The Future of Collaboration: US and China and advanced networks for research, teaching and learning

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Outline

- Challenges to today's Internet
- The future of advanced networks for research, teaching and learning
- Areas of collaboration for the US and China

Internet2 Yesterday and Today

- **Launched October 1996**
  - 34 US universities
  - Formally incorporated as not-for-profit corporation September 1997
  - Abilene backbone network announced April 1998
- **Today**
  - 208 US universities; 60+ corporate members, 40+ affiliates, 45 international partners
  - 2nd Generation Abilene backbone network; Internet2 Commons, Shibboleth, InCommon, NLR, QUILT, Arts & Humanities program, etc.
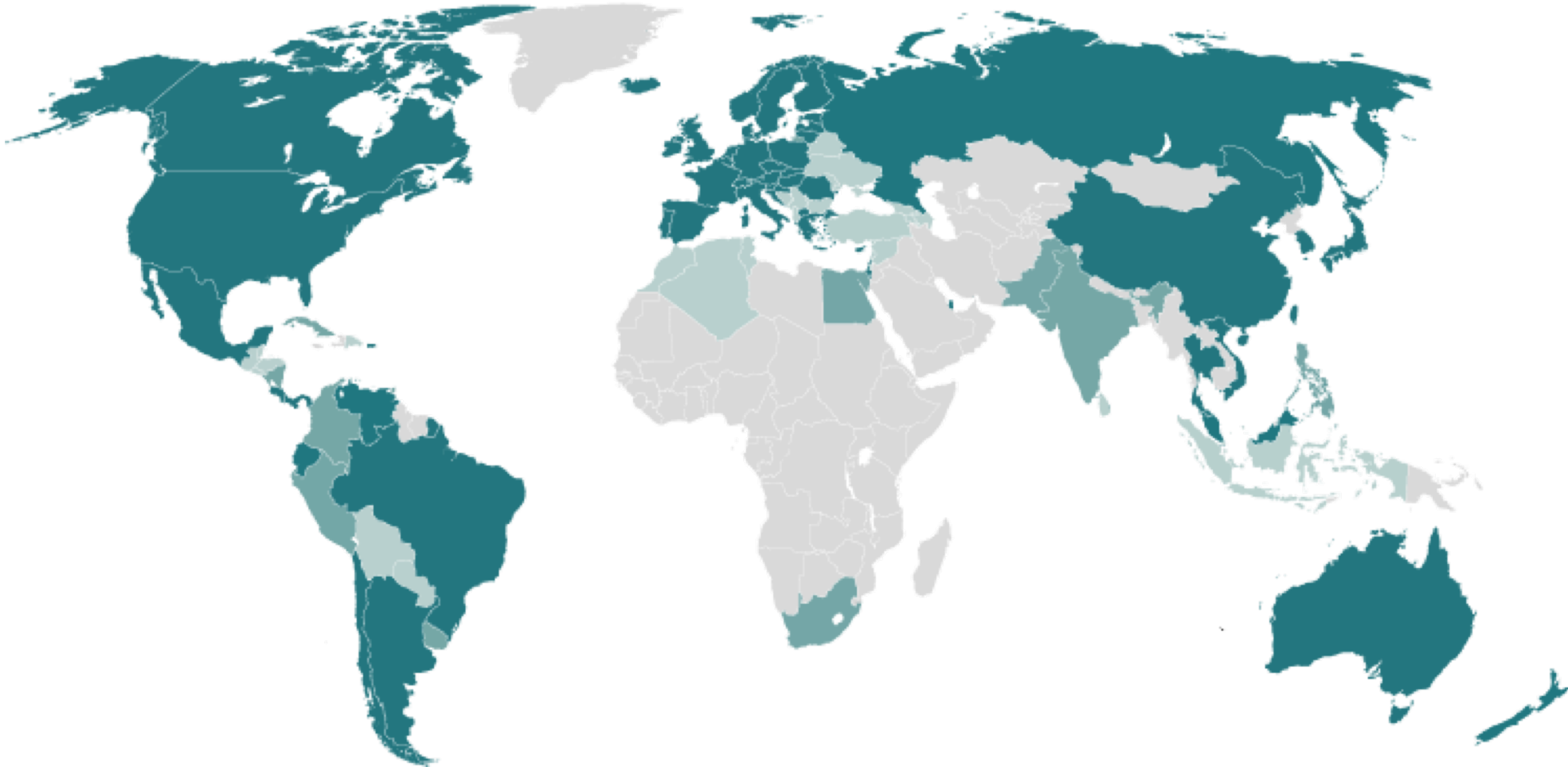
US and China

- **Partnership between Internet2 and CERNET, CSTNET and NSFC since May 2000**

- **Chinese-American Networking Symposium series**
  - Internet2 is delighted to be co-organizer with CAST, CERNET and CSTNET

Internet Success Factors

- Technology progress keeps capacity ahead of demand
- Open end-to-end architecture
  - Applications and content creation, enhancement, and dissemination
- Reachability
  - Metcalfe's Law and the Global Community
- A Commons
  - Community collaborates to maintain its health

Challenges to the Future of the Internet

- End-to-end performance
- Network architecture scalability
- Limited reach of advanced capabilities
- Abuse of network resources by applications
- Security: Authentication & privacy
- Reduced investment in the Internet commons

Keys to the Future of the Internet

- **Connectivity**
  - Scalable
  - Reliably high end-to-end performance

- **End-to-end architecture**
  - IPv6
  - Security without NAT

- **Reach**
  - Disseminate multicast, end-to-end architecture
  - Integrate packet switched and circuit facilities

- **Ease of use, privacy, and security**
  - Standard core middleware
  - Authenticated Internet within & between trust communities

- **Integration with advanced applications**

Motivate

Enable

Applications

Middleware

Services

Networks

End-to-end Performance
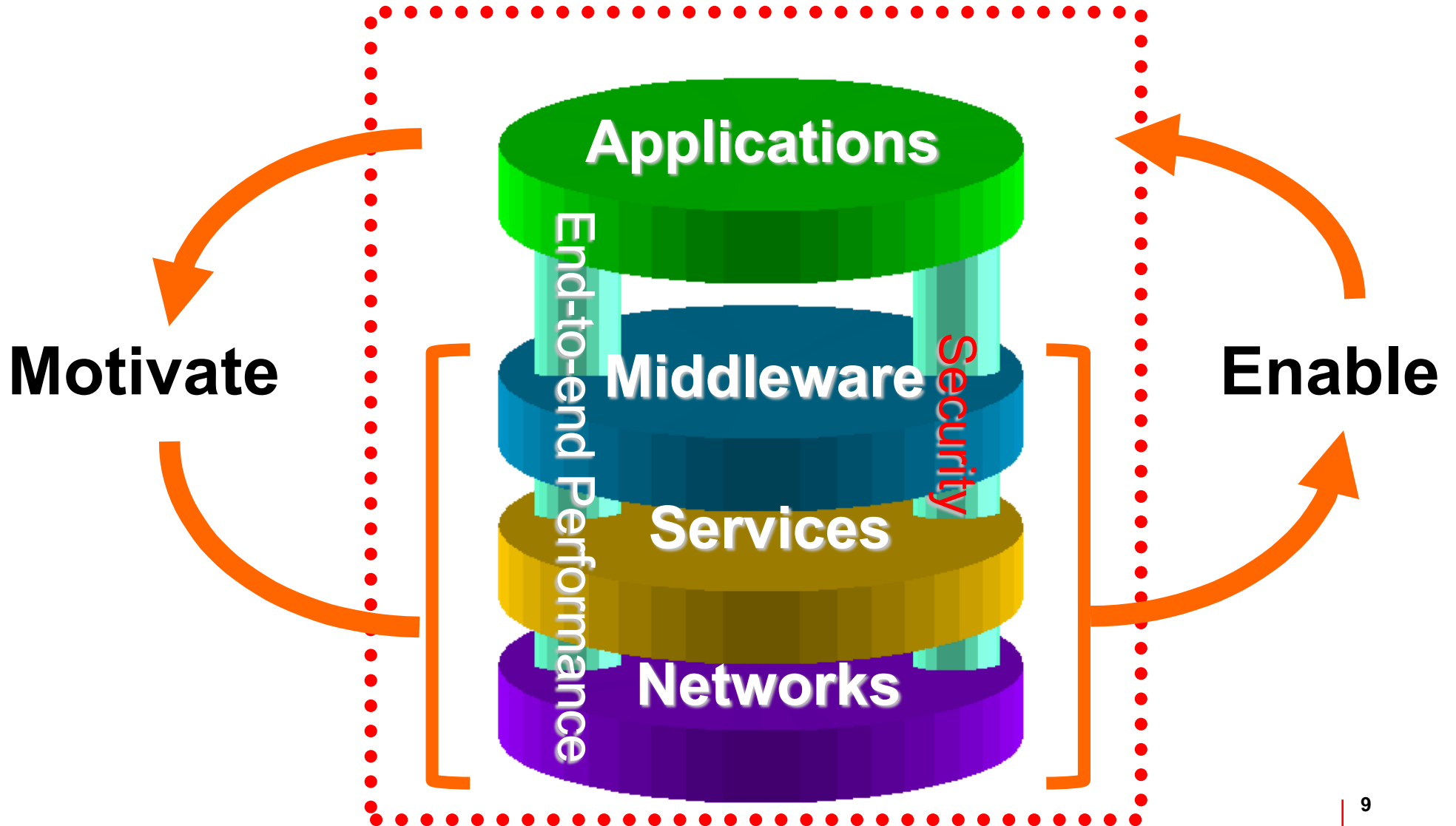
Security

Internet2 Programs

- **Network Infrastructure**
  - Abilene, Fiberco, NLR Support, HOPI

- **Network Services**
  - IPv6, multicast, end-to-end performance

- **Middleware**
  - Authentication, trust federations (InCommon)

- **Security**
  - Security at Line Speed

- **Applications**

  Collaboration environments (Internet2 Commons), SIP, high performance file transfer

- **International**
  - Coordination with regional & national network organizations

Network Scalability

- **Requirements:**
  - Internet protocol-based any-to-any connectivity
    - End-to-end architecture
    - IPv6, multicast
  - Reliable end-to-end performance
    - Streams approaching backbone cross-section capacity
  - Cost-effective use of available circuit facilities

- **Hybrid network solution:**
  - IP protocols
  - Routed paths for most applications & hosts
  - Real time measurement
  - Automatic allocation of optical circuits in real time
    - Persistent large point-to-point flows between major routing junctions
  - End-to-end circuit reservation available on demand

Hybrid Optical & Packet Infrastructure (HOPI) Project

- Examine a hybrid of shared IP packet switching and dynamically provisioned optical lambdas

- Motivation:
  - Scalability development
  - Users/Disciplines desire to provision networks with their own characteristics; or networks for specific services

- Rich set of switched optical paths becoming available:
  - National Lambda Rail
  - International connections

- IP packet switched network in place

- Goals:
  - Build understanding
  - Provide access to new capabilities

HOPI Resources

- The Abilene Network – High capacity packet switching and MPLS tunnels

- The Internet2 Wave on the NLR footprint

- End-to-end measurement facilities

- ManLan Experimental Facility
  - Collaboration with international partners
    - GLIF collaboration
  - Ethernet Switch – layer 2 switching
  - ONS Switch – layer 1 switching
  - HDXC/OME6500 switches – layer 1 and 2 switching

- The Regional Optical Networks – RONs

Optical Networking

- **National LambdaRail – www.nlr.net**
  - Enabling fiber infrastructure to support networks:
    - for research and development of Internet technologies and protocols
    - new applications and services

- **FiberCo – www.fiberco.org**
  - A fiber holding company; holds national/regional fiber assets with the capability of assignment to other organizations

- **Hybrid Optical and Packet Infrastructure Project (HOPI) – hopi.internet2.edu**
  - a facility for experimenting with future network infrastructures
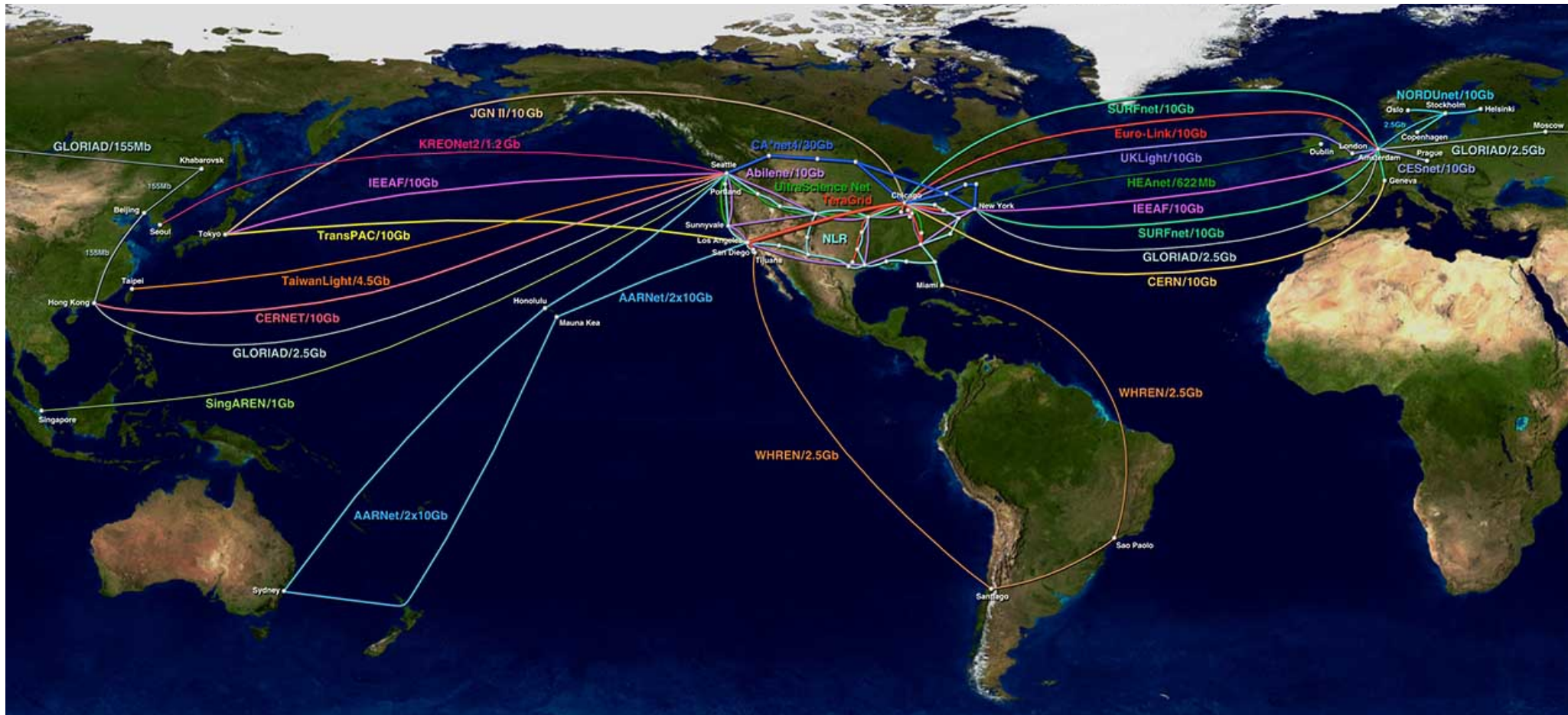
Global Lambda Integrated Facility
World Map – December 2004

Predicted international Research & Education Network bandwidth, to be made available for scheduled application and middleware research experiments by December 2004.

Visualization courtesy of
Bob Patterson, NCSA.

End to end Performance

- View whole path as system

- Give end users (and their system/network admins) tools to discover, diagnose, fix (or learn who to contact to fix) problems

- Network measurement and monitoring framework (piPEs)
  - Use data from regularly-scheduled tests; archived data from others' tests
  - Provides capability to support HOPI efforts

Middleware

- Middleware is the stuff that makes "transparent use" happen, providing persistency, consistency, security, privacy, and capability

http://middleware.internet2.edu
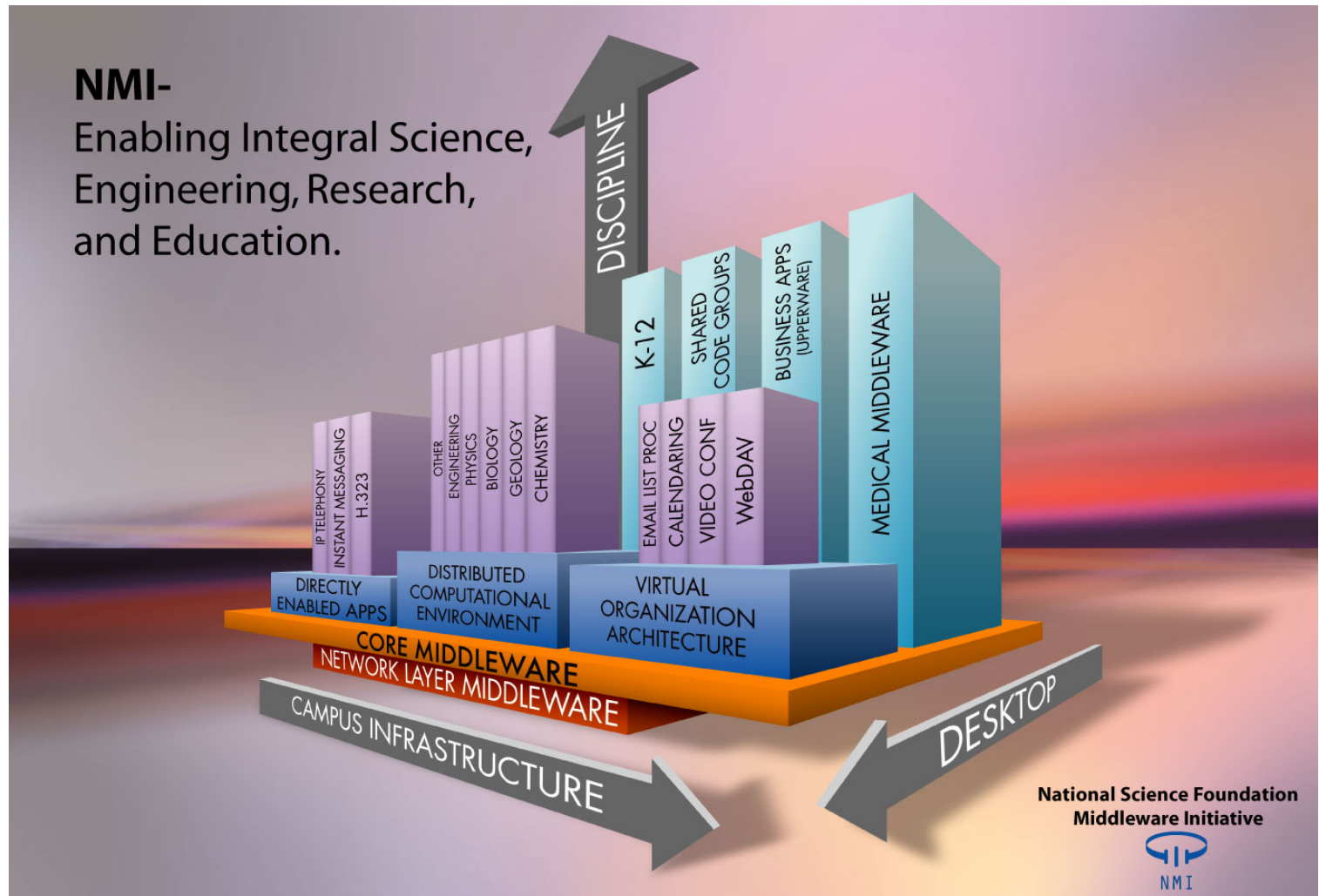
Federated Authentication

- Scalable, decentralized infrastructure
- Critical to a broad range of initiatives
- Being adopted and implemented
  - Industry
  - International
- Middleware is an increasingly enabling element

Shibboleth

InCommon™

Security

- **Require network security approaches that:**
  - Minimally compromise network performance and allow applications requiring advanced network services to function
  - Sustain, in so far as possible, the end-to-end nature of the Internet architecture

- **Network security, host software, and middleware become inter-dependent**

- **Security at Line Speed**
  - NSF-funded workshop
  - SALSA steering group

- **Outcome – An authenticated Internet based on trust communities?**

Imperatives for the Advanced Networking Community

- **Real progress in Internet technology and use is in doubt**
  - Not just connectivity, but performance, security, and reliability
  - New applications require capabilities unlikely to be available through evolutionary change

- **The higher education and research community must provide leadership**
  - Industry efforts focused on profit, maintaining the status quo
  - Our organizations continue to treat the Internet as a Commons

- **No organization, national or regional can succeed in isolation – we must engage these problems collaboratively on a global scale**

- Collaborate on the development and deployment of new network architectures
  - Within China: access to multiple wavelengths
  - Experimentation with new equipment/technologies
  - Exploring new service architectures and business models

- Connectivity between our countries
  - Work on new architectures important
  - Even before multiple wavelengths are available

Current infrastructure: US <-> China

IEEAF 622M + 10G

APAN/TransPAC 2.5G

45Mbps

CERNET 45Mbps

GLORIAD 155Mbps
(CSTNET)
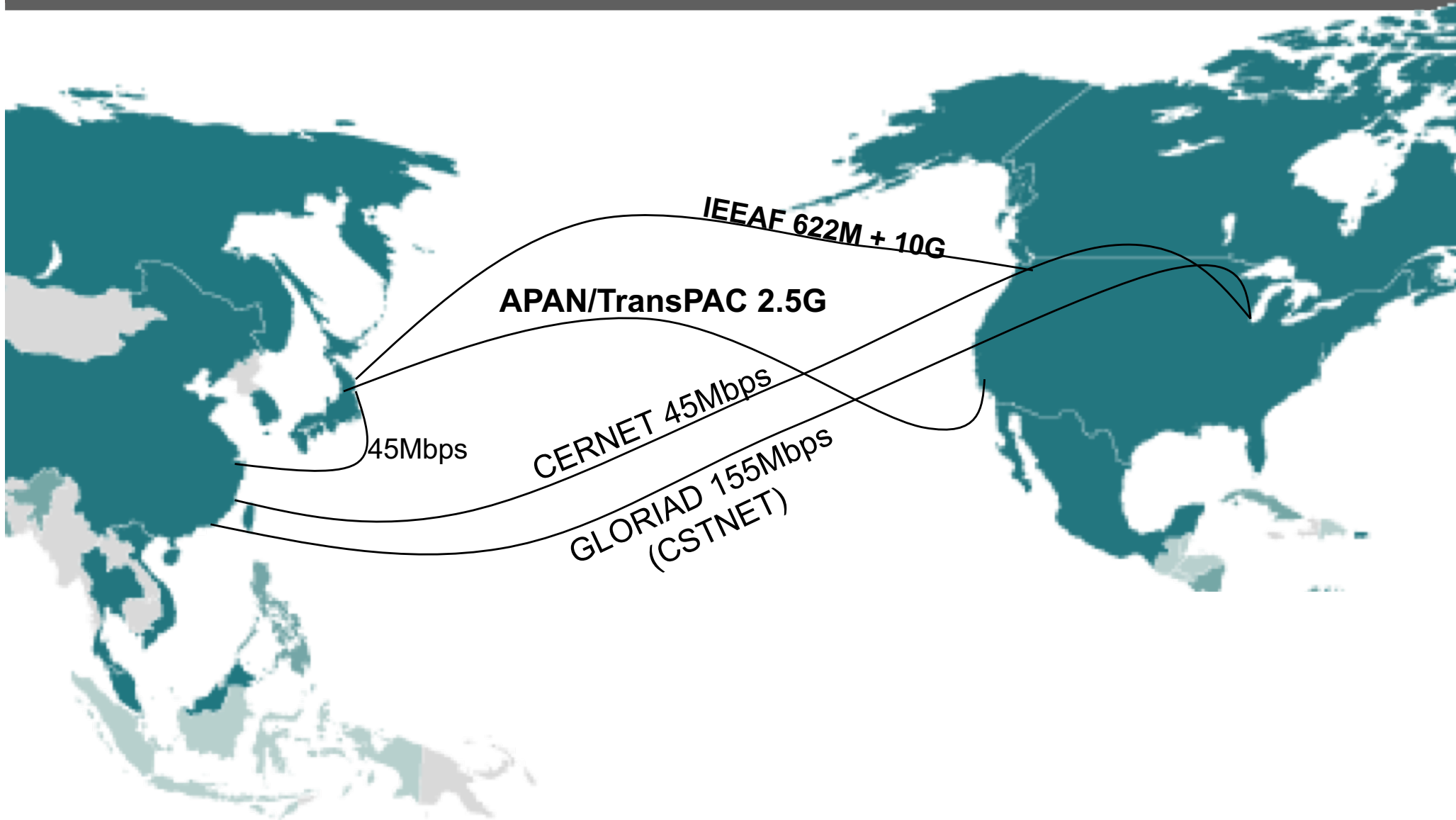
Middleware/Security/Performance

- Multiple dimensions and intersections between these areas
- US can benefit from China expertise and urgent demand for IPv6
  - End-to-end principle and NAT-less networks
  - Performance implications
  - Security implications
- Instrument our respective networks and interconnections
  - Performance-based measurements: partial-path analysis to diagnose problems (see tonight's performance demo)
  - Data for network researchers (Abilene Observatory model)

Agenda for US – China cooperation

- **Working together to support international science projects**
- **eVLBI**
  - Alan Whitney, MIT Haystack will present tomorrow
  - Internet2 working with VLBI community in US to understand topology/infrastructure, enhance performance
  - Several VLBI sites in China
  - Work together to support via our respective networks (and with trans-Pacific link managers)
- **High-energy and nuclear Physics**
  - Several panelists later in the week
  - Many sites, scientists
  - Massive bandwidth needs

Conclusions

- US and China have well-developed domestic advanced networking initiatives and infrastructures

- We have much to learn from each other

- We have much to gain from working together to support broader collaboration between our communities

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