The Future of R&E Networks and Cyber-infrastructure

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Looking Back

- Internet (aka cyber-infrastructure) started with R&E networks world wide

- Most popular Internet applications like web, Google, Facebook, etc started at universities connected to high speed R&E networks
  - Enabled by the permission free environment

- R&E networks pioneered much of the global Internet infrastructure such as Internet exchange points, caching networks, etc

- R&E networks pioneered the concept of customer owned dark fiber
  - Led to significantly lower costs for broadband and made The Netherlands world leader in consumer broadband

Impact of R&E networks & Cyber-infrastructure

- OECD: "The Internet is the most powerful infrastructure we've seen yet for the creation, exchange, and implementation of new ideas. By facilitating access to information and collaboration at previously unimaginable scale, one small idea shared online can quickly grow into a world-changing one. As a result, the Internet has become a wellspring of innovation and renewal across the economy…"

- R&E networks have enabled a trillion dollar industry, larger than transportation, construction and utilities combined
  - 13% of economic output and 6% of employment

- No other R&E infrastructure or program has such a direct and measurable impact on society and the economy

NRENs will play an even more important role looking forward

- Technologies developed at R&E networks today may have bigger impact on society then Internet had in the past
- Big Data and Clouds
- Global Collaboration
- Software defined networks
- Next generation Internet of integrated optical and wireless networks
- Green networking

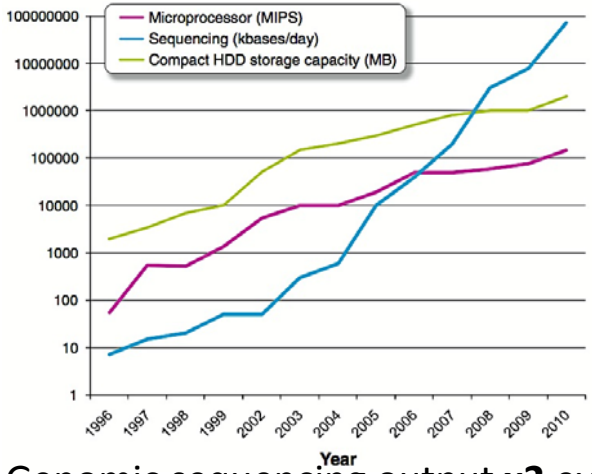
Changing R&E cyber-infrastructure environment

- Global Virtual Research Communities
- Increasing potential of commercial ICT-service providers i.e. Clouds, storage, apps
- Education: any time, any place, any device
- Citizen Science and M2M communications and sensors
- Funding models changing from direct allocations to user pays
  - networking computation can be purchased from commercial suppliers or R&E cyber-infrastructure
- Shrinking or disappearing IT department especially in small colleges

Issues and Challenges

- Campus bottleneck for big data flows
- Federated trust and Identity management
  - Campus remains main arbiter for identity management
- The “cableization” of campus networks
  - TV and content traffic much greater than research traffic
  - Netflix can be 60% of campus traffic
  - Most traffic on-off rather than within campus
- Biggest optical networks are run by clouds and content distribution networks
  - 98% of Internet content cachable
  - Google, Akamai, Facebook
  - How to interconnect to these facilities?

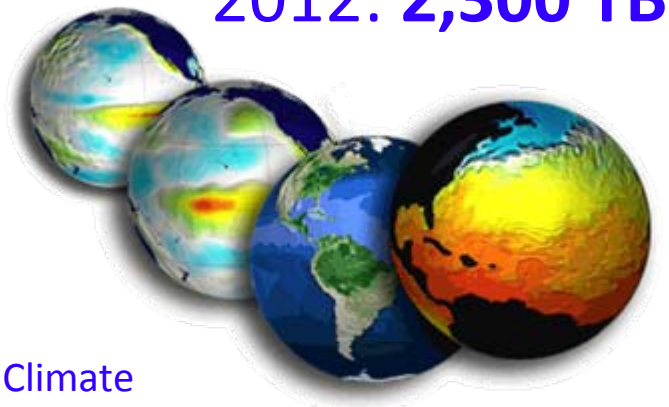
The Data Deluge



Genomic sequencing output **x2** every **9 month**

2004: 36 TB

2012: **2,300 TB**

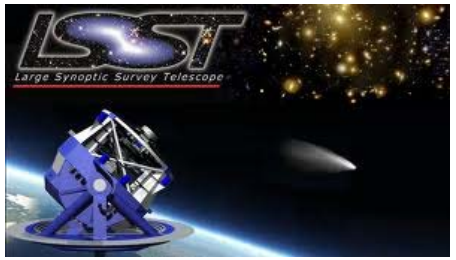


Climate model intercomparison project (CMIP) of the IPCC

1330 molec. bio databases

Nucleic Acids Research (96 in Jan 2001)

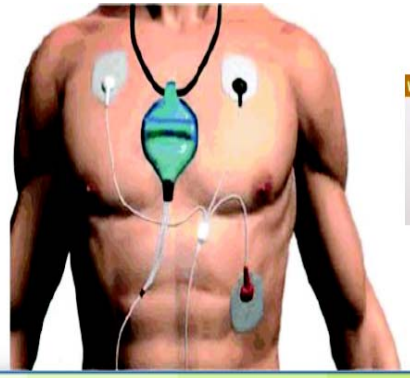
MACHO et al.: 1 TB
Palomar: 3 TB
2MASS: 10 TB
GALEX: 30 TB
Sloan: 40 TB
Pan-STARRS: 40,000 TB



Source: Ian Foster, UoChicago

Growth in sensor networks and Citizen Science

CARDIONET
Get to the Heart of the Problem.

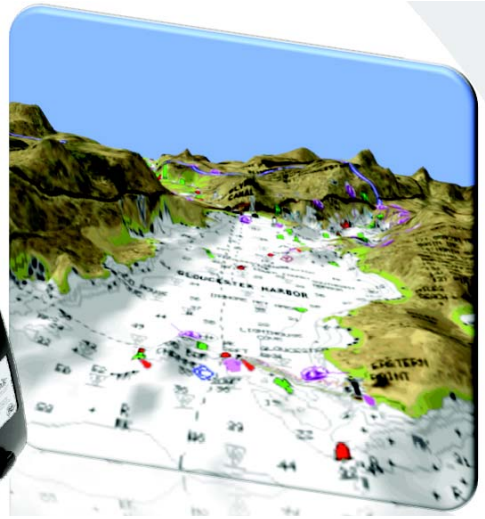


Sprint

Real Time Health Monitoring

omnilink
now you know™

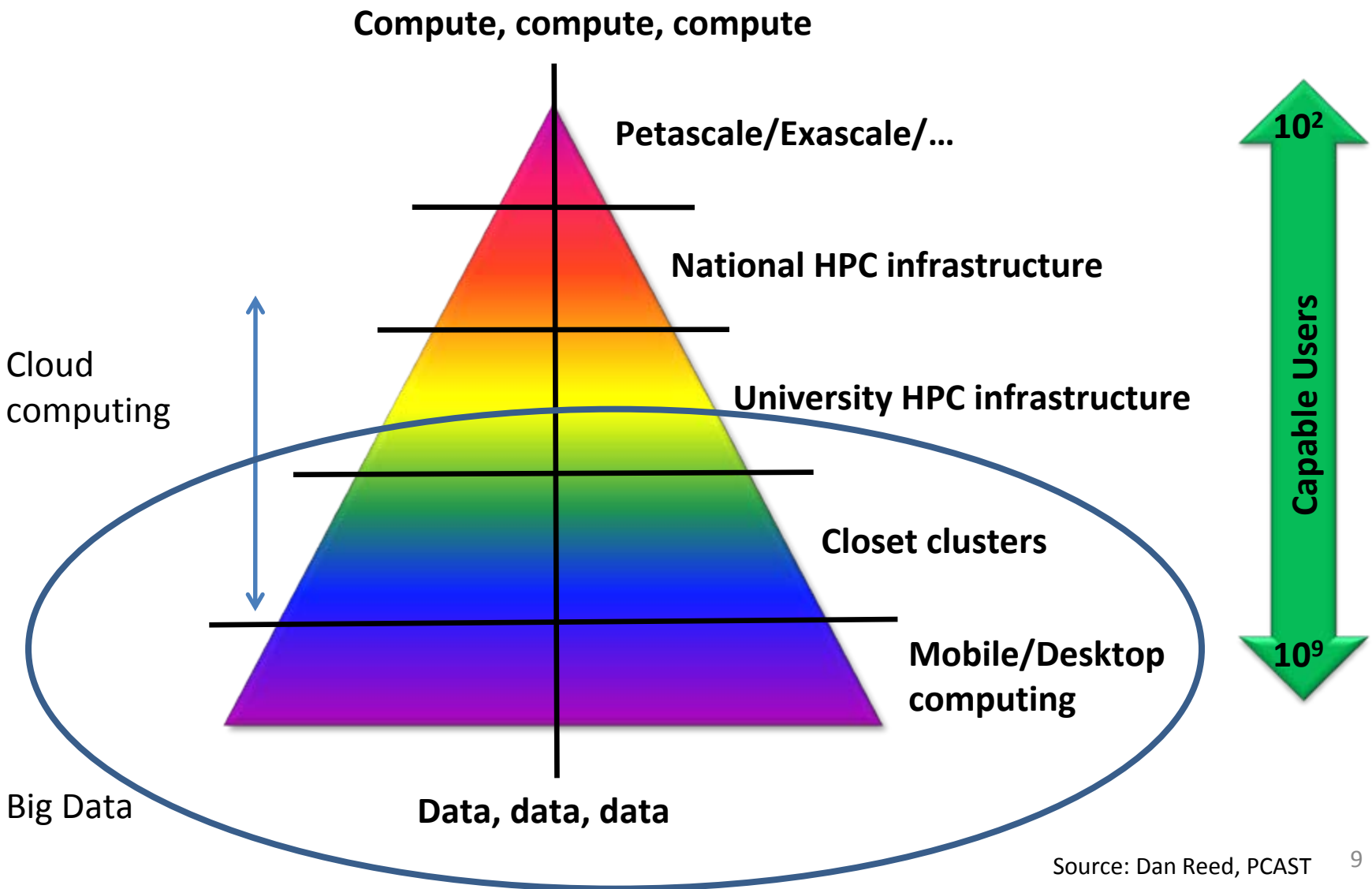
Sprint



Glacier Tracking

Smart Trash

Research Computing Pyramid



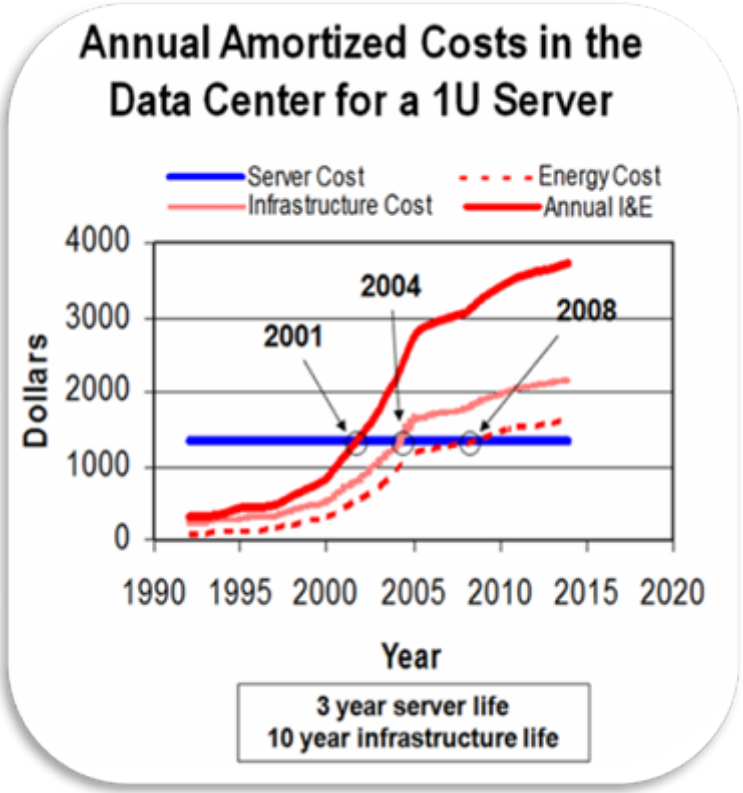
Source: Dan Reed, PCAST

Small science is struggling

More data, more complex data
Ad-hoc solutions
Inadequate software, hardware
Data plan mandates

Source: Ian Foster, UoChicago

The real cost of campus computing



- Land - 2%
- Core and shell costs – 9%
- Architectural – 7%
- Mechanical/Electrical – 82%
  - 16% increase/year since 2004

Belady, C., "In the Data Center, Power and Cooling Costs More than IT Equipment it Supports", *Electronics Cooling Magazine* (February 2007)

Source: Christian Belady

The ICT energy consumption in higher- ed

- Campus computing 20-40% electrical energy consumption on most campuses
  - Studies in UK and The Netherlands
  - http://goo.gl/k9Kib

- Campus data center alone represents 8-20% of electrical consumption
  - http://www.iisd.org/publications/pub.aspx?pno=1341

- IISD study demonstrated that moving Canadian research to cloud would pay for itself in energy savings and CO2 reduction
  - http://www.iisd.org/publications/pub.aspx?pno=1341

- Internet and ICT can reduce CO2 emissions by 15-20%
  - No other tool has this potential

We need a new nuclear plant per day to keep stabilization at 2C

To achieve stabilization at a 2°C warming, we would need to install ~900 ± 500 MW [mega-watts] of carbon emissions-free power generating capacity each day over the next 50 years. **This is roughly the equivalent of a large carbon emissions-free power plant becoming functional somewhere in the world every day.** In many scenarios, this pace accelerates after mid-century. . . even stabilization at a 4°C warming would require installation of 410 MW of carbon emissions-free energy capacity each day.

Caldeira et al. 2003

Source: Roger Pielke Jr

How fast can decarbonization occur?

- The honest answer no one knows
- Historical rates of 1-2% have occurred in developing countries – mostly by outsourcing manufacturing to China
- For short periods some countries have achieved rates > 2% e.g. France nuclear program
- US need to achieve 17% reduction while maintaining modest economic growth which requires rates of decarbonization of >5% per year
  - Need to shut down over 20 coal plants per year to meet this target

NREN Brokered Cloud for IT departments and Researchers

- Internet 2 Net +
  - Provisioning of multi vendor cloud services leveraging the Internet2 Network and InCommon Federated Authentication
  - Interoperable marketplace for services where individual institutions might procure services from a wide range of cloud services providers.

- HEFCE and JISC to Deliver Cloud-Based Services for UK Research
  - Besides providing brokered cloud services they are also providing cloud "solutions" for IT departments and researchers
  - http://www.hpcinthecloud.com/hpccloud/2011-06-27/hefce_and_jisc_to_deliver_cloud-based_services_for_uk_research.html?utm_medium=twitter&utm_source=twitterfeed

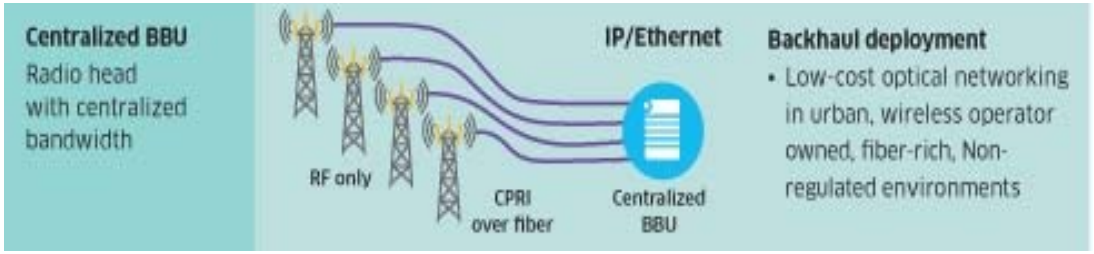
- SURFnet: Community Cloud Models and the Role of the R&E network as a broker for cloud services
  - http://www.slideshare.net/haroldteunissen/community-clouds-shared-infrastructure-as-a-service

Impact of NREN wireless networks

- The phone is a also a sensor platform

- Processing is done in real time in the cloud
  - Allowing processing that can't be done on the device
  - Big data analysis

- New campus or hot spot centric architectures integrating LTE and Wifi
  - See SURFnet pilot http://www.surfnet.nl/en/nieuws/Pages/Backgroundarticle.aspx



Three types of networks on campus

- "General purpose" IP network largely used by students and faculty for e-mail, web browsing, download videos, etc
  - IP router based
  - Often wireless WiFi
  - Consumes most of campus IT resources – security, routing, support, etc
- "eScience" network used for large data transfers, high performance computing, big instruments, etc
  - Currently eScience underutilized because of choke points on campus network that frustrates many science users
  - Most need dedicated fiber or VPN on campus to DMZ with dedicated lightpaths to major eInfrastructure facilities
- "Back office" university management computing/networking
  - Financial systems, Oracle, PeopleSoft, etc
  - Usually requires secure networks and/or VPNs
  - Many systems moving to cloud based services

Scientists are not network engineers

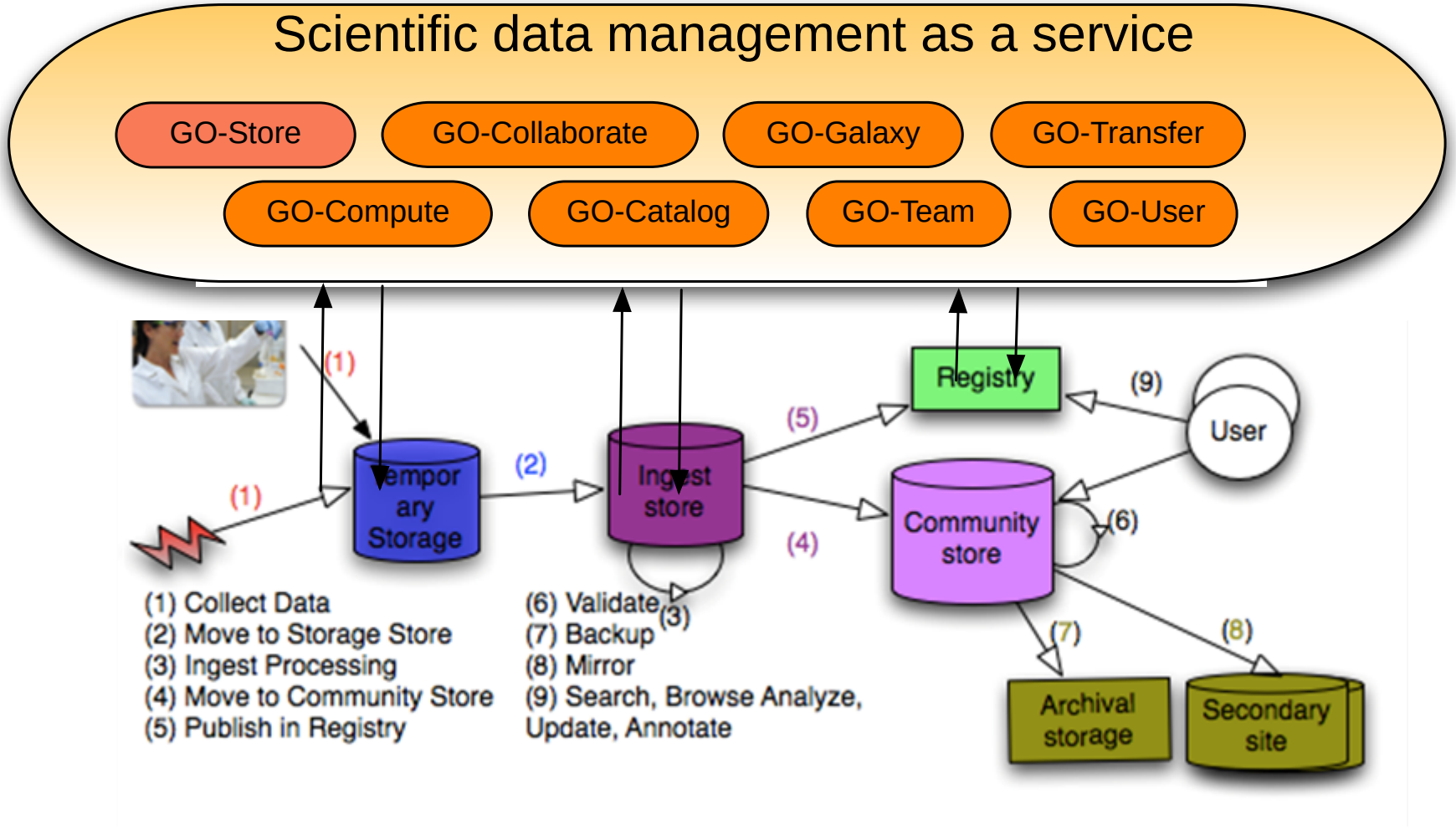
- Studies by Esnet and Internet 2 indicate a large degree of frustration by scientists with network
- Most scientists cannot do major file transfers or other data intensive work because of limitations of network on campus
  - Also tuning of servers etc
- In a few cases, such as High Energy Physics, scientists have technical resources to get around campus network problems
- To date most lightpath connections for scientists are mostly physics and astronomy
- Most campus IT staff don't have technical resources or inclination to provide special services for small number of eScience projects
  - Most campus IP networks not well suited for needs of eScience such as large file transfer

Disappearing Campus IT

- Traditionally all networked applications and services existed on campus
  - e-mail, web, HPC, authentication, etc
- Now most major applications exist off campus
  - Facebook, Twitter, Cloud apps, cloud computing
  - Grid computing, eScience, CERN, eVLBI, etc
  - Smart phones with 3G also bypass campus network
  - Collaborative tools and applications are being built outside of campus e.g. SURFconext, SURFmedia
- Globalization of universities, education and research will continue this trend of moving services off campus
  - Universities with multiple campuses
- Greatest volume of traffic is to and from outside of campus and not within
- Universities are under increasing pressure to reduce costs
  - IT represents 20%-40% energy consumption on campus

You can run a company from a coffee shop

Towards “research IT as a service”

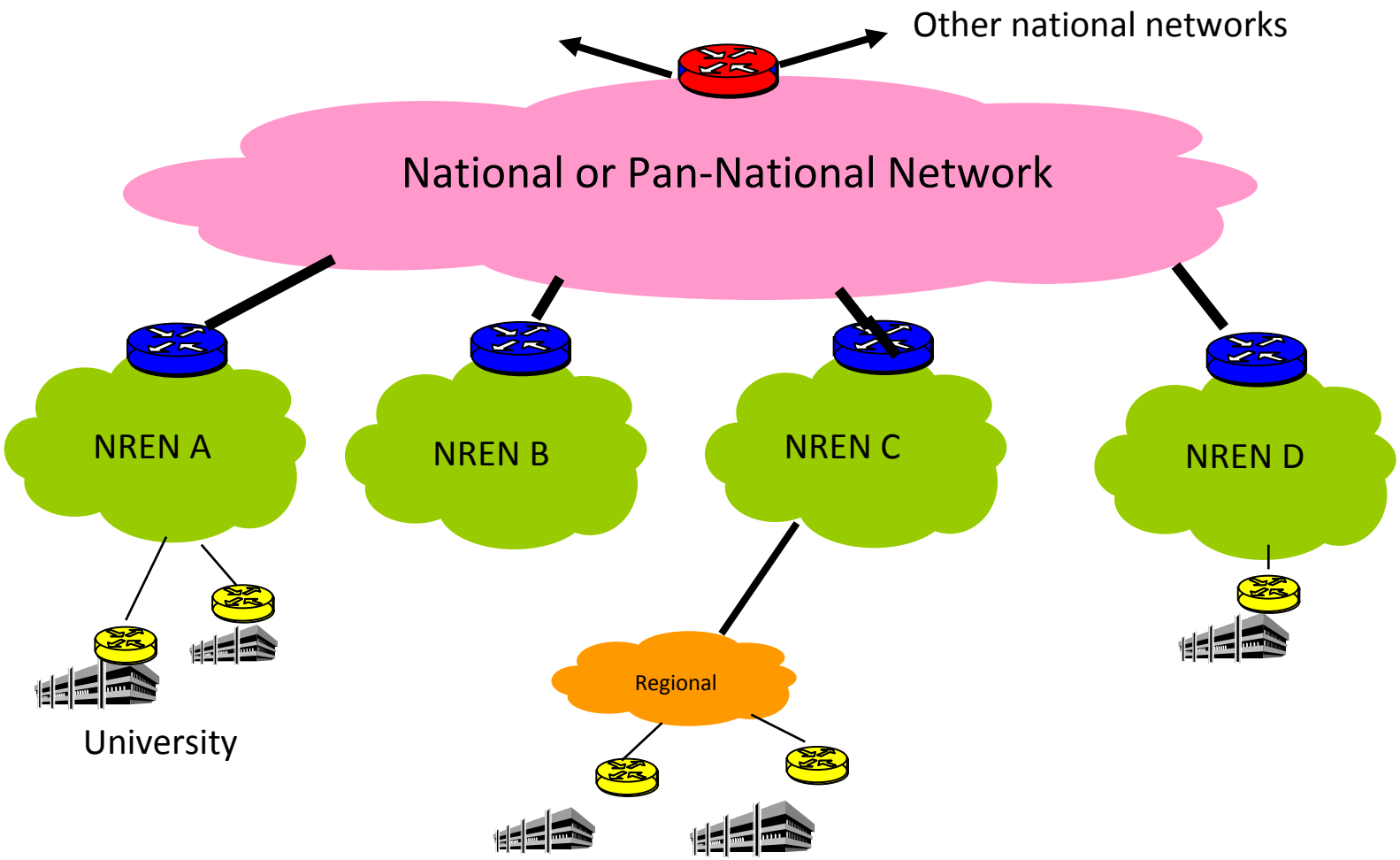


Source: Ian Foster, UoChicago

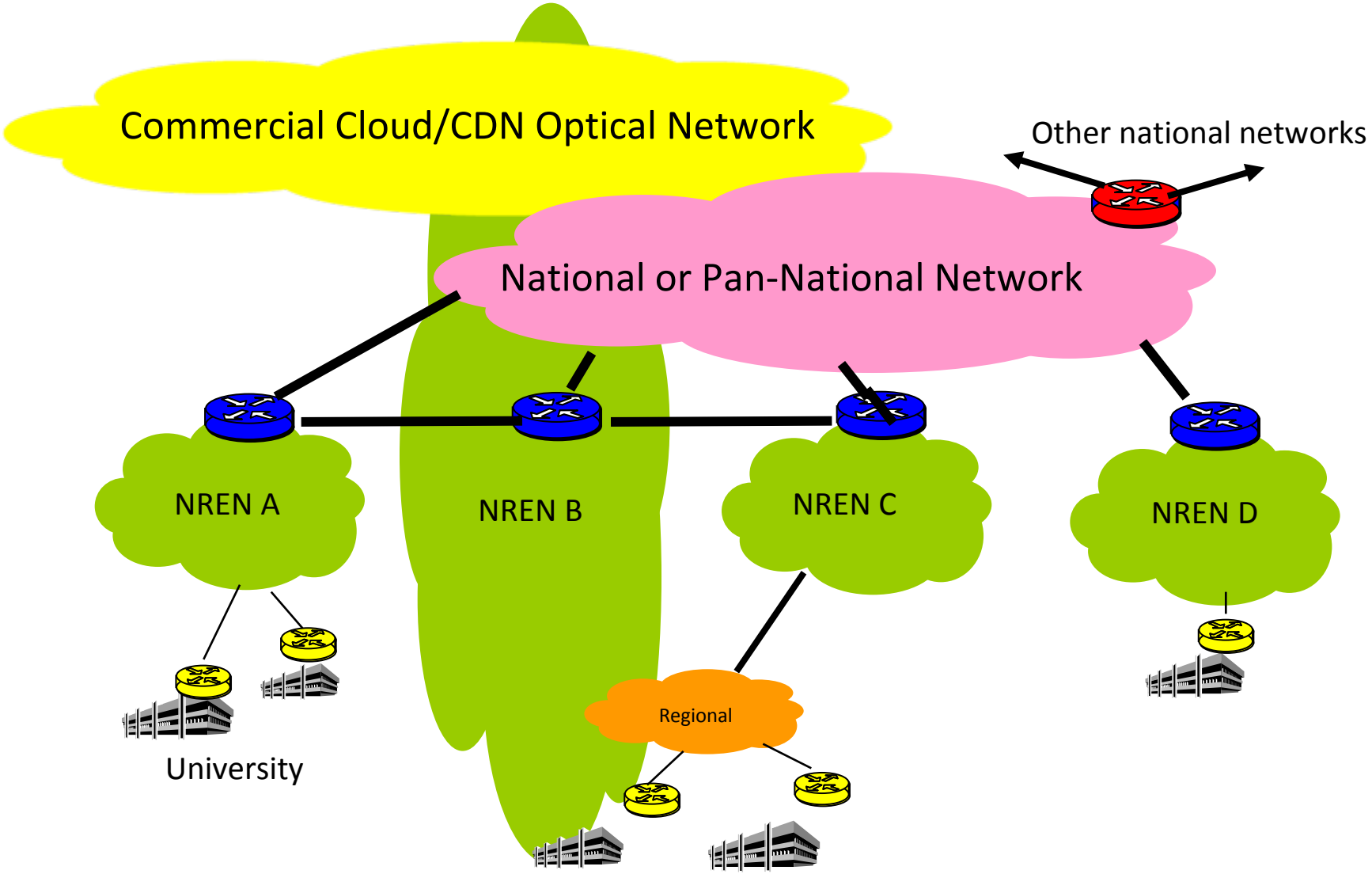
Extending science and education to the community

- Community anchor Internet Exchange Points help clear the bottleneck of content peering
  - Co-hosting of CDN caching boxes
  - Managed by NREN
  - Examples include KAREN (New Zealand), BCnet and UNINETT (Norway)
- Minimize tromboning of R&E traffic to homes and schools
- Can support extension of Eduroam to community WiFi spots and/or community last mile networks – see Sunet TheCloud announcement
- Allows for M2M traffic and anywhere, anytime traffic to propagate through the community

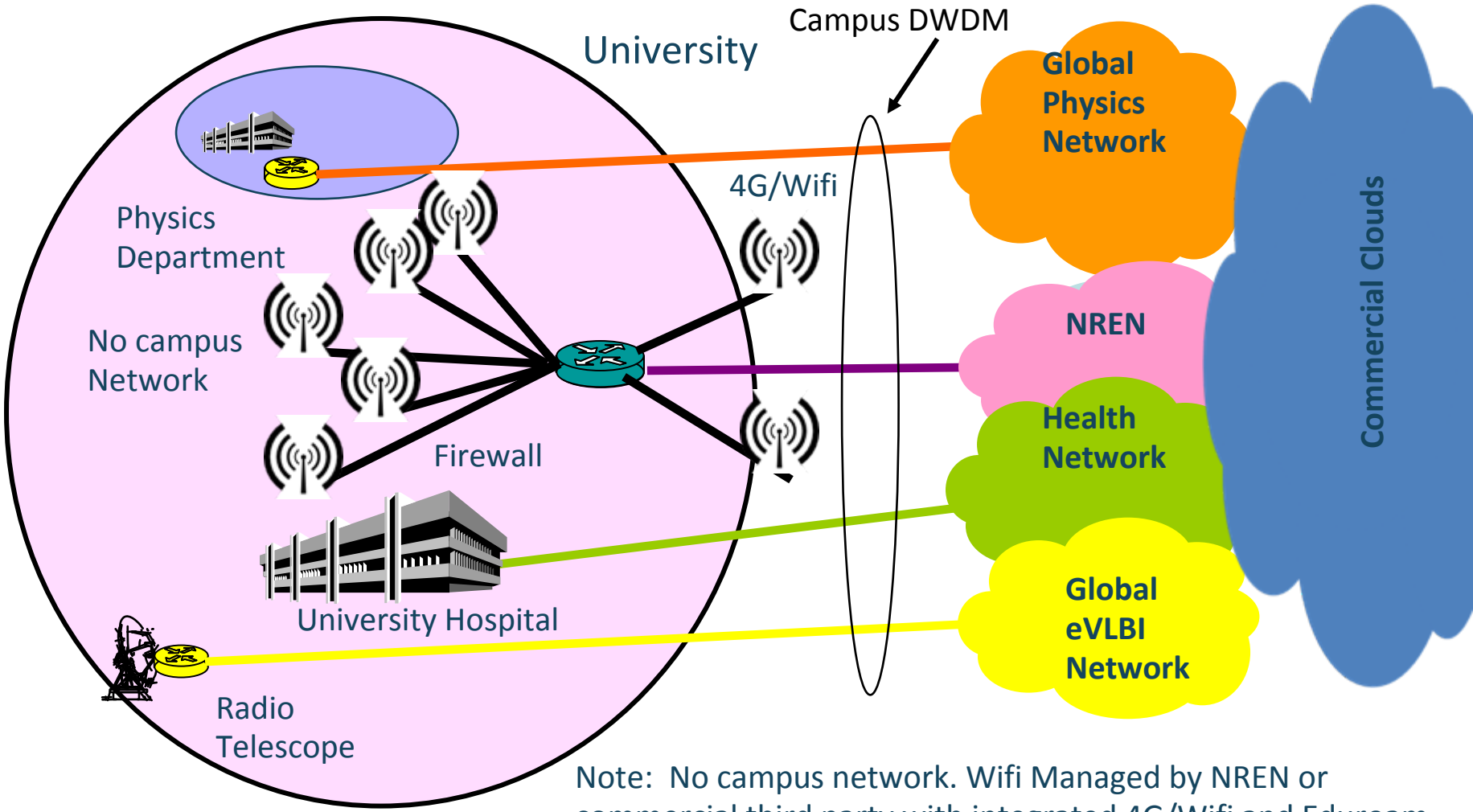
Today's hierarchical network



Future Federated network



Campus view



Note: No campus network. Wifi Managed by NREN or commercial third party with integrated 4G/Wifi and Eduroam

Let’s Keep The Conversation Going

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