Thinking About Future Internet Architecture

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Contents

- What is Internet Architecture？
- OSI Model and Internet Model
- IETF: Body for Internet Architecture
- Future Internet Architecture Research
- Some Progress of FI/NGI Research in China
- Evolution and/or Revolution
- Conclusions

What is Internet Architecture?

Network architecture is the design of a communications network. It is a framework for the specification of a network's physical components and their functional organization and configuration, its operational principles and procedures, as well as data formats used in its operation.

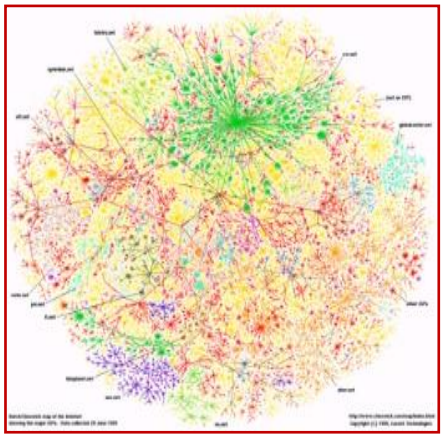
The network architecture of the Internet is predominantly expressed by its use of the Internet Protocol Suite.

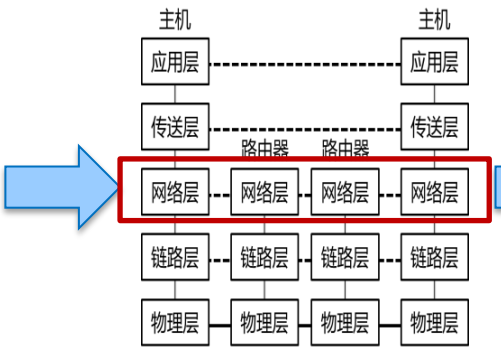
Internet DNA

Merging all of network and communication technology

All applications developed by users

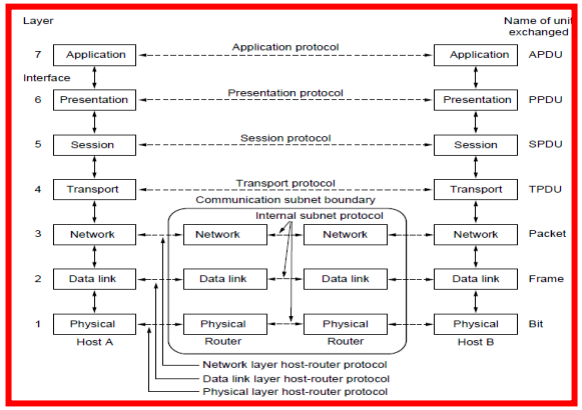
OSI Model and Internet Model





Internet TCP/IP

- **Format**
- **Forwarding**
- **Routing**



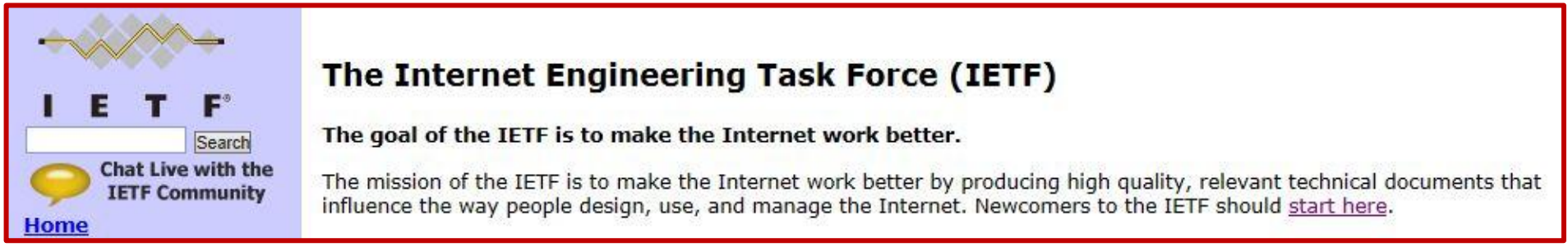
?

OSI Model

Three basic elements in Network Layer

- Format
  - Data format transmitted in end-to-end of network
  - IPv4，IPv6
- Forwarding
  - Data forwarding methods in Network Nodes
  - Connectionless packet forwarding
- Routing（and Addressing）
  - In the conditions of meeting multivariate for optimality
  - RIP, OSPF, BGP, CIDR, MPLS, VPN, SDN,……

IETF: Body for Internet architecture



- Mission: Make the Internet work better
- Top committee： IAB (Internet Architecture Board)
- Documents about internet architecture：
  - RFC 1958; B. Carpenter, et. al.; Architectural Principles of the Internet; Jun 1996
  - RFC 3426; S. Floyd, General Architectural and Policy Considerations; Nov 2002
  - RFC 3439; R. Bush, D. Meyer; Some Internet Architectural Guidelines and Philosophy; Dec 2002

IETF: Future Internet Arch. In 1991

Network Working Group
Request for Comments: 1287

D. Clark
MIT
L. Chapin
BBN
V. Cerf
CNRI
R. Braden
ISI
R. Hobby
UC Davis
December 1991

Towards the Future Internet Architecture

Status of this Memo

This informational RFC discusses important directions for possible future evolution of the Internet architecture, and suggests steps towards the desired goals. It is offered to the Internet community for discussion and comment. This memo provides information for the Internet community. It does not specify an Internet standard. Distribution of this memo is unlimited.

To begin to attack these issues, the IAB and the IESG held a one-day joint discussion of Internet architectural issues in January 1991. The framework for this meeting was set by Dave Clark (see Appendix A for his slides). The discussion was spirited, provocative, and at times controversial, with a lot of soul-searching over questions of relevance and future direction. The major result was to reach a consensus on the following four basic assumptions regarding the networking world of the next 5-10 years.

(1) The TCP/IP and OSI suites will coexist for a long time.

There are powerful political and market forces as well as some technical advantages behind the introduction of the OSI suite. However, the entrenched market position of the TCP/IP protocols means they are very likely to continue in service for the foreseeable future.

(2) The Internet will continue to include diverse networks and services, and will never be comprised of a single network technology.

Indeed, the range of network technologies and characteristics that are connected into the Internet will increase over the next decade.

(3) Commercial and private networks will be incorporated, but we cannot expect the common carriers to provide the entire service. There will be mix of public and private networks, common carriers and private lines.

(4) The Internet architecture needs to be able to scale to 10**9 networks.

The historic exponential growth in the size of the Internet will presumably saturate some time in the future, but forecasting when is about as easy as forecasting the future economy. In any case, responsible engineering requires an architecture that is CAPABLE of expanding to a worst-case size. The exponent "9" is rather fuzzy; estimates have varied from 7 to 10.

TCP/IP and OSI

Never support single network technologies

Scale ability

OSI: The Internet That Wasn’t

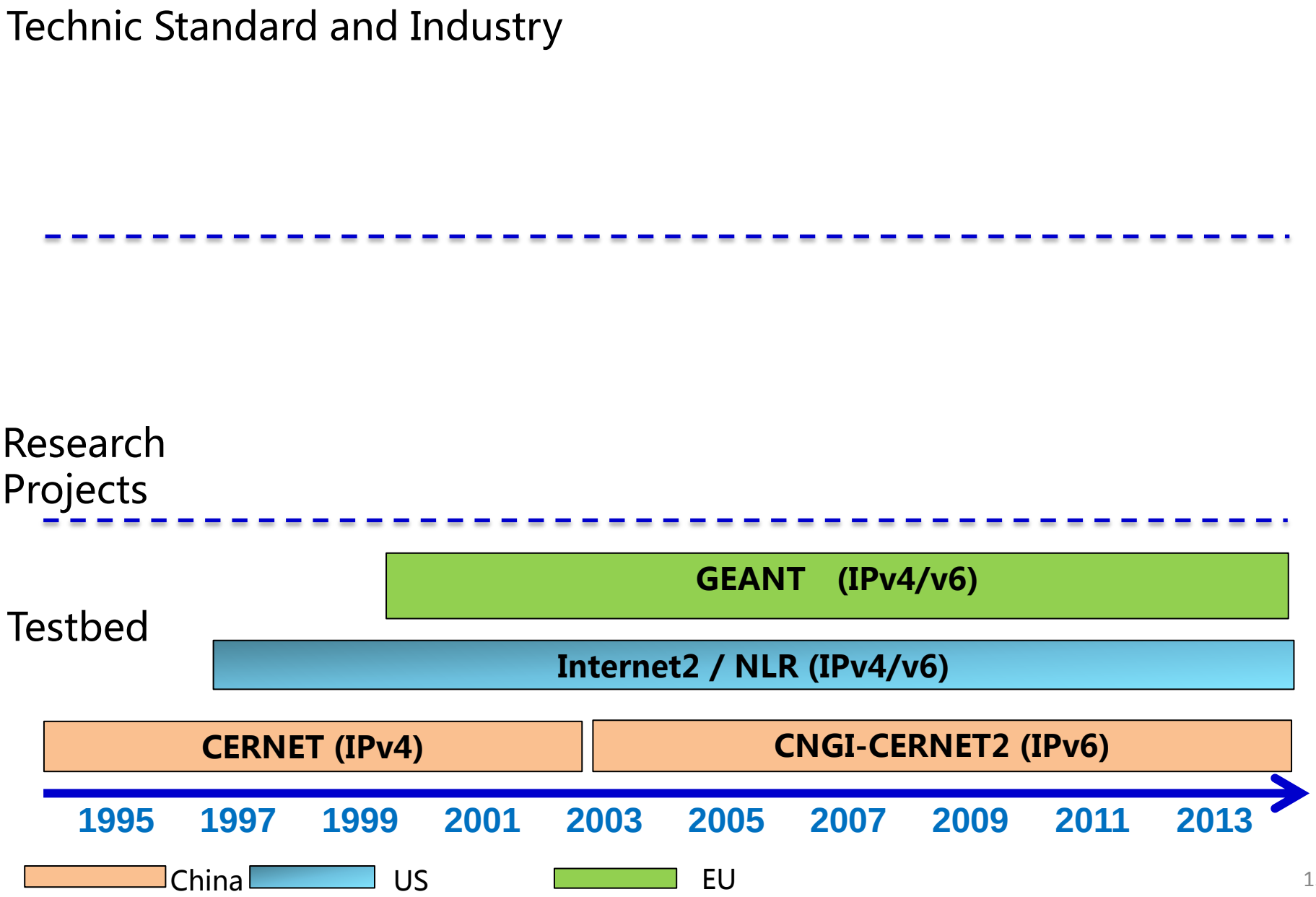
Some Words related Future Internet

- Next Generation Internet （NGI）： 1996
  - 1996， Internet2
- Next Generation Network（NGN）： 2000
  - ITU
- Future Internet： 2005
  - Future Internet
  - Internet for the Future
  - Future of the Internet
- Future Network

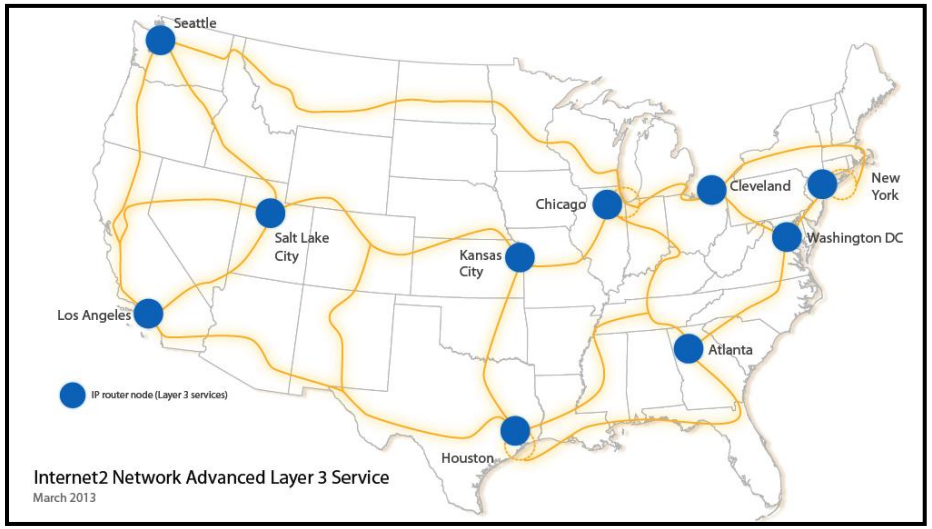
Challenges from current Internet

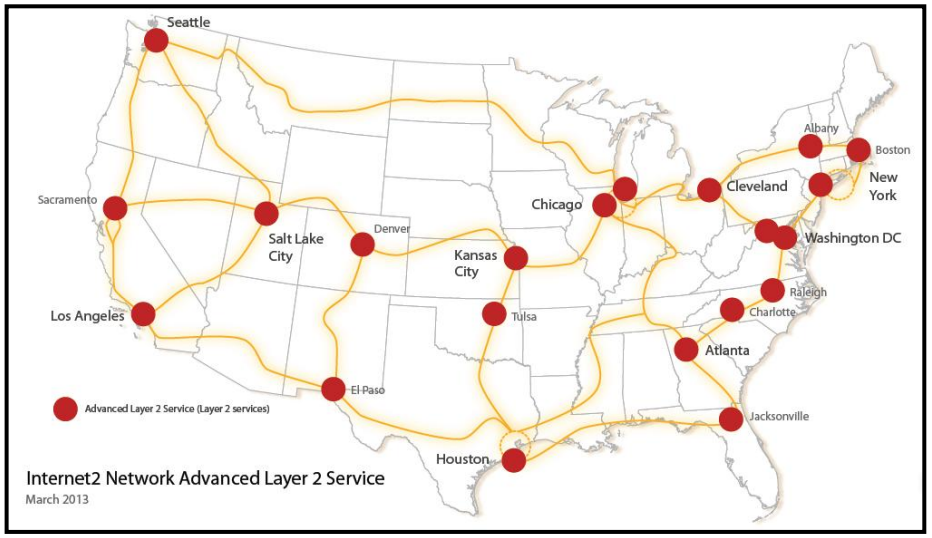
- Scalability： from connecting computers to connecting all of electronic devices
  - 3G，Internet of things，……
- Security： more trustiness
- High performance： end-end performance
- Real time： more timely
- Mobility： mobile communications over Internet
  - Not 3G only
  - WiFi/WiMax based mobile communication
- Management

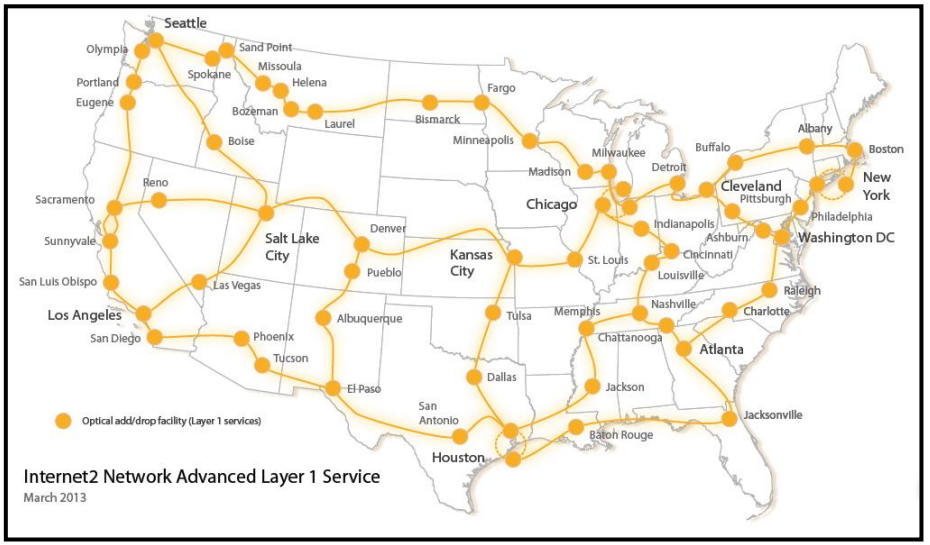
Future Internet Architecture Research



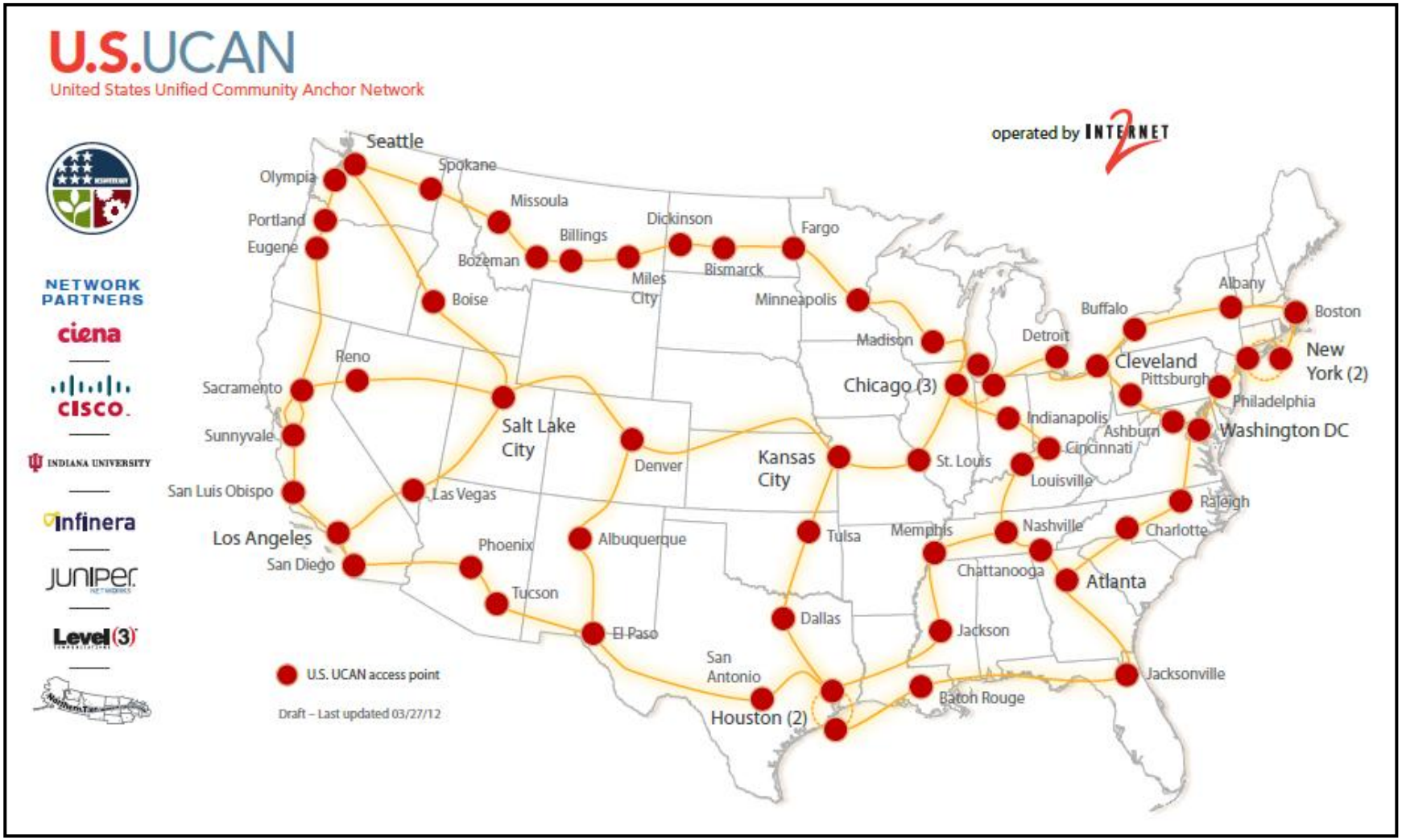
Internet2 Backbone:



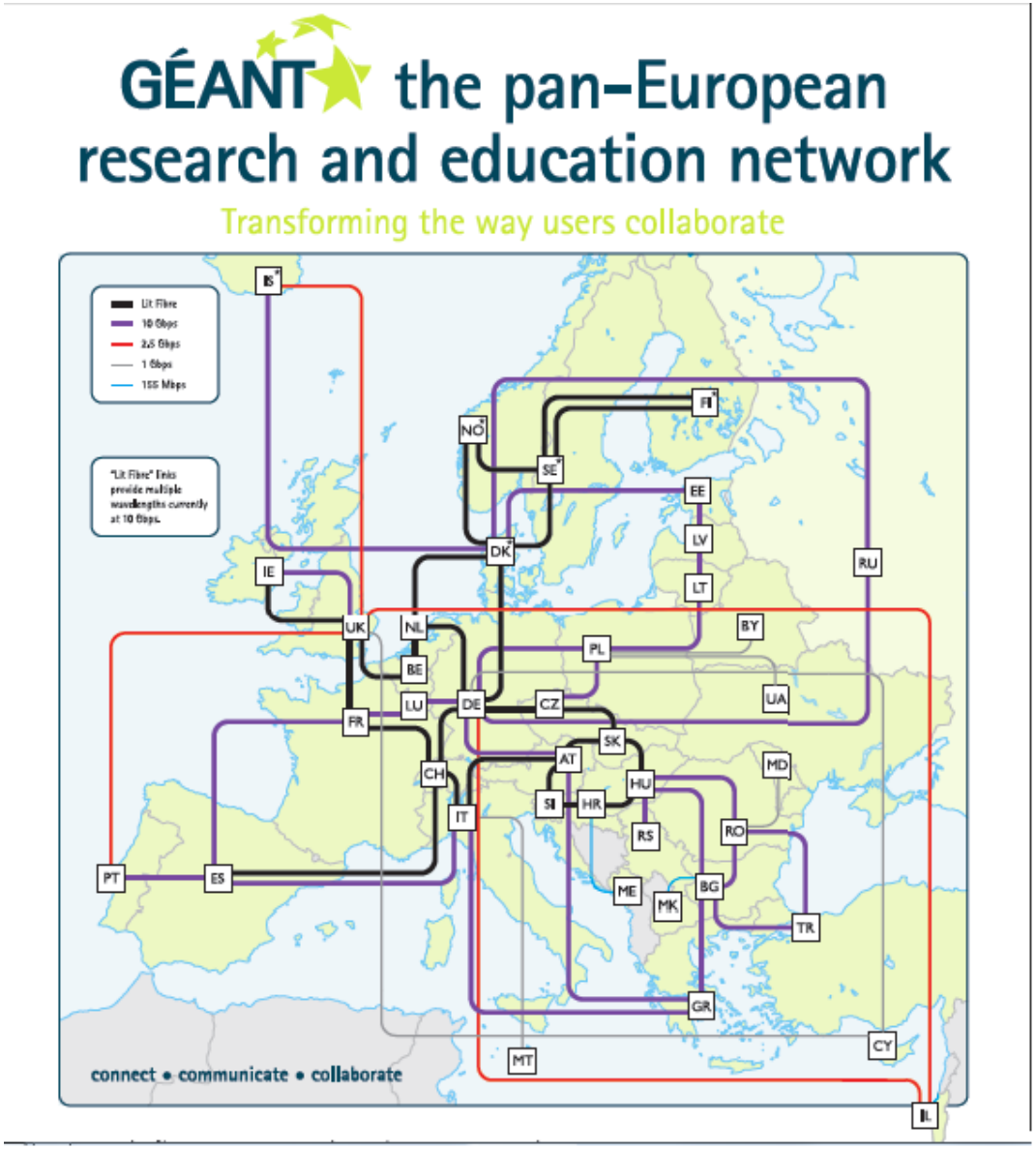




US UCAN Backbone

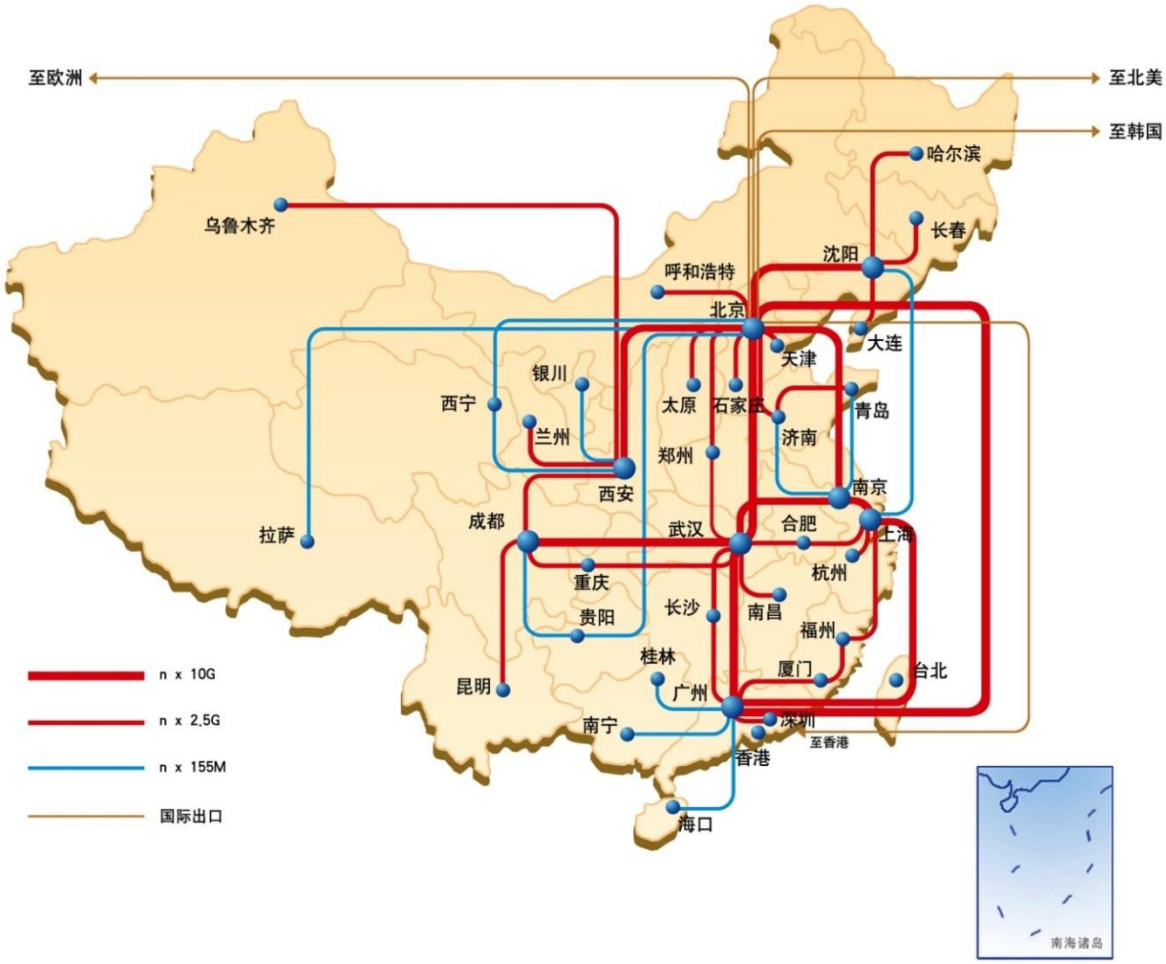


GÉANT backbone in 2011



- 2000-2004 GN1
- 2005-2009 GN2
- 2009-2013 GN3
  - 40 countries
  - 50,000 km network infrastructure
  - 12,000 km lit fibre
  - 25 PoPs, 44 routes, 18 dark fibre routes
  - Core network 10G
  - 8000 Institutions
  - 40M Users

CERNET： Largest NREN in China

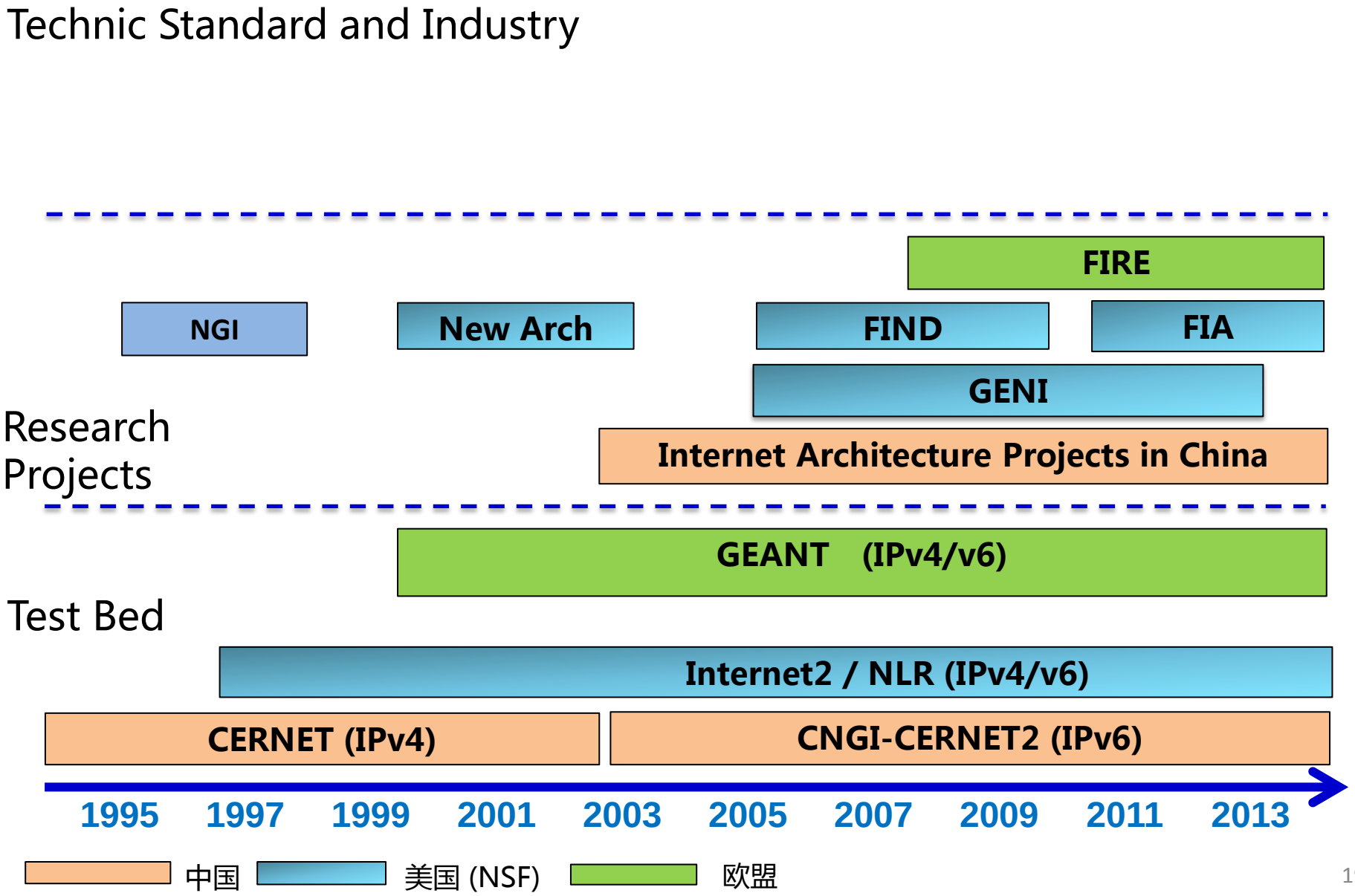


- Fibre network backbone 100G(40λ) DWDM
- IPv4 backbone 100G
- 31 provinces and over 200 cities
- 38 PoPs
- Over 2000 universities and institutes
- 30M users

CNGI-CERNET2 IPv6 Backbone

- IPv6 Backbone 10G to 100G
- 25 PoPs in 20 cities
- Over 300 IPv6 access networks, most of them /48 IPv6 addresses
- 5M users

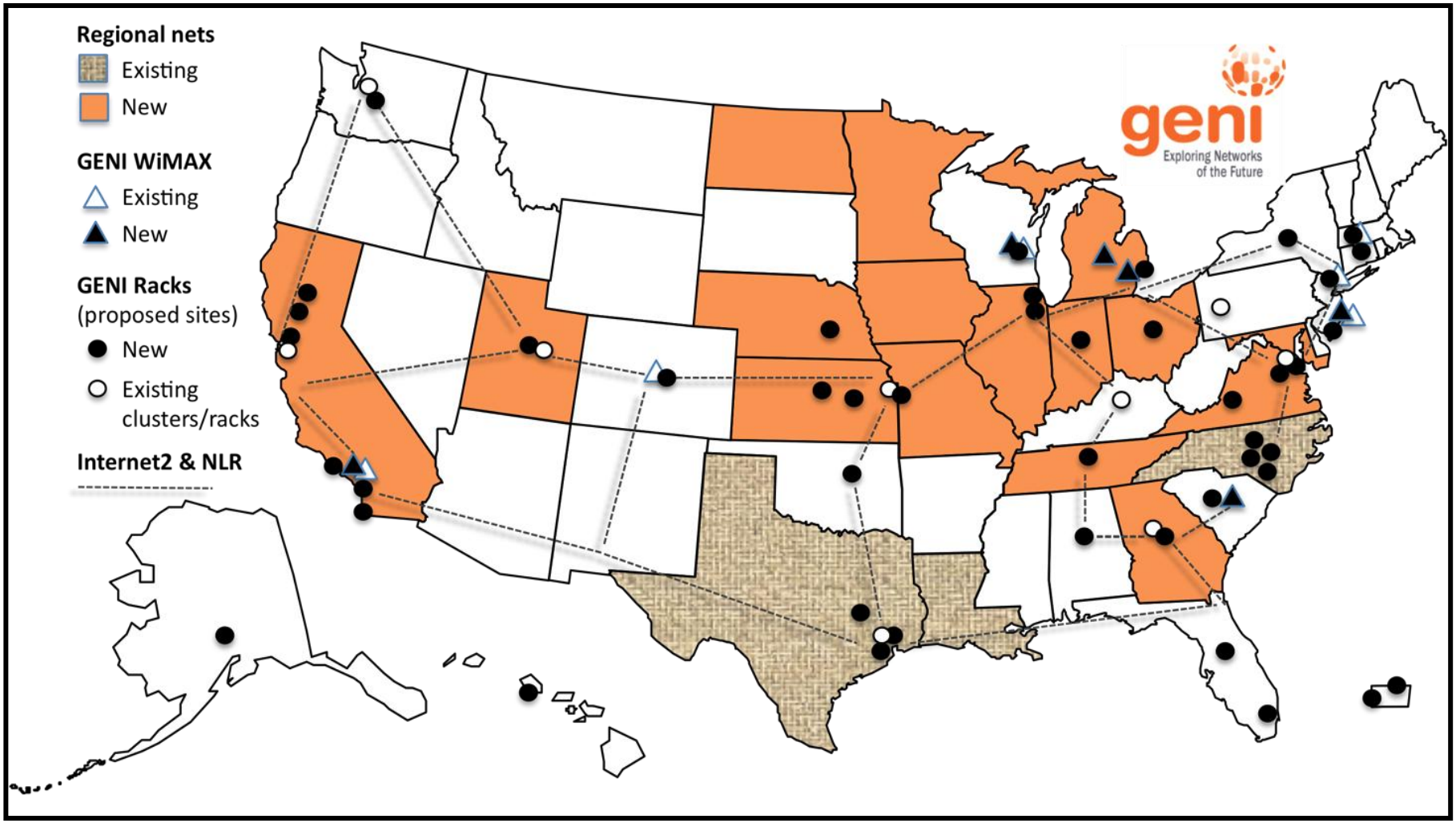
Future Internet Architecture Research



Future Internet Research and Project in US

- 1996, NSF support NGI (Next Generation Internet)
- 1999, NFS support New Arch. Project (Dave Clark)
- 2005, NFS support FIND and GENI
  - Clear State and redesign Internet
- From FIND to FIA
  - NDN(Named Data Networking)
  - XIA(eXpressive Internet Architecture)
  - Mobility First
  - Nebula
- GENI and SDN

SDN used for GENI



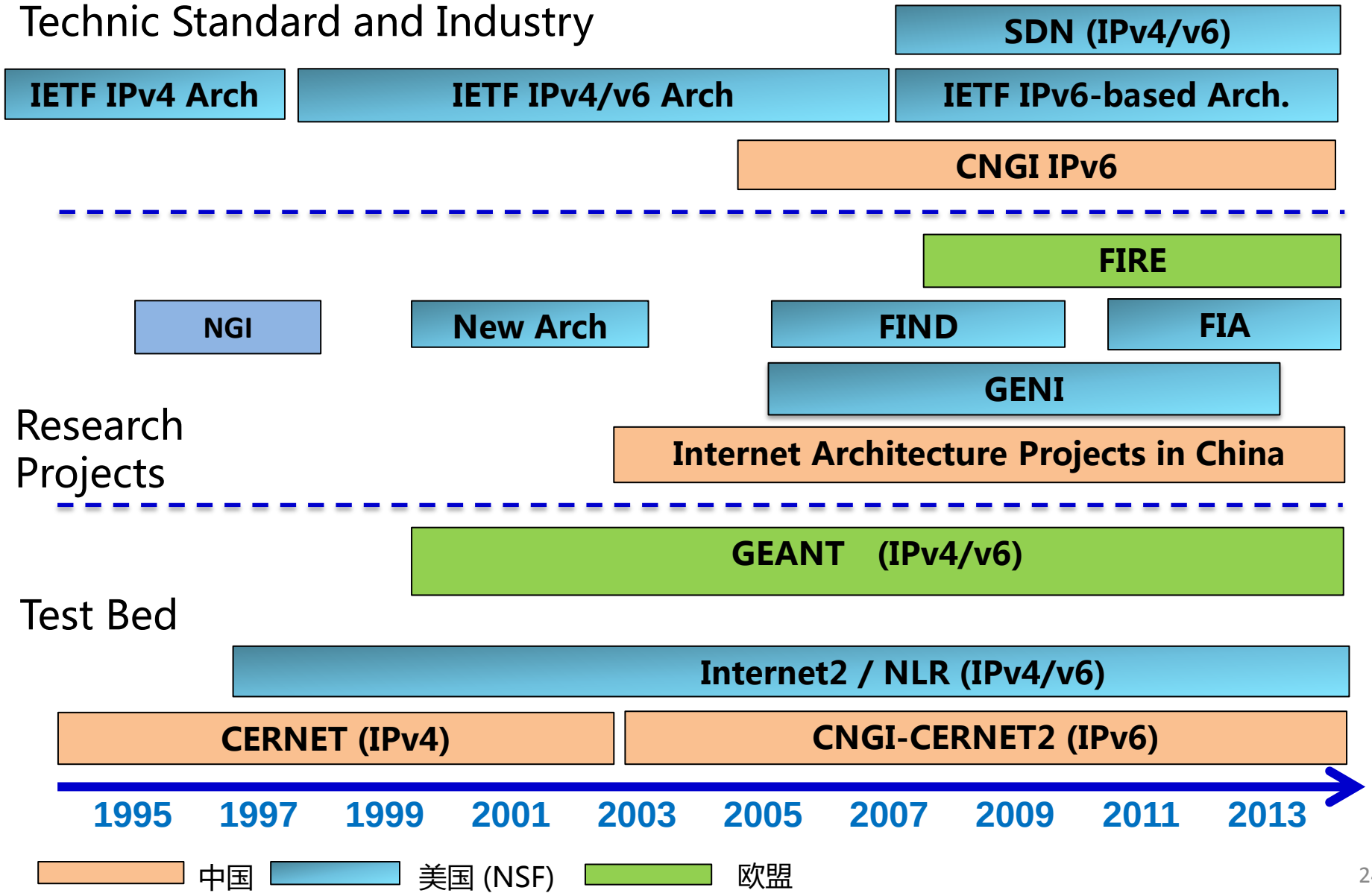
Special Challenges from China

- Same with all challenges from current Internet
- Penetration Rates: from 30% to 70% in the future 10 years (900+ Millions users)
  - IP addresses: only IPv6
  - New challenges from design, management and operation of the largest infrastructure in the world
  - Innovation capability in Internet development
  - Governance, administration and management
  - Money?
  - Technologies?
  - Public Services?

NGI and FI Development in China

- NSFC
  - Basic Research Plan on Future Internet
- MOST-973
  - Research Plan on Future Internet Architecture
- MOST-863: Next Generation Internet
  - 3Tnet，Broadband Network
  - NGI，NGN and NGB
- CNGI Project:
  - First phase：5B+ RMB

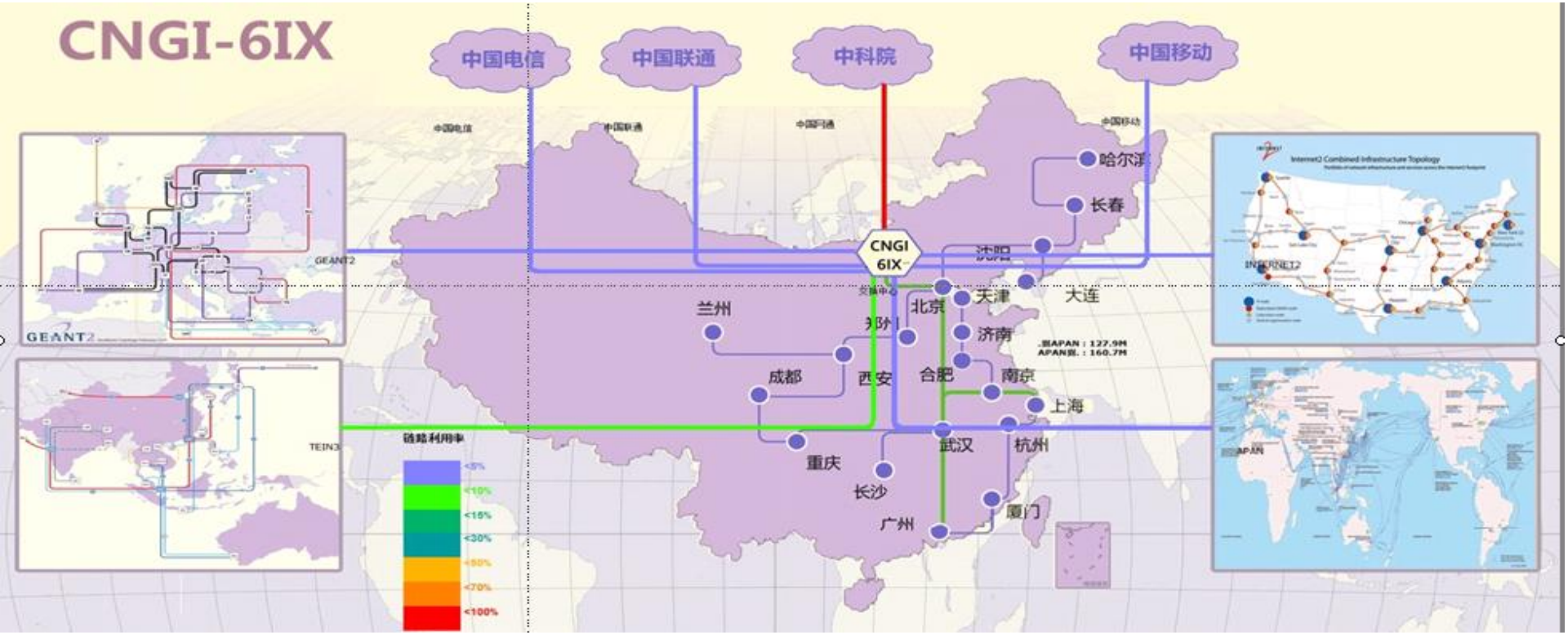
Future Internet Architecture Research



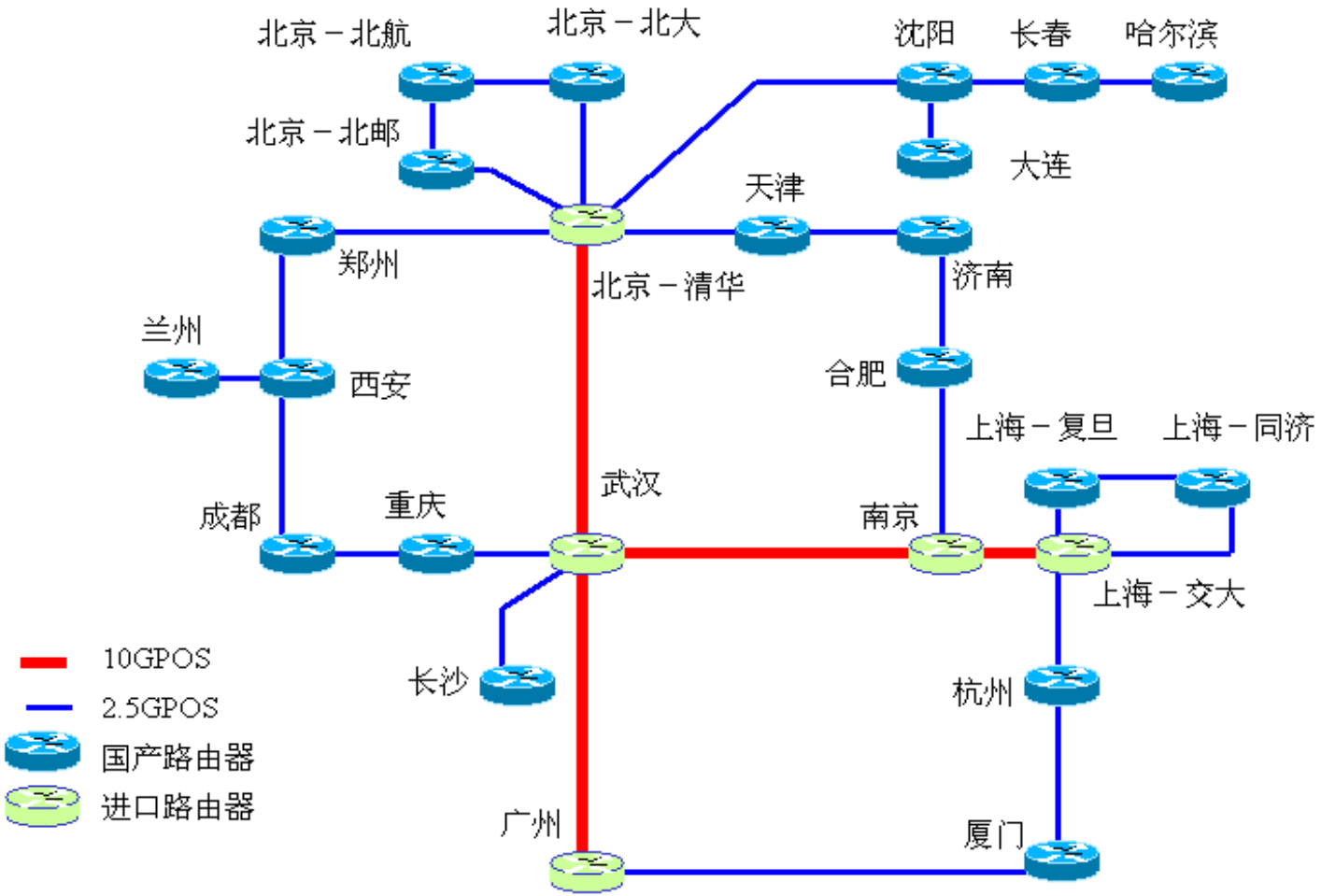
CNGI Project

- Leaded by National Reform and Development Committee
- Joint with MST, MOE, CAS, MII, NSFC, CAE, …
- First phase：2003-2008
- Main contents
  - CNGI Backbone: nation wide, 30-40 Giga POPs and 300 campus networks, international links
  - Network technology and applications
  - Delivery to information industry
- All NSPs have jointed this project
  - CERNET, China Telcom，UniCom and China Mobile

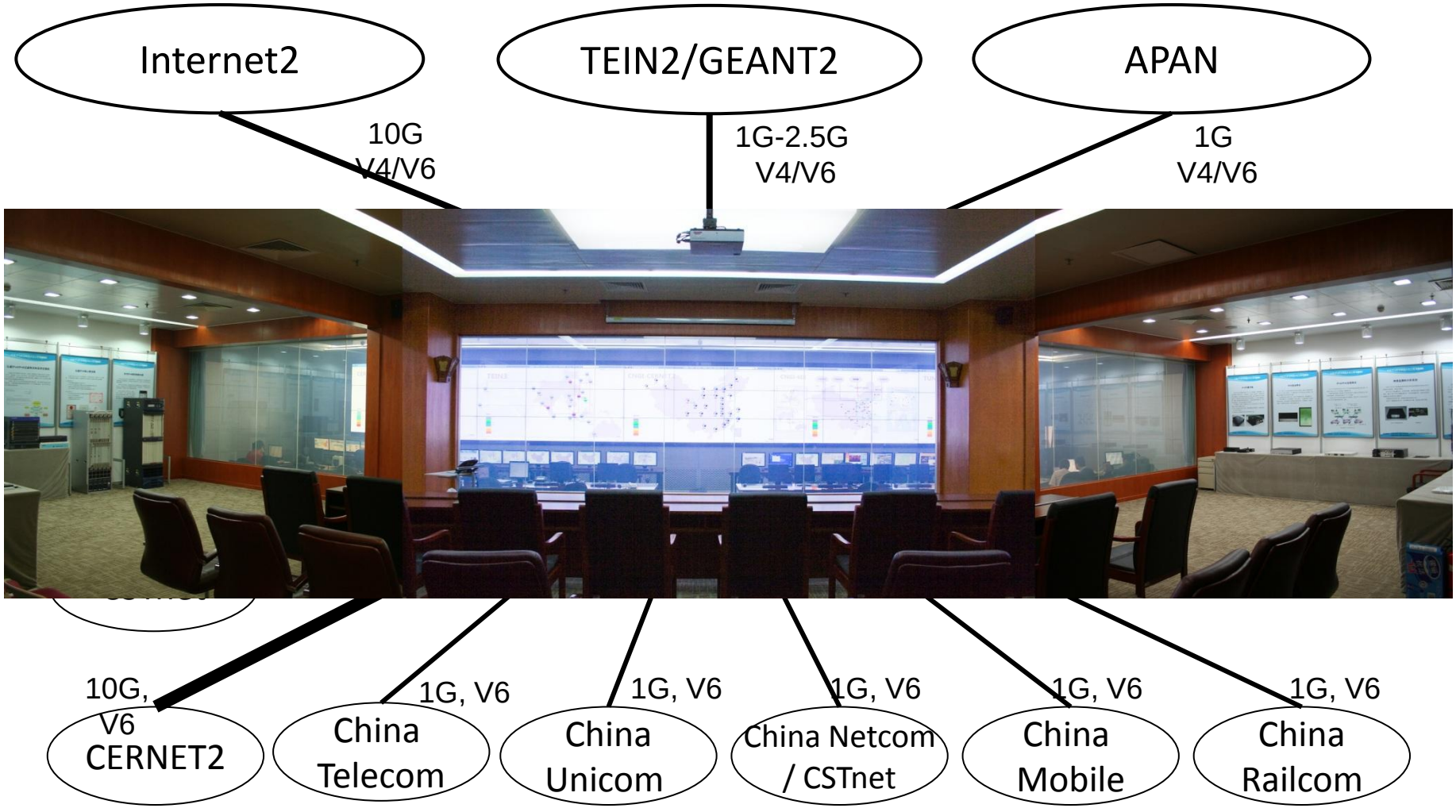
CNGI Network and Connectivity



CNGI—CERNET2 Backbone



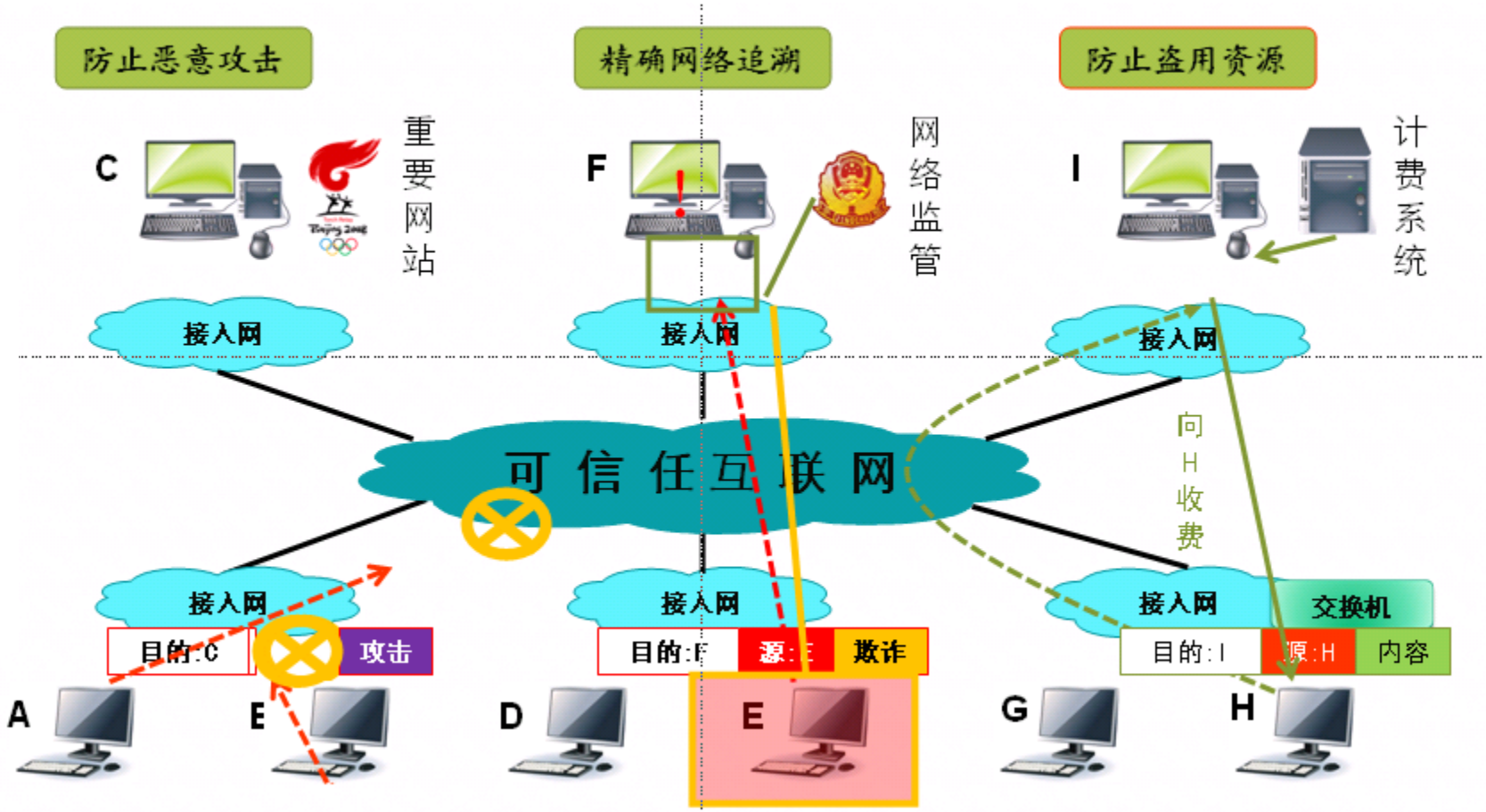
CNGI—6IX in Tsinghua University



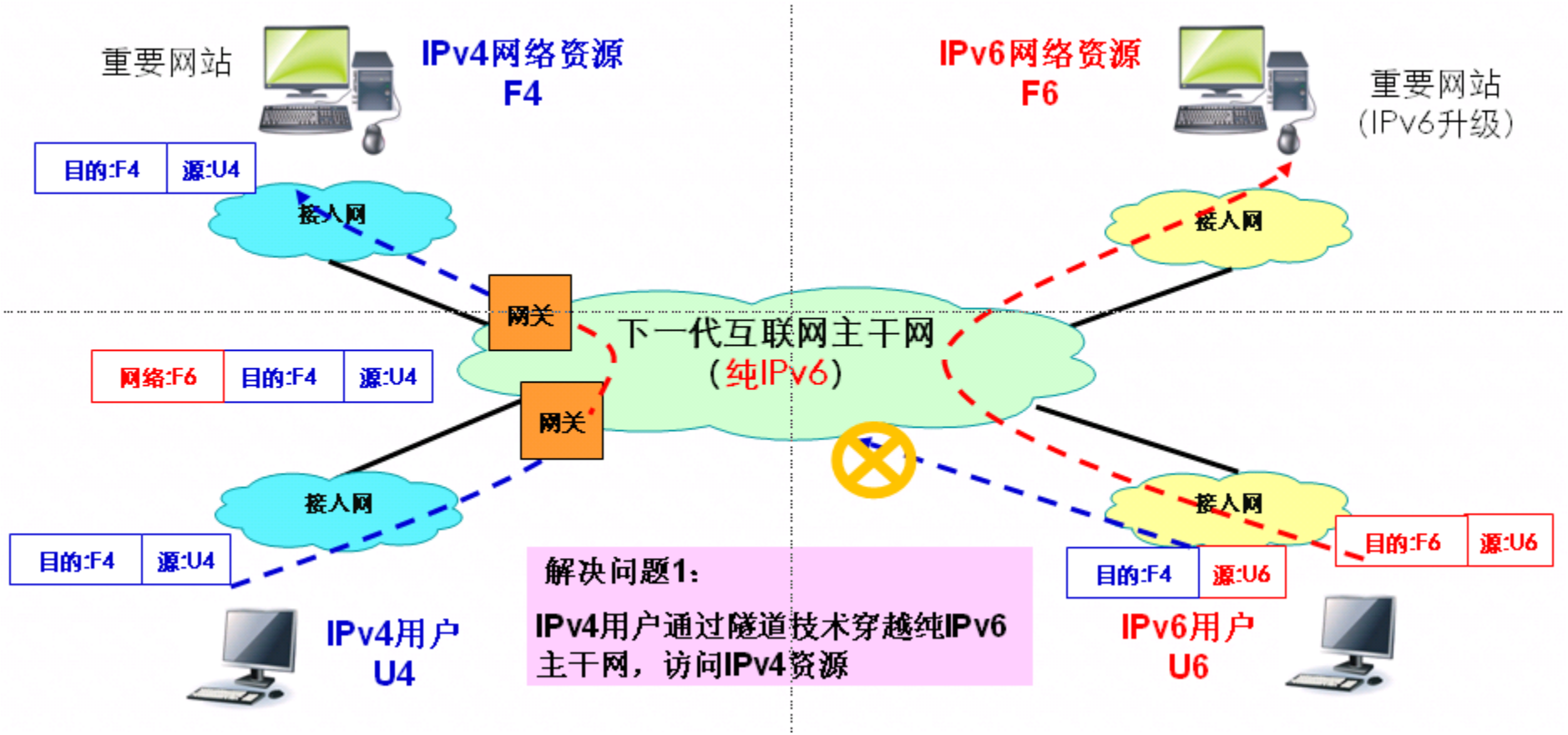
Some Experiences from China

- Native IPv6 Network: the largest one in the world
  - Large scale IPv6 addressing and routing
- Authentic IPv6 Addressing Architecture
  - SAVA: Source Address Validation Architecture
  - SAVI: a new IETF working group in 2008
  - RFC 5210，RFC 7039
- Transition from IPv4 to IPv6：4over6
  - IPv4 over IPv6: Softwire-a new IETF working group in 2006
  - RFC 4925，RFC 5565，RFC 5747，RFC 7040
- Transition from IPv4 to IPv6：IVI
  - IVI：RFC6052，RFC6144， RFC6145，RFC6219

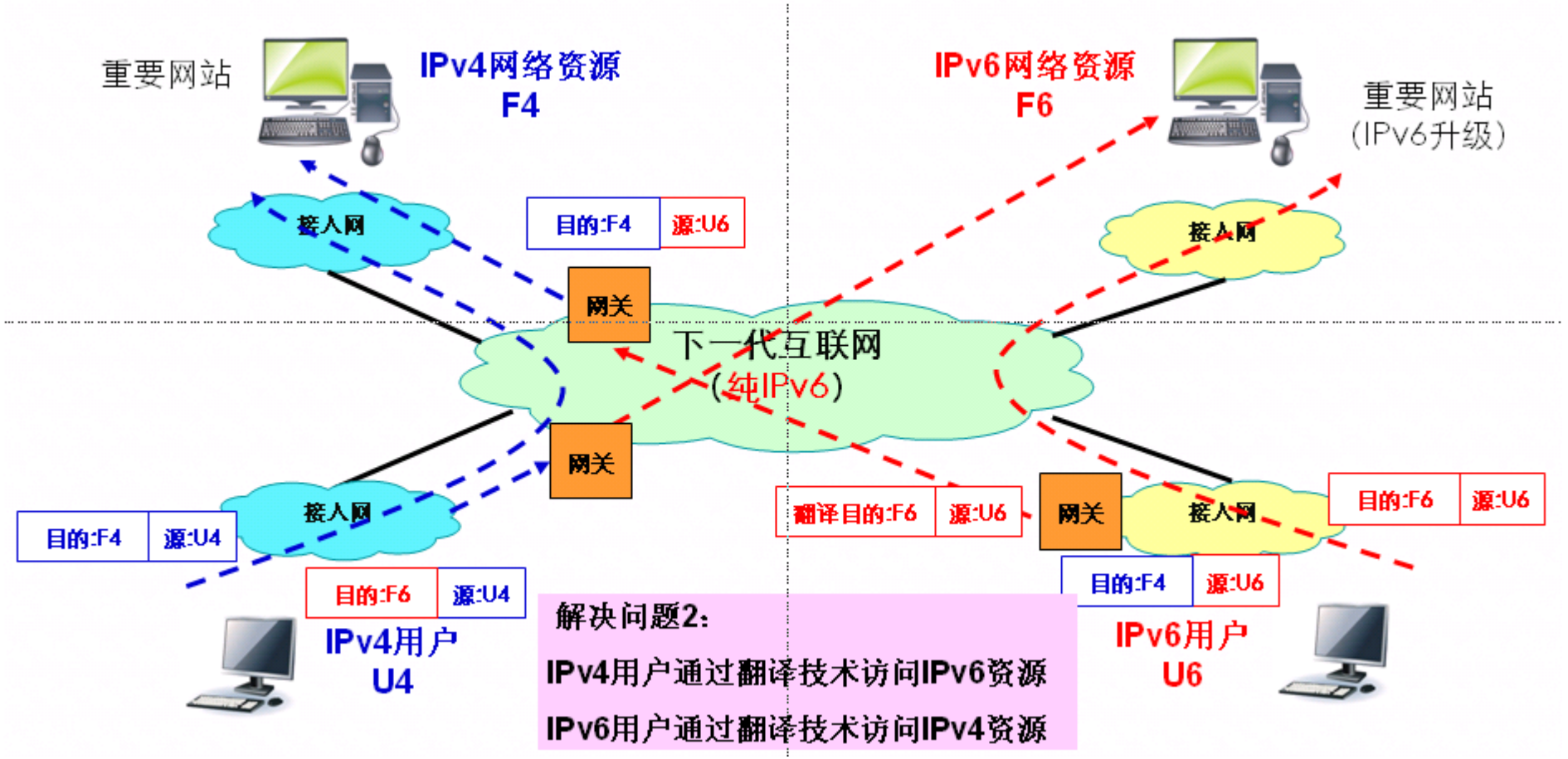
SAVA: Source Address Validation Architecture



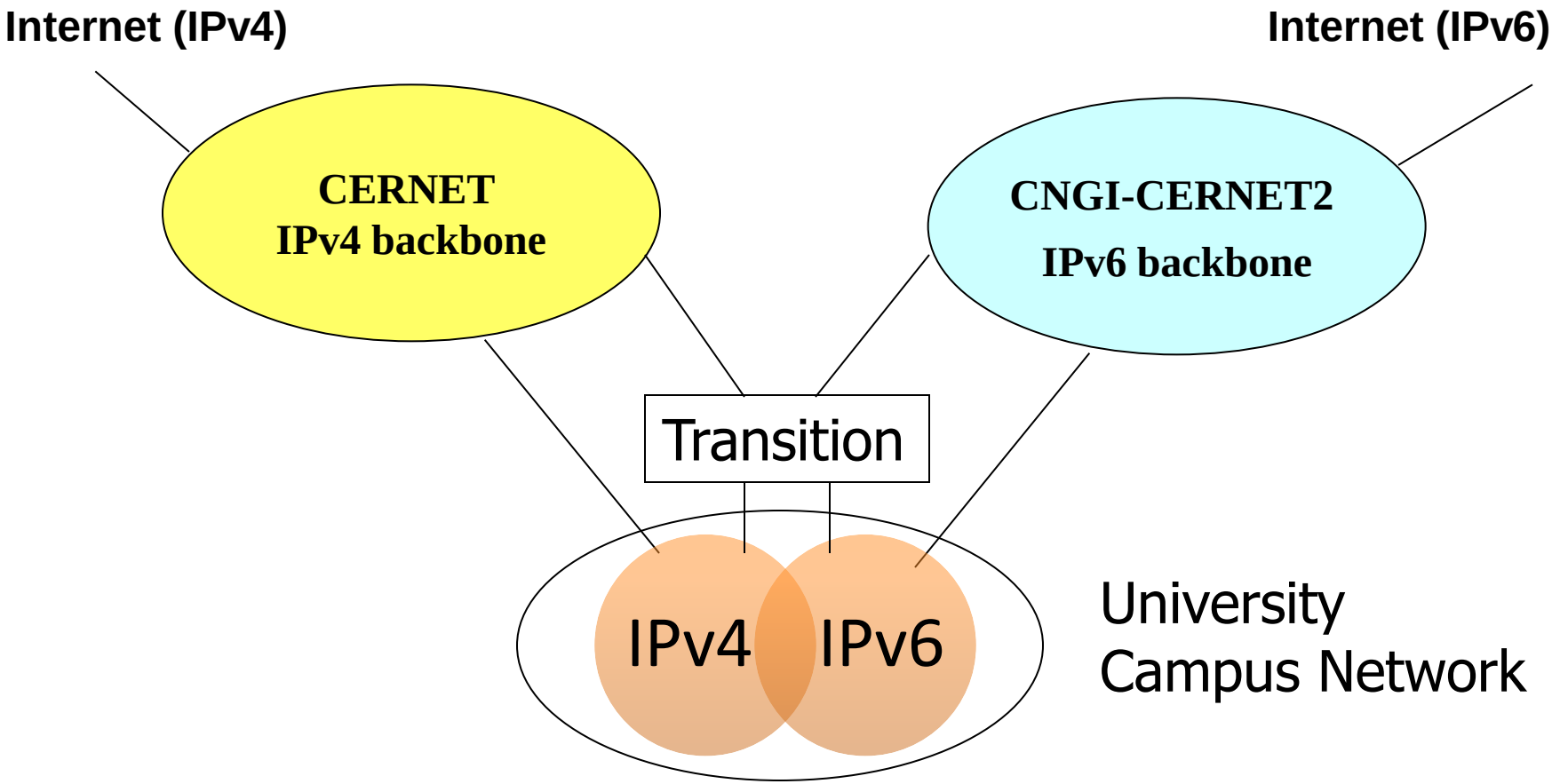
Transition: IPv4 Over IPv6



Transition： IVI



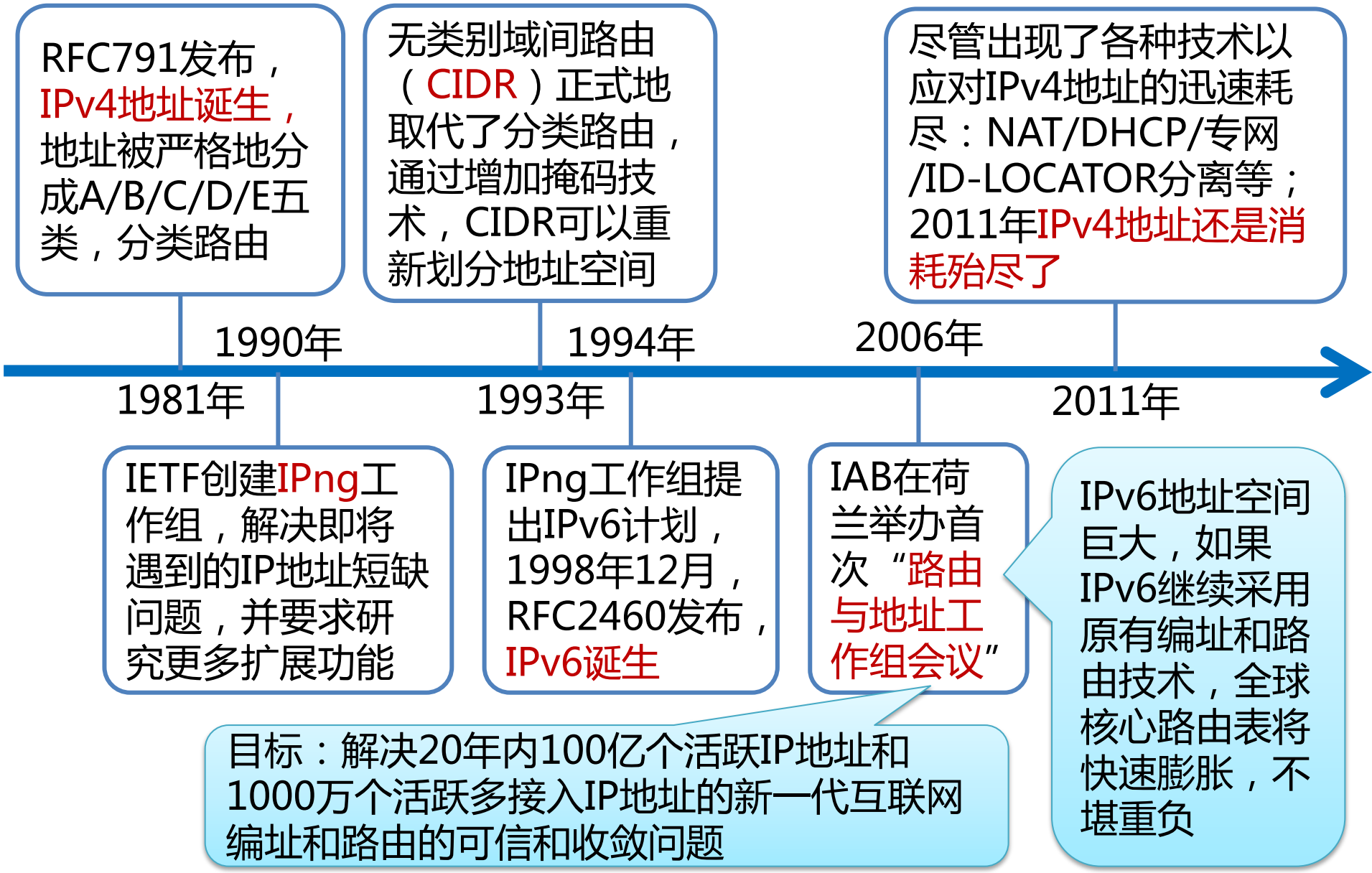
Coexistence and Transition



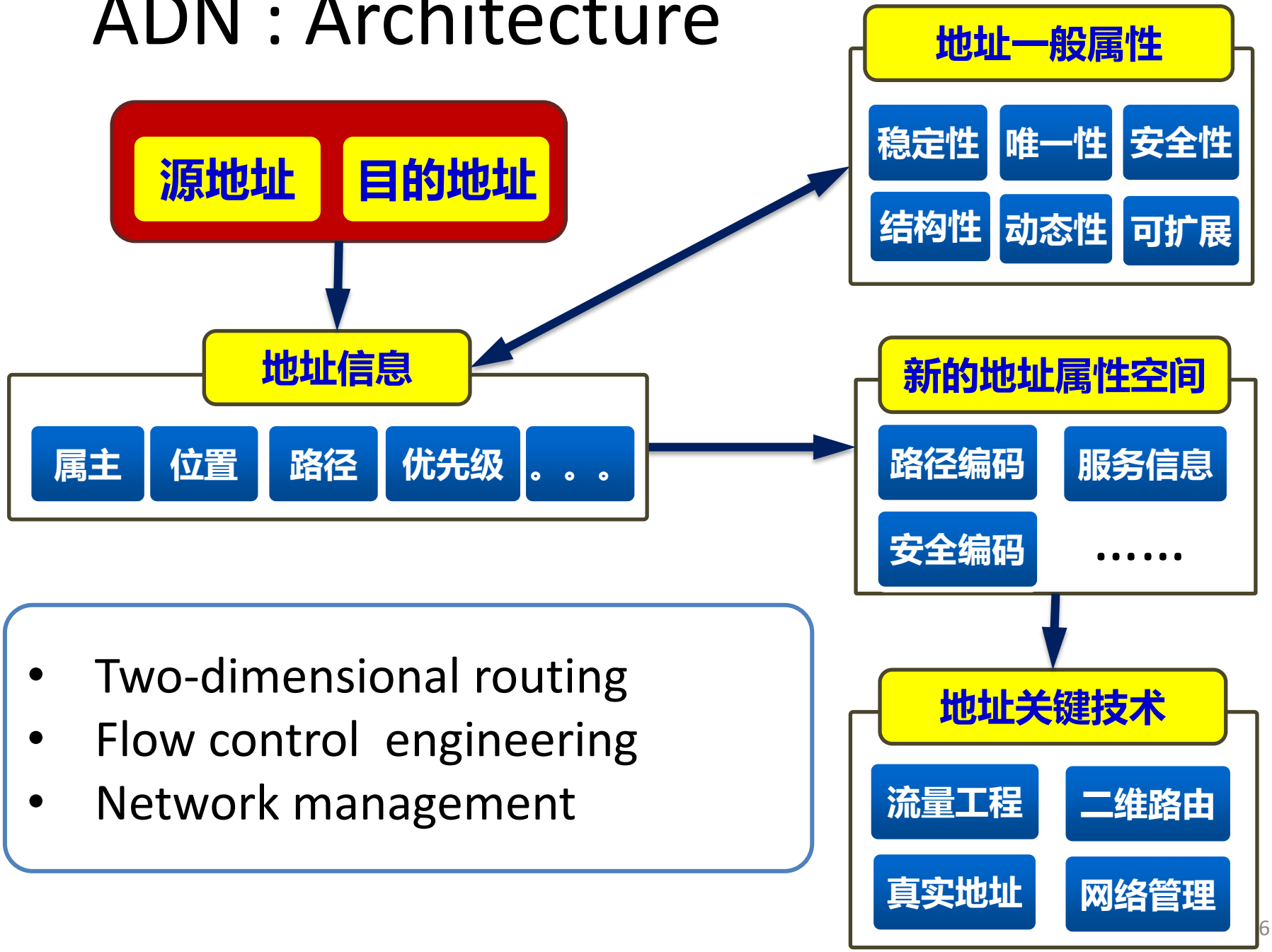
Address Driven Network (ADN)

- Address is the core element in Internet architecture
  - Format/Forwarding/Routing use IP address
- Current Internet only use destination IP address for routing, but never use source IP address
- ADN： Address Driven Network
  - Use both destination and source IP address
  - Two dimensional routing
  - Network security control
  - Network measurement
  - Network management
  - ……

Role of IP Address on Internet History



ADN : Architecture

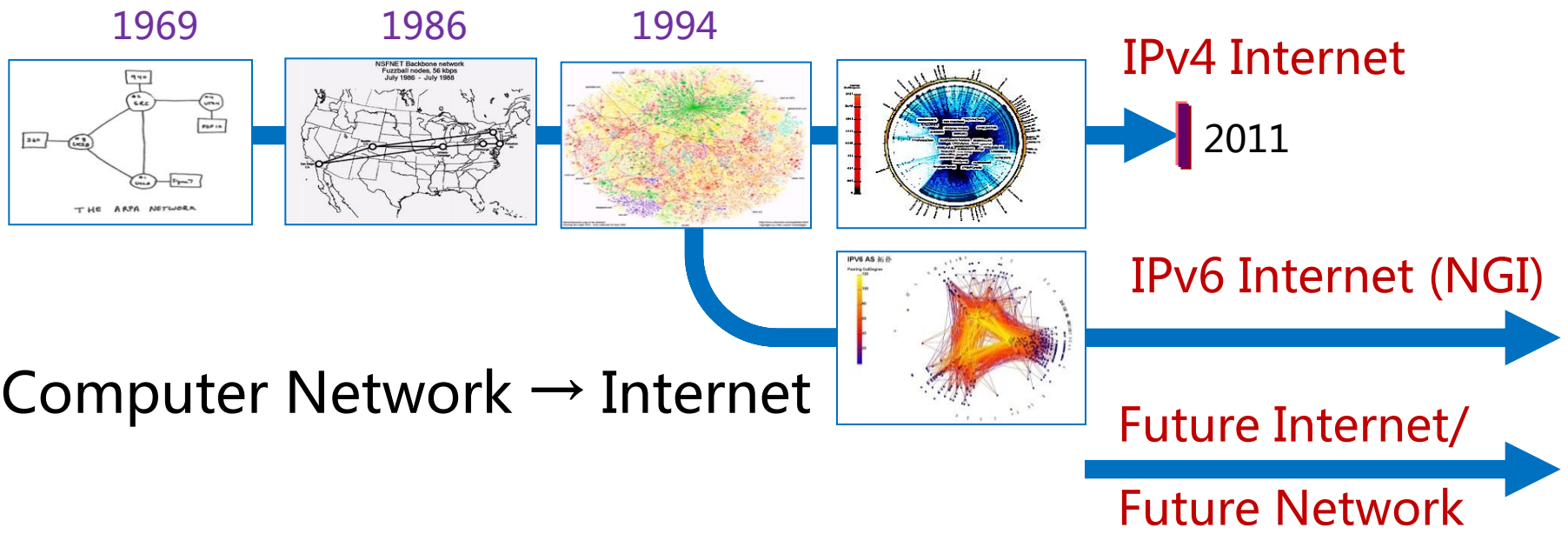


- Two-dimensional routing
- Flow control engineering
- Network management

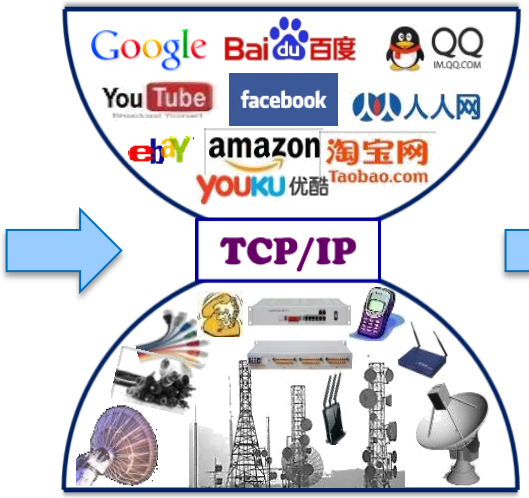
Challenges and Opportunities

- Meet Special Challenges from China Internet Development
  - Another 500M Internet Users in the next 10 years
  - IPv6 based Technologies and Services
- Meet Challenges from the current Internet to Cyberspace
  - Global Infrastructure in the world
  - Innovation from Technology and Application
  - IT Public Services using FI
- Collaboration Opportunity
  - Globally

Evolution and/or Revolution



Scalability
Security
High Performance
Mobility
Real Time
Management



Routing

NGI and Future Internet

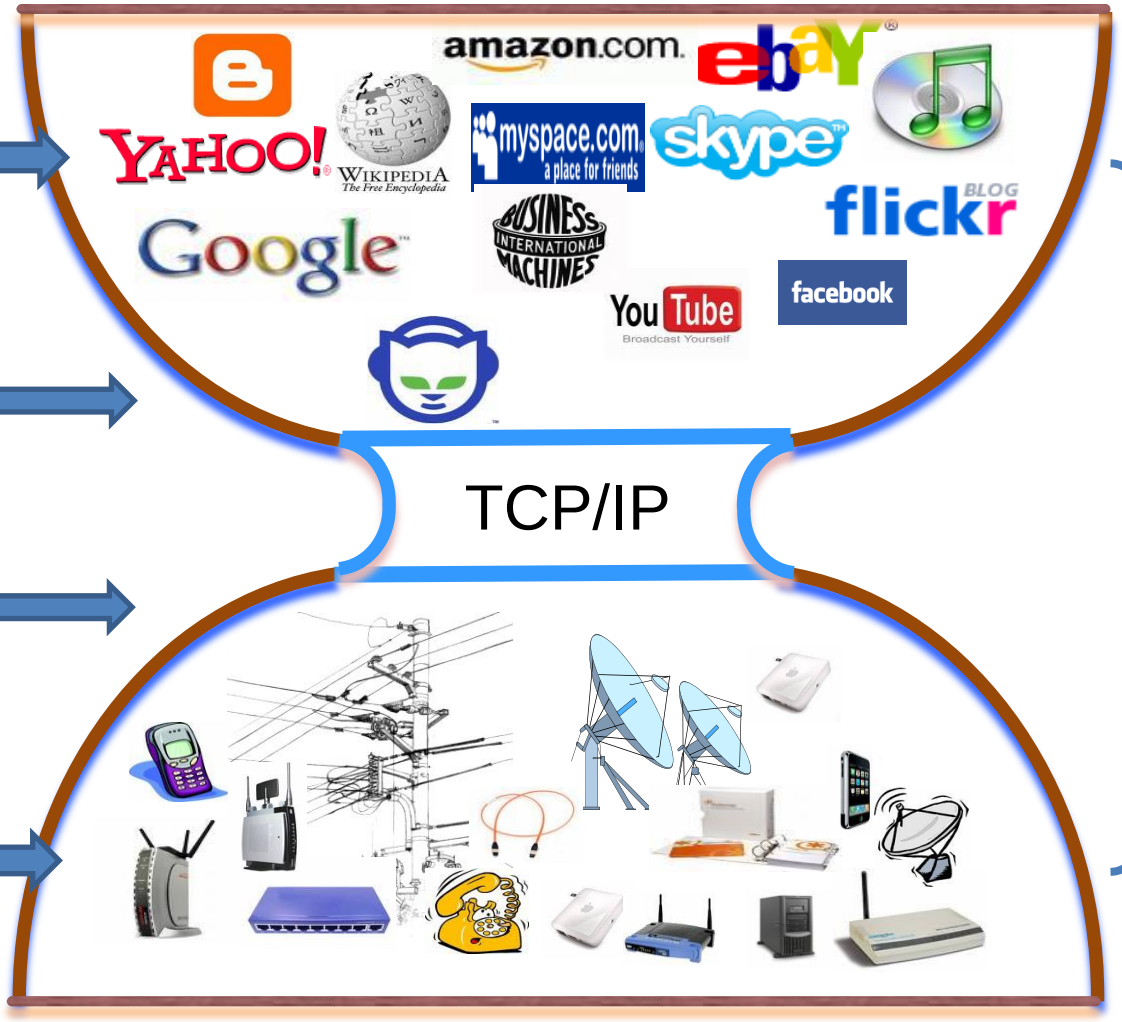
- Evolution： NGI or Future Internet
  - IPv4
    - NAT
  - IPv4/IPv6： Internet2, Geant2, TEIN3
    - Less use IPv6
  - IPv6： CNGI-CERNET2
    - Native IPv6: a new platform for Internet evolution
- Revolution： Future Internet
  - GENI and FIND: Clean Slate
  - EU FIRE
  - May or may not be Internet DNA

Internet and Some New Technologies

Cloud Computing
Apple Store
……

Internet of Things
……

3G，4G，5G
WiFi，LTE
Mobil Internet
CPS



Cyber Space

Conclusion

- Internet architecture is a very important part of Internet technology
- Network layer is the core of Internet architecture
- Under relatively stable format and forwarding, routing will be a very important platform for evolution and innovation of Internet architecture
- Future Internet (Evolution) should include IPv6 Internet （10+ years） and new IP architecture （20+ years）
- Clear state (Revolution) still should be tried in the future

Thanks !