Network strategies:
Combining NREN with commercial and private networks

The NYU Global Network University (GNU) Case Study

Topics

- NYU Background

- The NYU Global Network University (GNU) Vision

- NRENs at NYU

- Different Types of Networking Services (NRENs, Commodity Internet, Private Links)

- Evolution of NYU's Global Network – Combining the Three Services

- NYU Abu Dhabi – the beginning of The Future

- Some New Features for the NYU Global Network

- NYSERNet (New York State Education and Research Network): Service offerings by a Regional R&E Network Provider

- A New Challenge in Global Networking: IPv6

- Final Thoughts

New York University

- **Main campus in New York City**

- **Largest private university in US**
  - **55,000 students**
  - **16,000+ employees**

- **14 schools, colleges and divisions**

Evolution of NYU

- **Founded in 1831 as a university**

    "in and of the City"

- **Evolution to**

    "in and of the World"

    - **40% of undergrads now do study abroad**

        - **Largest study abroad program in US**

    - **10% of student population is international**

    - **Study abroad programs in 25 countries**

NYU International Sites

- **Abu Dhabi, United Arab Emirates**

- **Accra, Ghana**

- **Berlin, Germany**

- **Buenos Aries, Argentina**

- **Florence, Italy**

- **London, England**

- **Madrid, Spain**

- **Paris, France**

- **Prague, Czech Republic**

- **Singapore, Republic of Singapore**

- **Tel Aviv, Israel**

- **Shanghai, China (current site and possibly much larger site in future)**

Global Network University (GNU) – The Vision

… to enable **seamless mobility** of faculty, students, researchers, and teaching and learning between branch campuses and across international study sites

Source: NYU Vision Document, February 2009

To achieve this vision, NYU has identified several technology-focused objectives:

a **world-class, fully-meshed** network

access to **new communications technologies**

globalize **shared services** & applications

Network with Sufficient Bandwidth is ESSENTIAL to the GNU

Creating a Global Community

- **Global Intranet (with access to internal-only resources)**

- **Global, secure wireless (802.11) service**

- **Videoconferencing/voice services**

- **Streaming class lectures**

- **Access to academic systems in New York**

- **Access to administrative systems in New York**

Enabling Research

- **Moving large research data sets**

- **Access to special facilities such as supercomputing**

- **Collaboration**

NRENs at NYU: Current Status

- Berlin, Germany

- Florence, Italy

- London, England

- Prague, Czech Republic

- New York, US

Current NRENs in use by NYU: Berlin, Germany

DFN (Deutsches Forschungsnetz) provides both R&E and commodity Internet connectivity

Site profile: 20Mb; 1 building; ~100 students

(http://www.dfn.de/en/)

Current NRENs in use by NYU: Florence, Italy

GARR provides both R&E and commodity Internet service to our La Pietra site

Partnered with the University of Paris and GARR to get direct fiber connection to GARR

Site profile: 100Mb; 5 buildings (including conference center); ~400 students

(http://www.garr.it/eng/)

Current NRENs in use by NYU: London, England

ULCC - the University of London Computing Centre – provides a connection to JANET (the United Kingdom's NREN) as well as commodity Internet connectivity

(ULCC also provides dark fiber to interconnect our 3 London sites)

Site profile: 100Mb; 3 buildings; ~400 students

(http://www.ulcc.ac.uk/) (http://www.ja.net/)

Current NRENs in use by NYU:
Prague, Czech Republic

CESNET (via PASNET, which also provides the commodity Internet service) provides R&E connectivity to our Prague sites (academic centers and residence halls)

Site profile: 20Mb; 4 buildings; ~200 students

(http://www.ces.net/) (http://www.pasnet.cz/)

Current NRENs in use by NYU: New York, US

Internet2 (via NYSERNet) currently at 360Mb, going to 1Gb

(http://www.internet2.edu/)

National Lambda Rail (NLR) currently at 1Gb, looking to go to 10Gb

- Using the NLR TelePresence Exchange (of which Tata and AT&T are a part)

- Provides R&E path, in addition to Internet2, to numerous US sites

(http://nlr.net/)

CERN/US-LHC-Net connectivity to CERN at 1Gb

- Supports NYU's ATLAS research at CERN

(http://lhcnet.caltech.edu/)

NRENs at NYU

- Note on routing:
  When available, NREN path between connected NYU sites preferred over Internet path

- Upcoming NREN additions include:

  - ANKABUT in Abu Dhabi, UAE (in progress)

    - US connection terminates nearby our data center

    - Looking forward to collaborating, sharing resources (e.g., HPC)

  - CERNET in Shanghai, China (in planning stage)

Different Types of Networking Services

- **NRENs (and Regional Research & Education Networks)**

  - "Intranet" within Higher Education (HE) community
  - If Commodity Internet service offered, often cost-effective when compared with commercial offerings
  - Chance to collaborate and support NRENs in various countries
  - Unique service offerings sometimes available
  - Best effort delivery; sometimes over-provision to avoid congestion

- **Commodity Internet**

  - Cost-effective, general-purpose network service
  - Quality can be unpredictable

Different Types of Networking Services (continued)

- Private Links

  - Excellent for critical traffic

  - No congestion issues (if provisioned at high service level)

  - Strong SLAs available (e.g., for jitter, latency)

  - Customized architecture

  - University-implemented QoS possible within links

  - Higher cost -> limited bandwidth
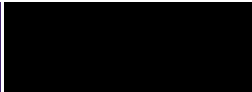
    (Note: NYU using MPLS for private links)

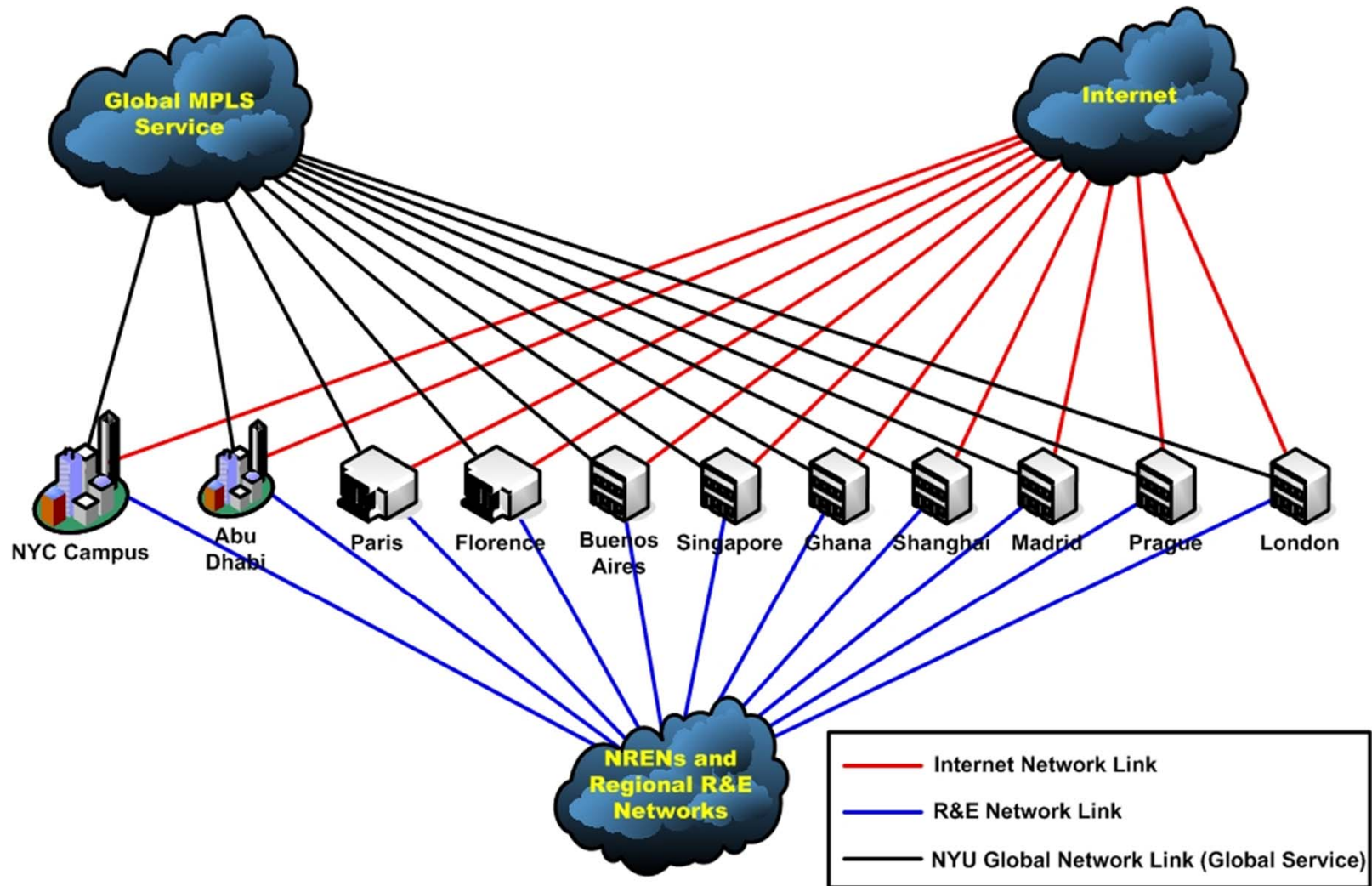# Evolution of the NYU Global Network – Combining the Three Types of Services

- Was

  - Commodity Internet or Commodity Internet + NREN
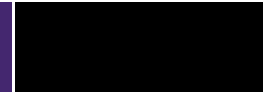
- Future vision

  - Utilize all three services as available/feasible

    - Commodity Internet

    - NRENs

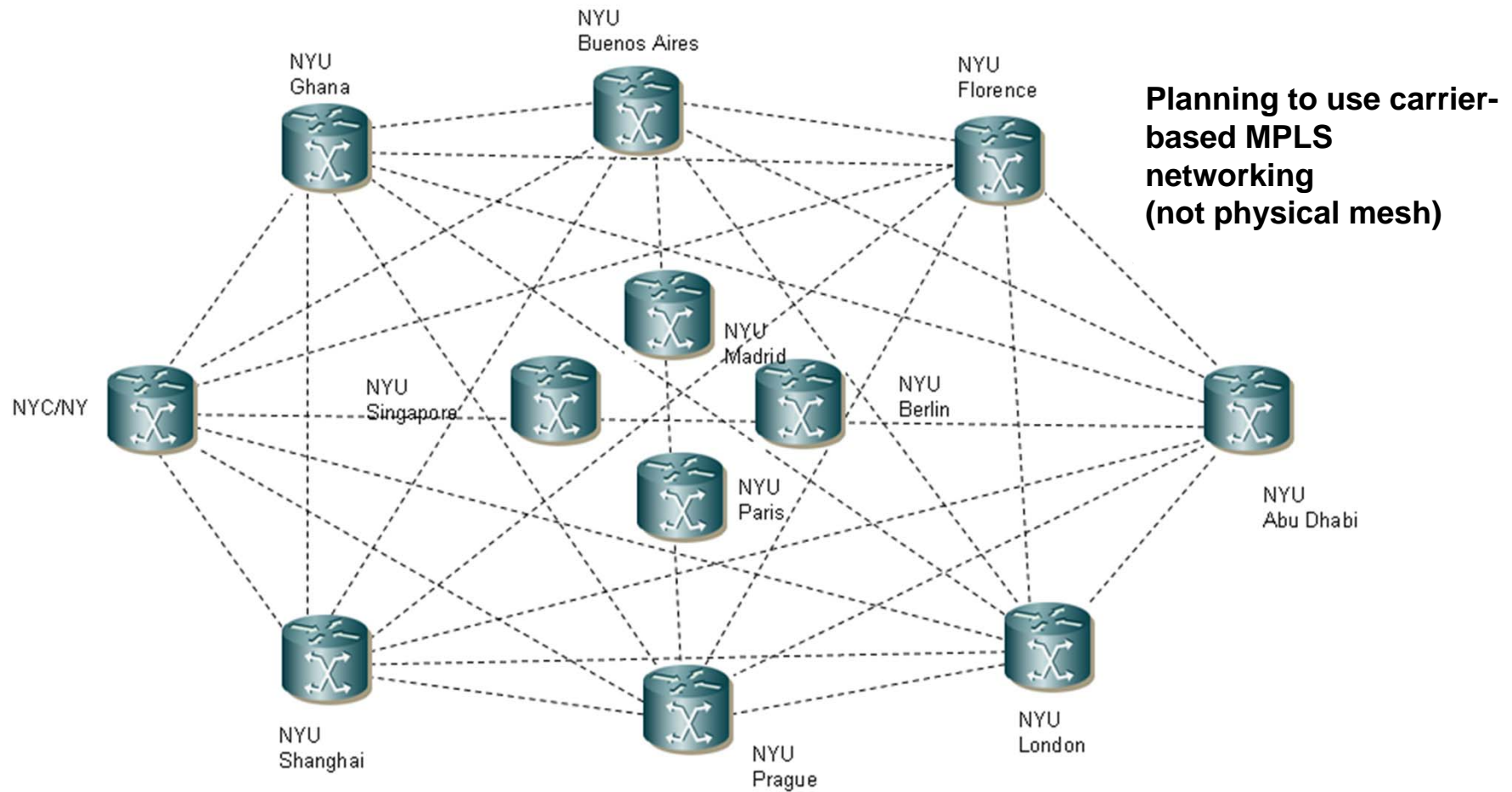   - Private links – Multiprotocol Label Switching (MPLS) network

The Ideal Future State

NYU's GNU Future Meshed Private Network

Planning to use carrier-based MPLS networking (not physical mesh)

NYU Abu Dhabi – The beginning of The Future

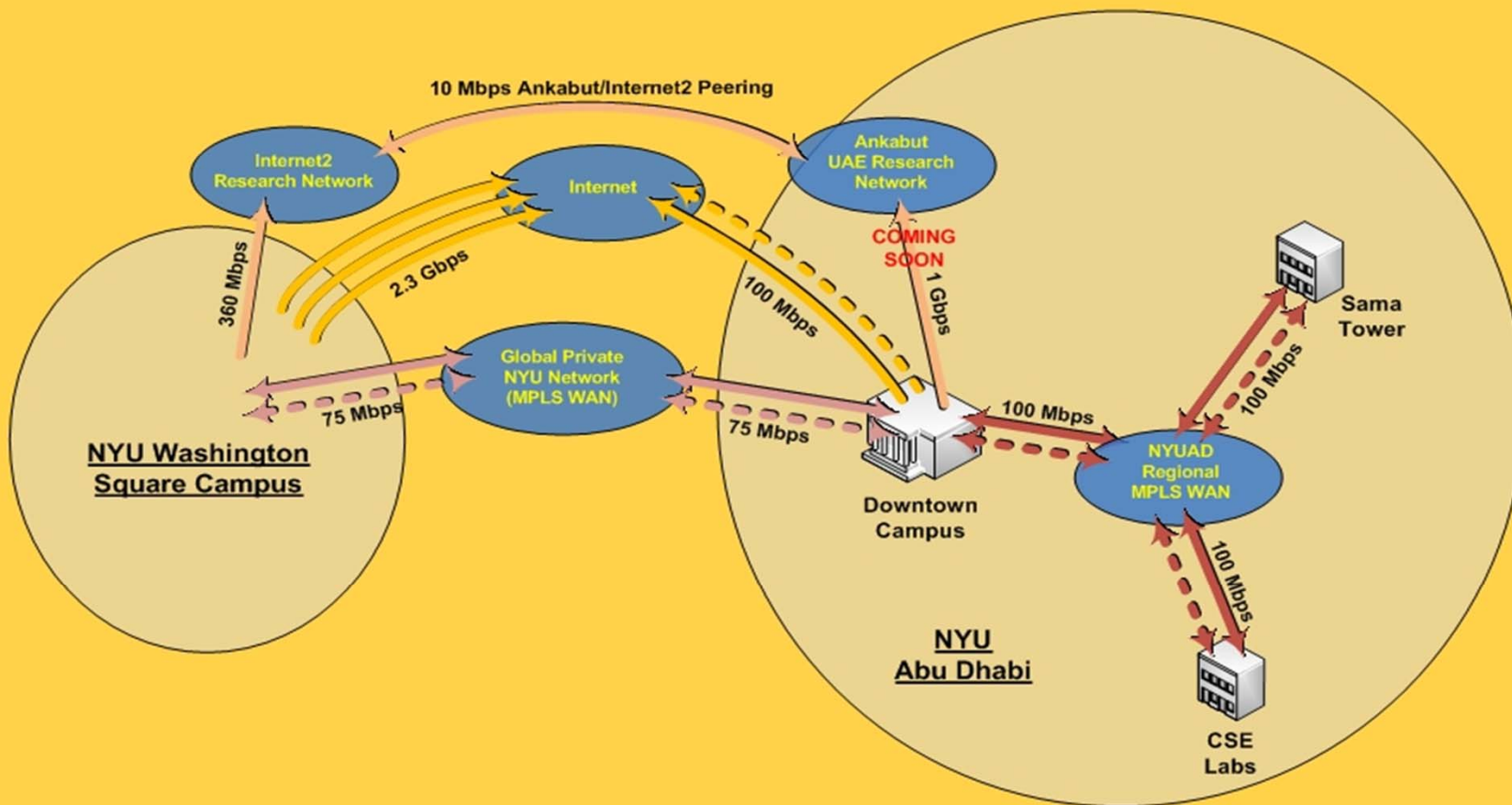# Abu Dhabi Locations – Current and In-Progress

Now:
- Downtown Campus
- Sama Tower
- Musaffah Labs
  (Center for Science and
    Engineering - CSE)

In-Progress:
- Saadiyat Island Campus

Global NYU-NET Connectivity to NYU Abu Dhabi

Abu Dhabi Networking

- **Current**

  - **75 Mb MPLS link to NYU NY**

  - **100 Mb commodity link**

- **Near-term planned upgrades**

  - **150 Mb MPLS link to NYU NY**

  - **150 Mb commodity Internet**

  - **1 Gb Ankabut link**

- **Future – when larger campus built on Saadiyat Island – will require significantly more bandwidth to scale to larger student population**

Near-Term Future: NYU GNU Network
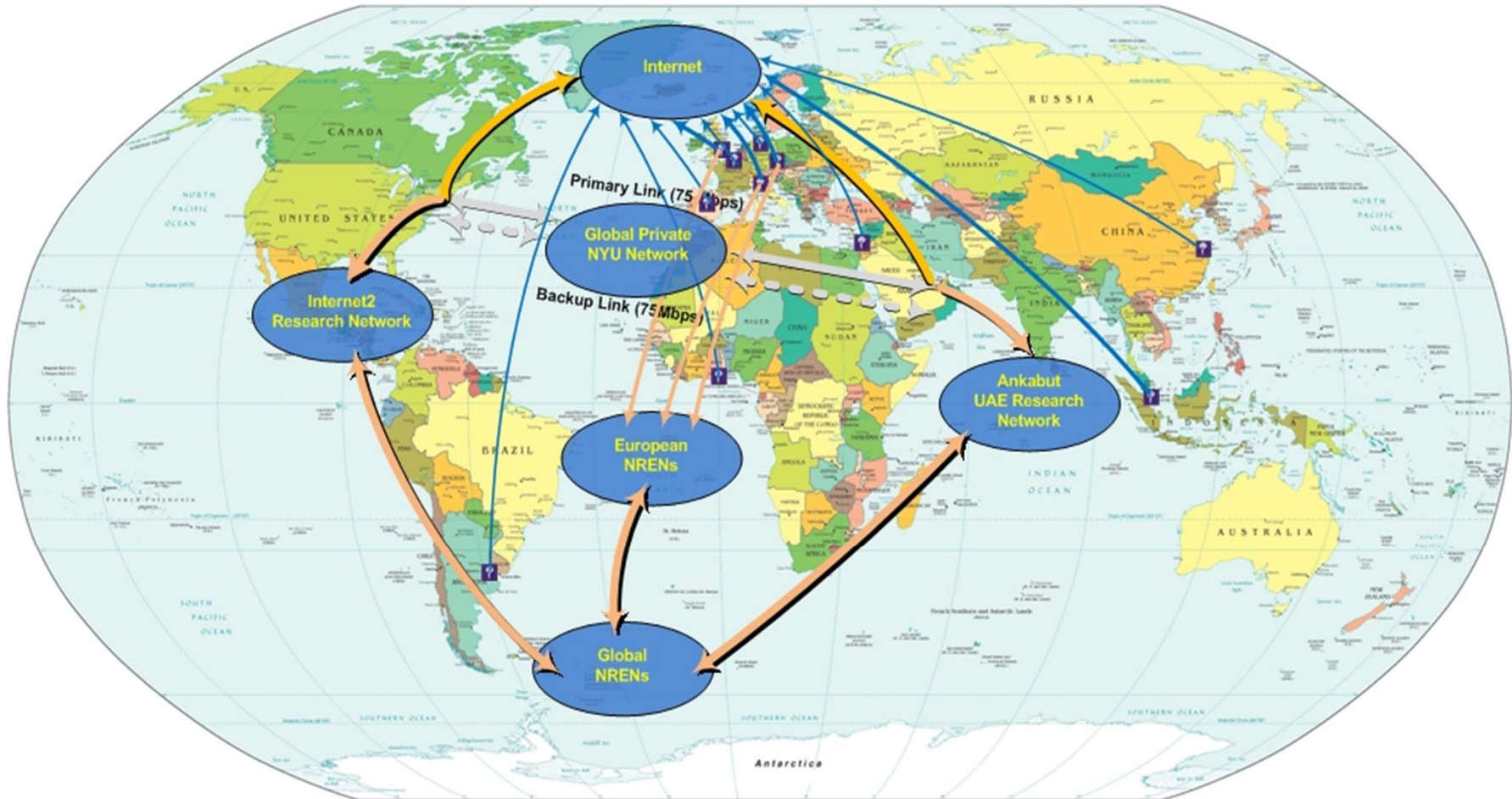
Some New Features for the NYU Global Network

- For sensitive traffic (e.g., financial or student records), there are strong mandates to protect confidentiality

  - Private links provide isolation of sensitive traffic
  - NYU also is starting to deploy Cisco's Dynamic Multipoint Virtual Private Network (DMVPN) feature, where feasible, to protect the confidentiality of sensitive information
    - Works over both private lines and other links (e.g., commodity Internet)
    - Creates a secure mesh network

  - Application-based routing – a work in progress. For example:
    - Videoconferencing, to another NYU site, over private links
    - HPC collaborations over the NREN
    - General web browsing on the Commodity Link

Regional R&E Network Provider in New York City: NYSERNet

- New York State Education & Research Network   (www.nysernet.net)

- Partner, with Internet2 and Indiana University, in MAN LAN (New York City peering point for national and international networks)

- Interesting array of services provided to New York State community, some of which are used by NYU

  - Statewide fiber network (NYU buys a lambda to upstate NY)
  - Data Center in upstate NY used by several universities as a backup site
  - Discounts with a carrier for commodity Internet service
  - Connections to Internet2
  - New York City dark fiber
    - NYU uses to connect several buildings
  - Willingness and excitement about collaborating on new technologies (e.g., IPv6)
- Other services being considered

NYSERNet and Commodity Internet Offerings

- **Bulk discounts (buying consortium)**

- **Larger schools take advantage of better pricing**

  - Advantage varies depending on geographic location of school and competition in market (New York City has considerable competition, but some other locations in New York State do not)

- **Smaller organizations like bundling of Commodity + R&E connectivity**

A New Challenge in Global Networking: IPv6

- Depletion of IPv4 addresses is nearing

- NYU has already experienced a need for IPv6 to collaborate with locations in the Far East

- IP Version 6 deployment at NYU

  - Full global unicast & multicast IPv6 connectivity via NYSERNet/NRENs
  - First IPv6-connected supercomputer in the United States
        http://www.nysernet.org/news/nyu_20050823.pdf

  - First end site in North America with Global Native IPv6 Multicast Connectivity
        http://www.nysernet.org/news/nyu_20050914.pdf

A New Challenge in Global Networking: IPv6

- On-campus collaborations:

  - Steinhardt School of Music graduate student support (Sept. 2010)

    - Music/audio transmission collaboration with a group in Beijing, China

- Video conferencing collaboration with School of Transnational Law, Peking University

  - DVTS used over IPv6 to Peking University for instructional videoconferencing support (ready to use now)

- Intrusion Detection System (IDS) algorithm research support

  - Research with Bayesian analysis of network traffic to detect anomalous behavior indicating security events

- Secure File System research support

  - Research into a secure filesystem implementation, with collaborators in Japan
  - IPv6 connectivity required to foster communications between research groups

Final Thoughts

- There is a significant benefit for many higher education institutions to use multiple types of network provider services in their overall networking strategy

  - Use best features in each type of service to provide comprehensive, quality services at a reasonable price point
  - But using multiple network provider types can increase complexity of managing the institution's network infrastructure

- NRENs (and Regionals) may offer services that are unique and important to higher education institutions

  - Collaboration between researchers
  - Collaboration between IT/networking staffs in member institutions
  - Special services can be tested and nurtured and potentially hosted
  - Organization where network research can be hosted

NEW YORK UNIVERSITY

Questions?

Contact Information:

Doug Carlson
Associate Vice President, Communications & Computing Services
New York University
10 Astor Place, 5th Floor
New York, NY 10012

Phone: (212) 998-3445
email: doug.carlson@nyu.edu

NYU Global Websites:
www.nyu.edu/global.html
www.nyuad.nyu.edu
www.nyu.edu/its/global
www.nyu.edu/studyabroad