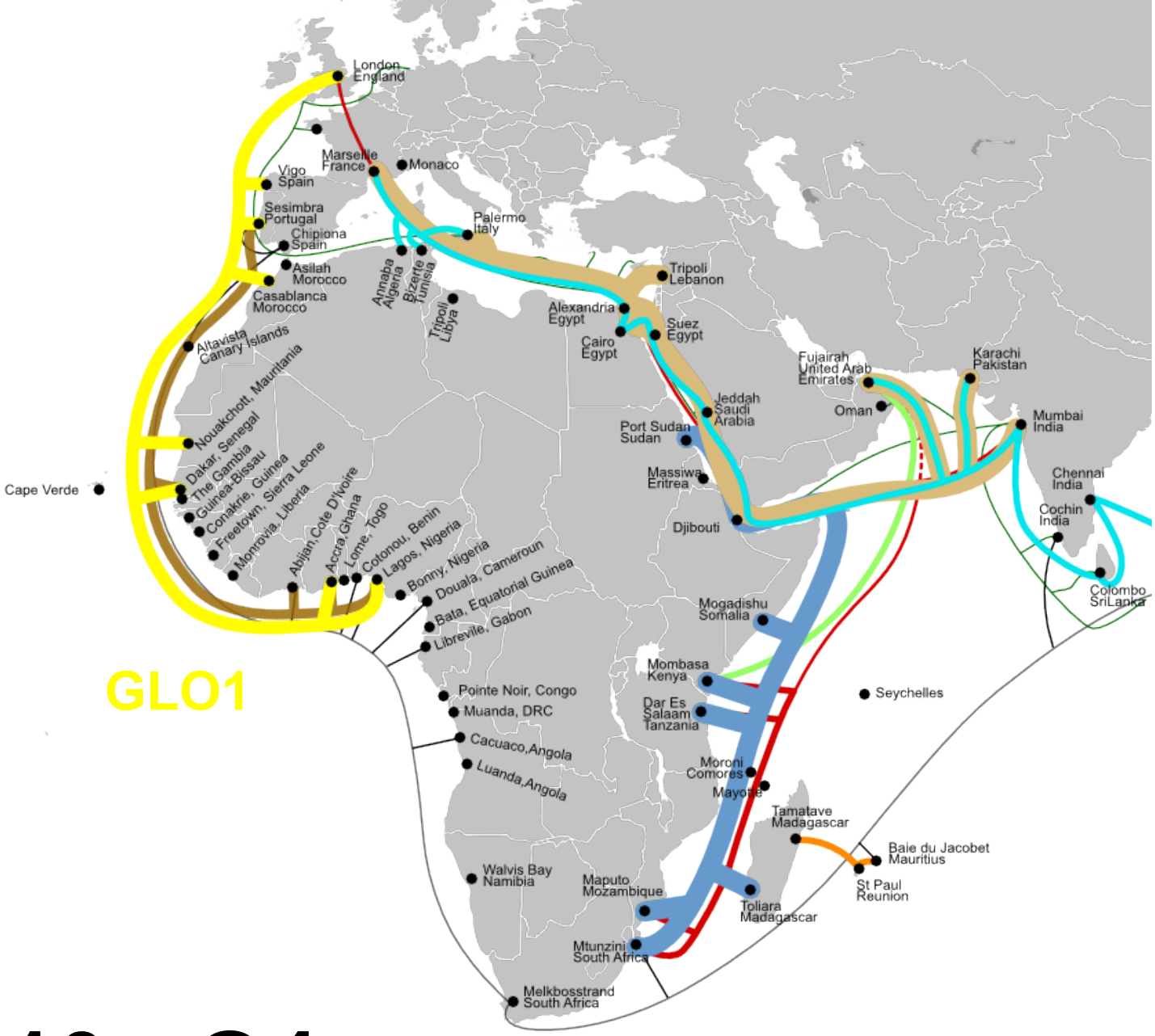
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GLO1

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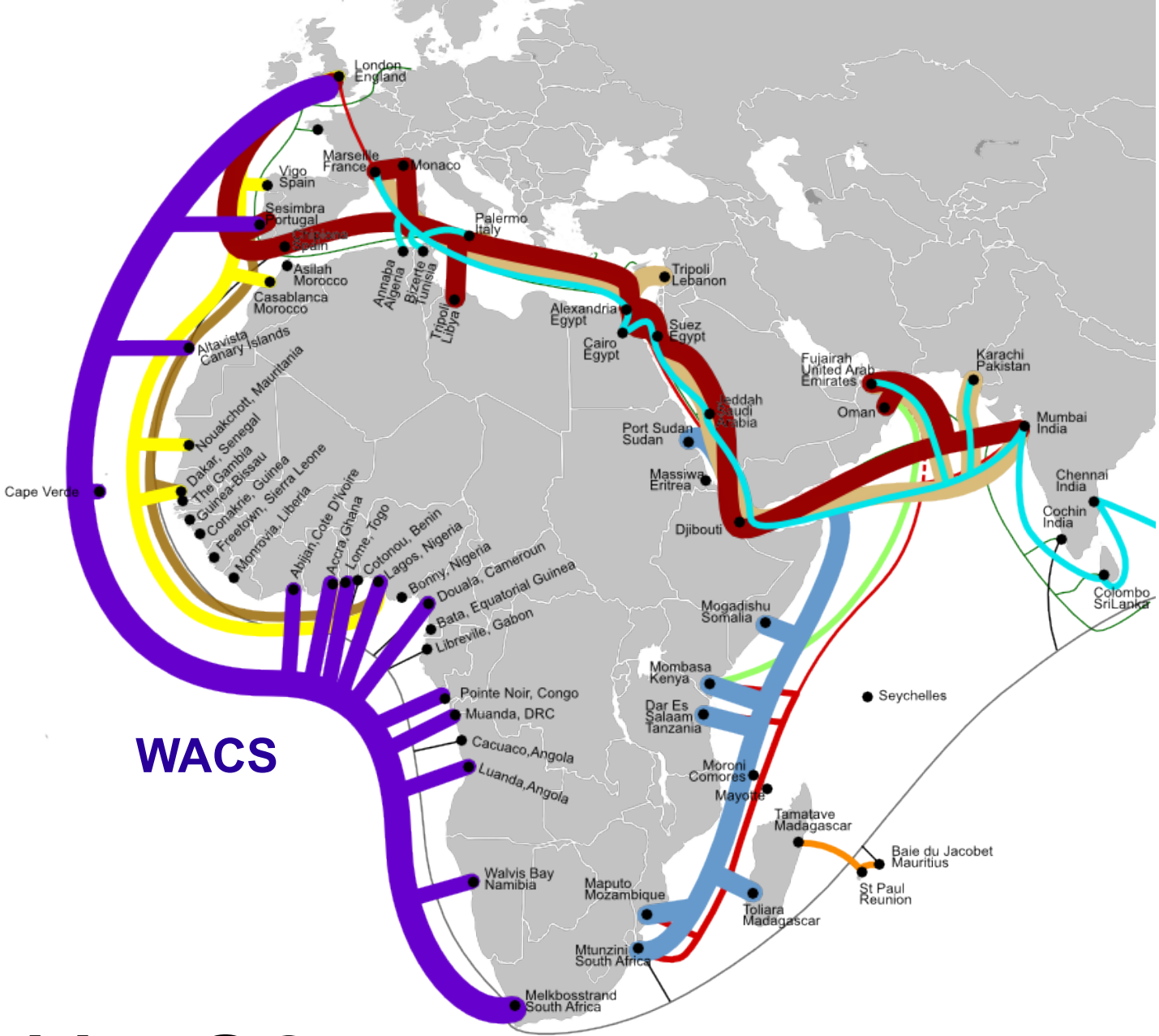
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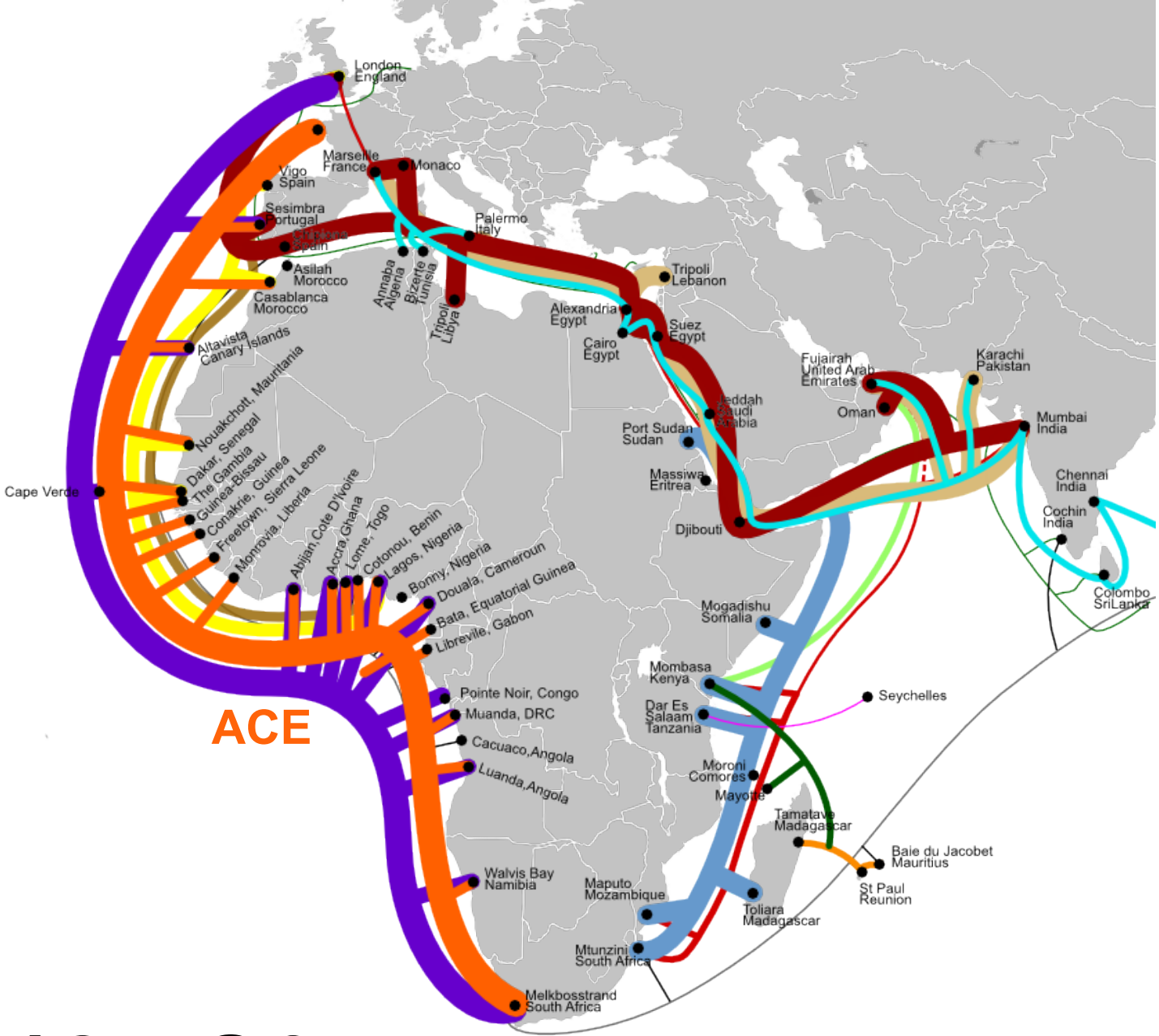
# 2011 - Q2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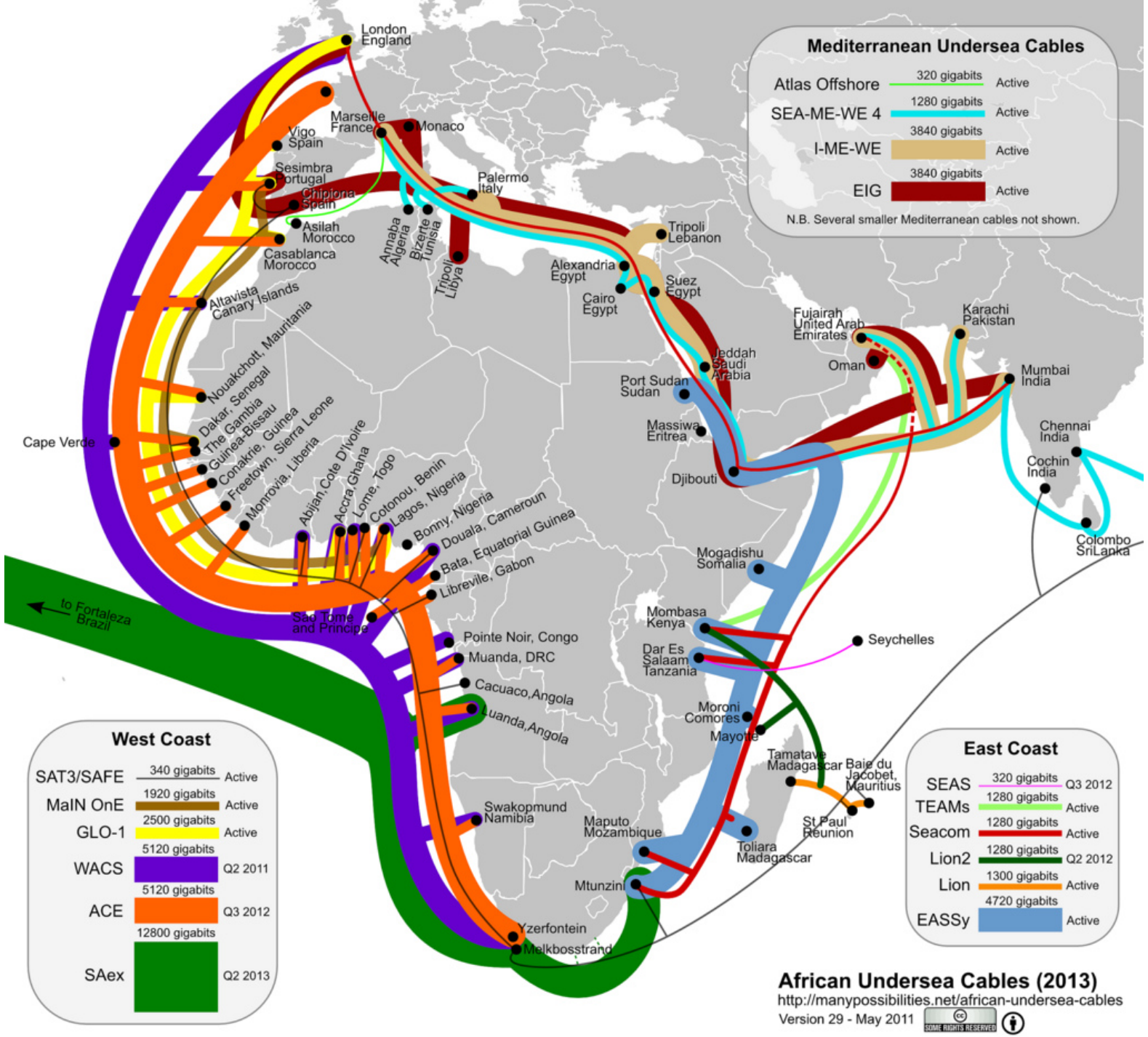
# 2012 - Q3


Mediterranean Undersea Cables
Atlas Offshore 320 gigabits Active
SEA-ME-WE 4 1280 gigabits Active
I-ME-WE 3840 gigabits Active
EIG 3840 gigabits Active
N.B. Several smaller Mediterranean cables not shown.
London England
Marseille France
Monaco
Vigo Spain
Sesimbra Portugal
Chipiona Spain
Asilah Morocco
Casablanca Morocco
Palermo Italy
Annaba Algeria
Bizerte Tunisia
Tripoli Libya
Tripoli Lebanon
Alexandria Egypt
Cairo Egypt
Suez Egypt
Altavista Canary Islands
Nouakchott, Mauritania
Dakar, Senegal
The Gambia
Guinea-Bissau
Conakrie, Guinea
Freetown, Sierra Leone
Monrovia, Liberia
Cape Verde
Abijan, Cote D'Ivoire
Accra,Ghana
Lome, Togo
Cotonou, Benin
Lagos, Nigeria
Bonny, Nigeria
Douala, Cameroun
Bata, Equatorial Guinea
Libreville, Gabon
Sao Tome and Principe
to Fortaleza Brazil
Pointe Noir, Congo
Muanda, DRC
Cacuaco,Angola
Luanda,Angola
Swakopmund Namibia
Yzerfontein
Melkbosstrand
Fujairah United Arab Emirates
Karachi Pakistan
Jeddah Saudi Arabia
Oman
Port Sudan Sudan
Massiwa Eritrea
Djibouti
Mumbai India
Chennai India
Cochin India
Colombo SriLanka
Mogadishu Somalia
Mombasa Kenya
Dar Es Salaam Tanzania
Seychelles
Moroni Comores
Mayotte
Tamatave Madagascar
Baie du Jacobet, Mauritius
St Paul Reunion
Toliara Madagascar
Maputo Mozambique
Mtunzini
West Coast
SAT3/SAFE 340 gigabits Active
MaIN OnE 1920 gigabits Active
GLO-1 2500 gigabits Active
WACS 5120 gigabits Q2 2011
ACE 5120 gigabits Q3 2012
SAex 12800 gigabits Q2 2013
East Coast
SEAS 320 gigabits Q3 2012
TEAMs 1280 gigabits Active
Seacom 1280 gigabits Active
Lion2 1280 gigabits Q2 2012
Lion 1300 gigabits Active
EASSy 4720 gigabits Active
African Undersea Cables (2013)
http://manypossibilities.net/african-undersea-cables
Version 29 - May 2011
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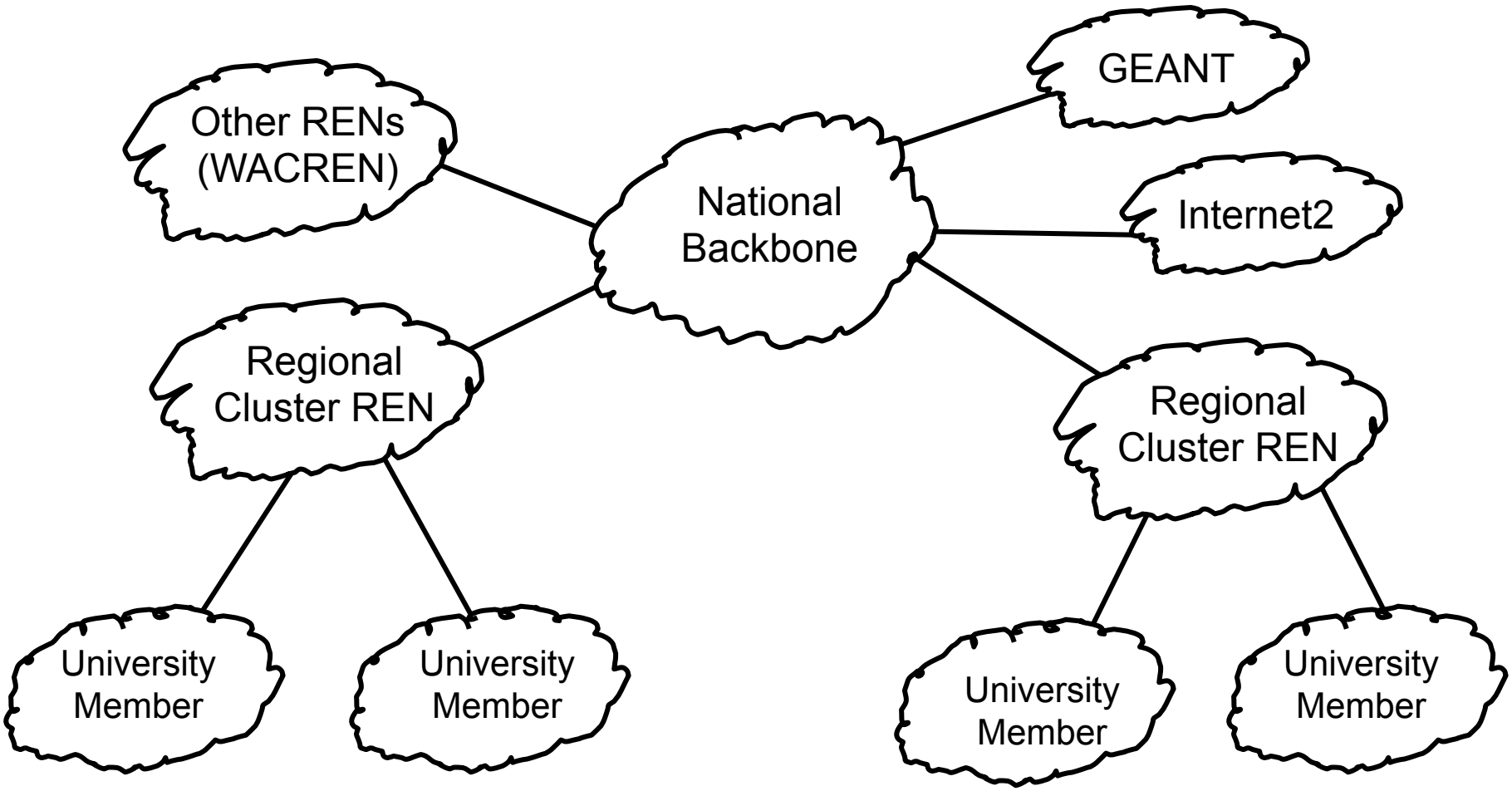
# Thoughts about Nigeria

- Don't sign more than a 1 year contract for bandwidth
- You will get better pricing if you negotiate as a group rather than individual universities.

# What might Nigeria Look Like



# Open Questions about Nigeria

- What are the regional clusters?
  - Who operates them
  - Do they provide Internet access or just peering?
- What about the National Backbone
  - Will there be one or will the clusters provide their own International connectivity?
  - Who will operate it (world bank project)?
  - Where will connections to the clusters be?

# Questions/Discussion?