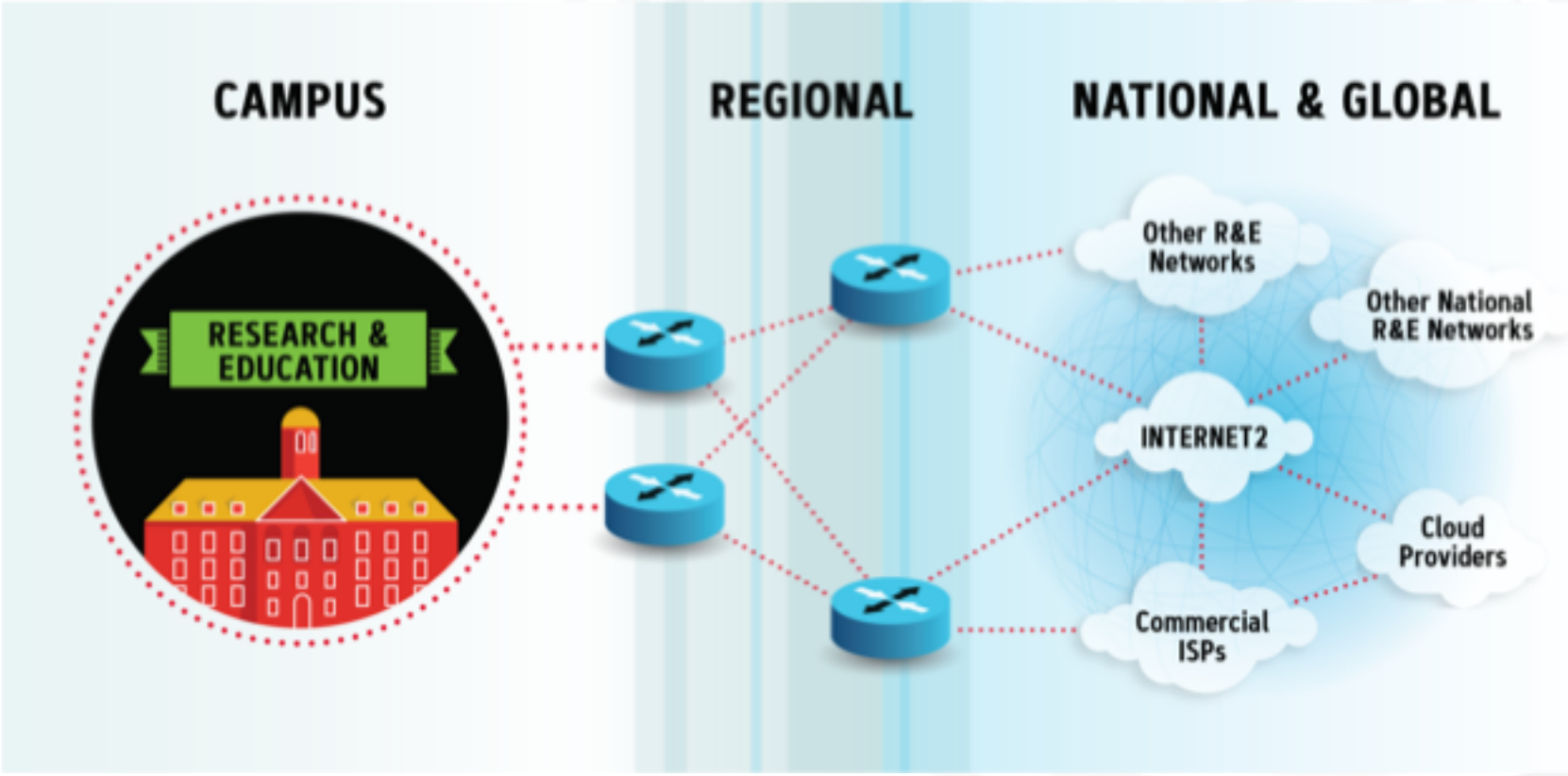
Internet2 Ecosystem Infrastructure Planning aka Planning for next generation big data transfers

Transition from discussion to active planning and major objectives for 2018/19

PRESENTED BY: Rob Vietzke, Internet2 Network Services

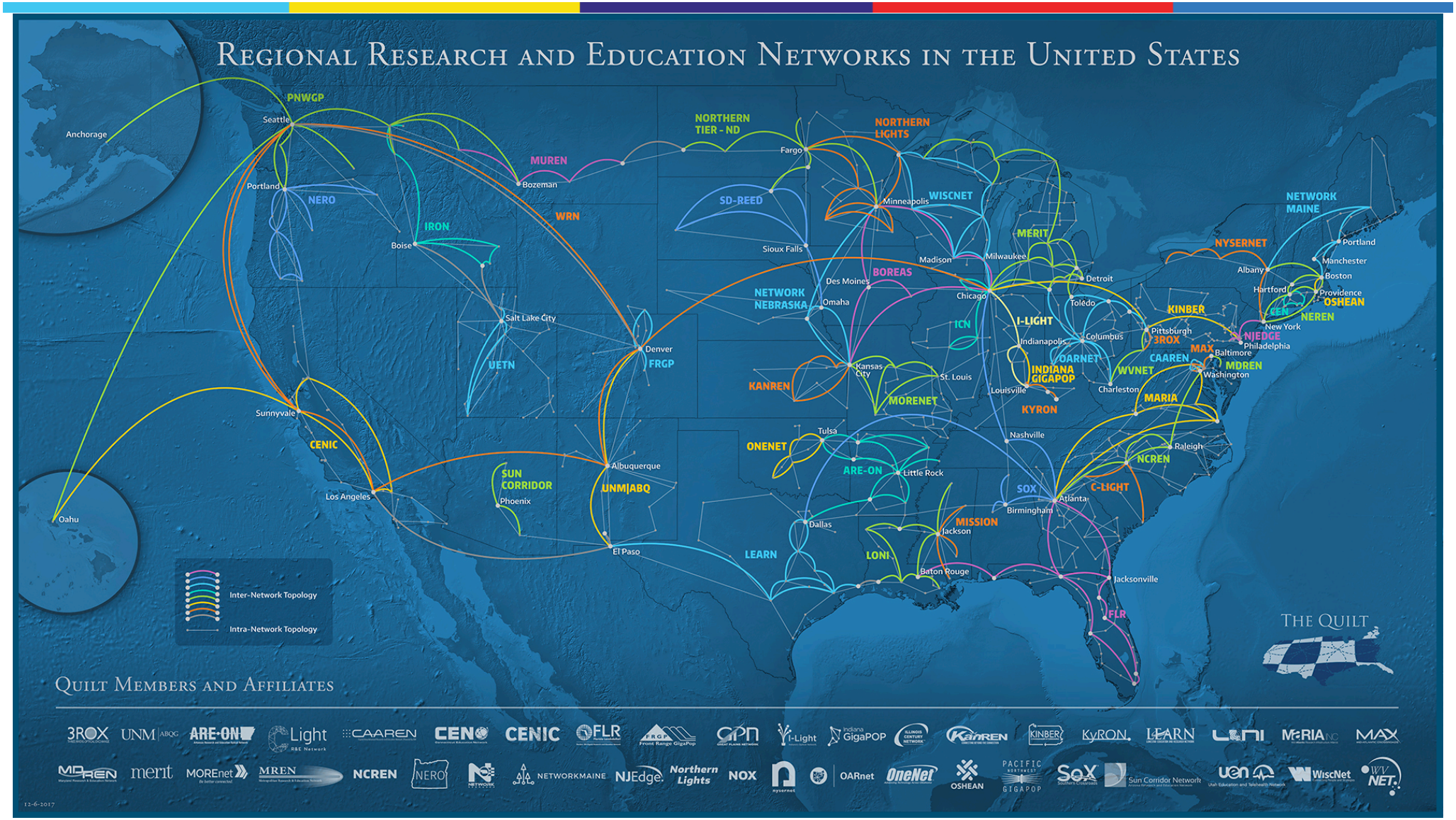
ADVANCED NETWORKS

Research and Education Network Ecosystem



ADVANCED NETWORKS

100G Nationwide Network: secure, stable and trusted network for R&E


Regional Research and Education Networks in the United States
PNWGP
Seattle
Anchorage
Portland
NERO
IRON
Boise
MUREN
Bozeman
WRN
NORTHERN TIER - ND
Fargo
NORTHERN LIGHTS
SD-REED
Sioux Falls
Minneapolis
WISCNET
MERIT
Madison
Milwaukee
BOREAS
Des Moines
NETWORK NEBRASKA
Omaha
Chicago
Detroit
Toledo
ICN
I-LIGHT
Indianapolis
Columbus
KANREN
Kansas City
St. Louis
MORENET
INDIANA GIGAPOP
Louisville
KYRON
DARNET
WVNET
Charleston
KINBER
Pittsburgh
3ROX
CAAREN
MAX
Baltimore
Washington
MDREN
MARIA
NJEDGE
Philadelphia
CEN
New York
NEREN
OSHEAN
NETWORK MAINE
NYSERNET
Albany
Hartford
Portland
Manchester
Boston
Providence
Salt Lake City
UETN
Denver
FRGP
Sunnyvale
CENIC
Los Angeles
Oahu
SUN CORRIDOR
Phoenix
Albuquerque
UNM|ABQ
El Paso
ONENET
Tulsa
ARE-ON
Little Rock
Nashville
Raleigh
NCREN
SOX
Birmingham
Atlanta
C-LIGHT
MISSION
Jackson
Dallas
LEARN
LONI
Baton Rouge
Jacksonville
FLR
Inter-Network Topology
Intra-Network Topology
The Quilt
Quilt Members and Affiliates
12-6-2017

What's Changed in "networking" in the last 8 years?

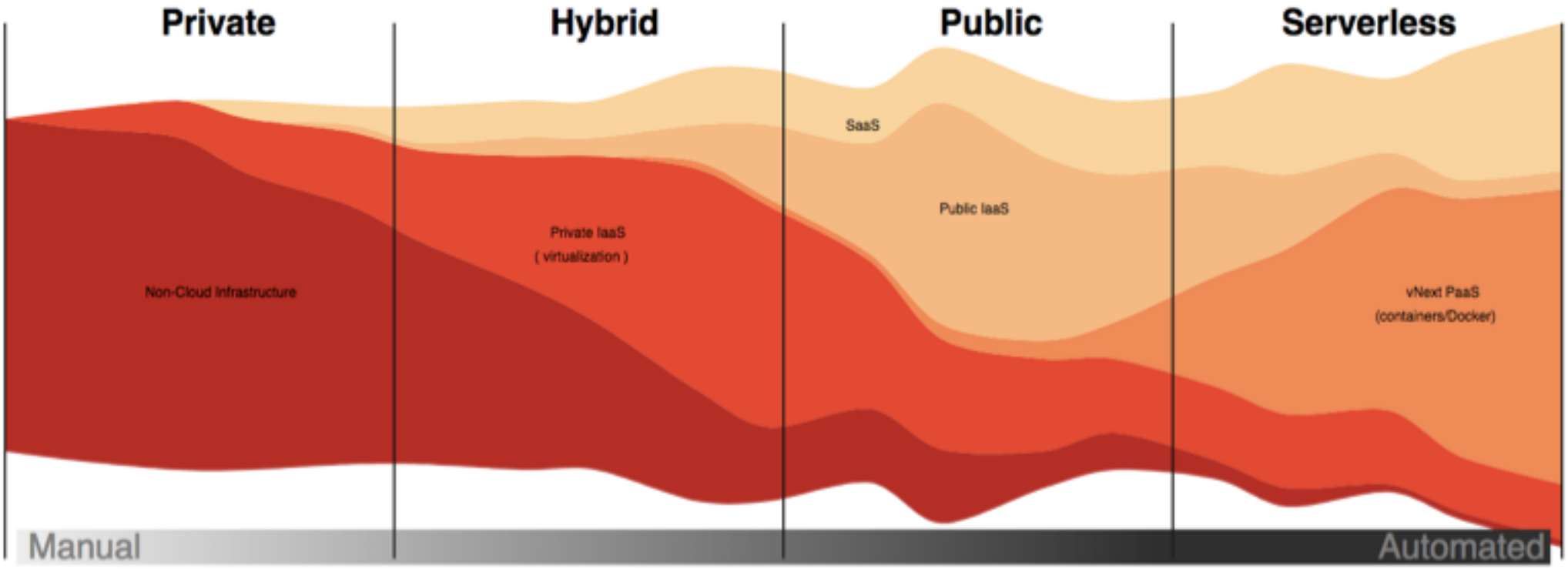
Themes:

- "Age of Cloud Scale"
- Security
- Open *Network* Systems
- Software Driven Everything
- Big Science Collaboration

Cross-Cutting trends:

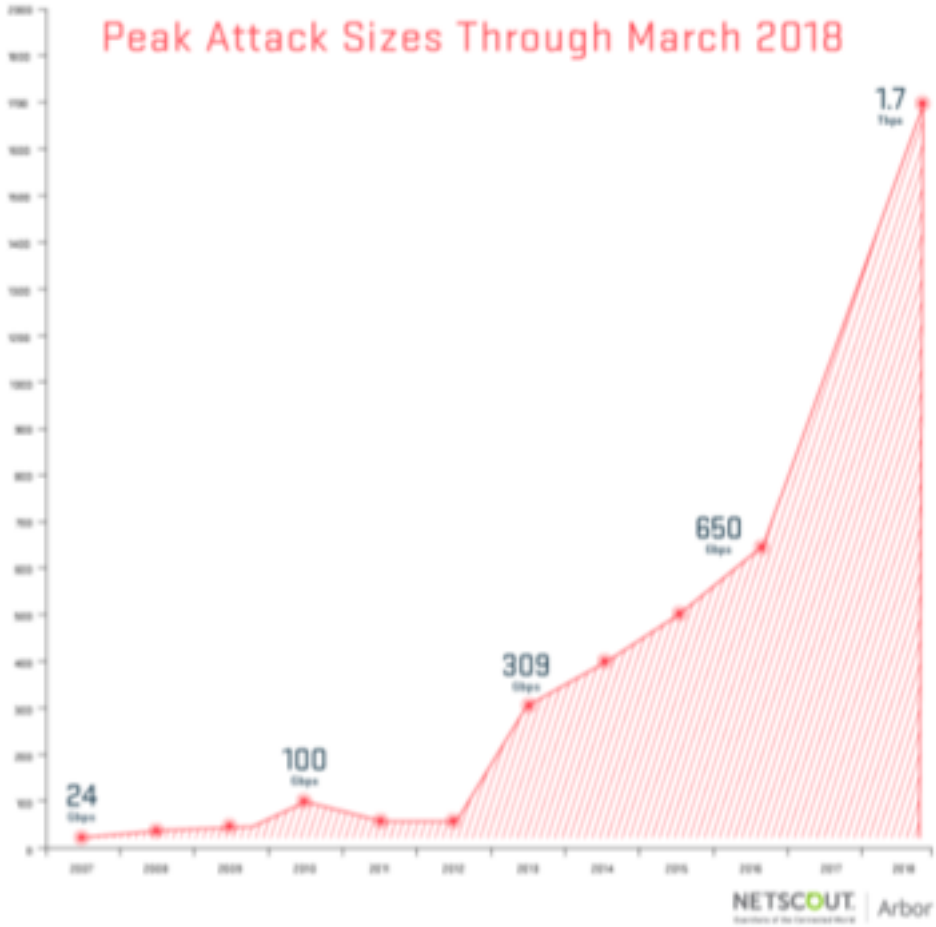
- Continued bandwidth explosion
- Economics and Commoditization

What's Changed : Age of Cloud Scale



What's Changed : Security

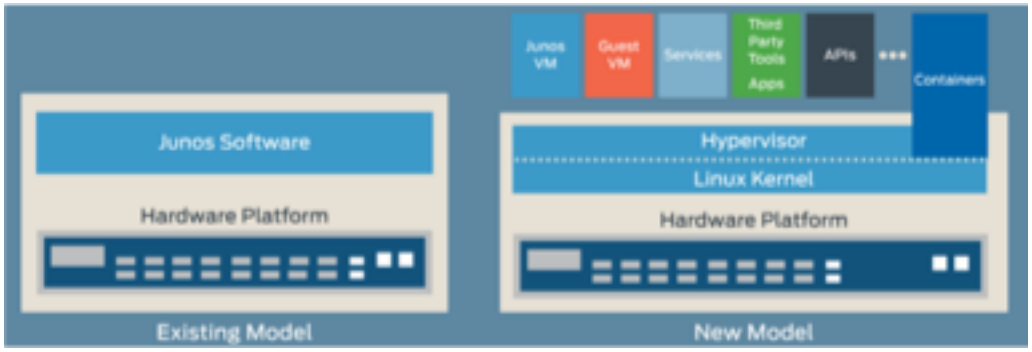
- Hacking is a profession
  - For profit
  - State sponsored
  - Increasingly sophisticated threats
- Data Breaches Are Common
- DDoS & Infrastructure attacks will crash the Internet again
- Encryption & Multi-factor authentication everywhere



What's Changed : Open Network Systems

2010:

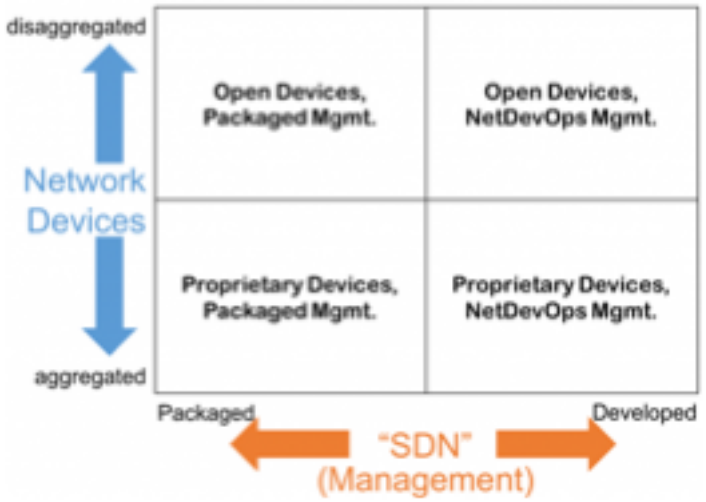
- OpenFlow *was* the example of "SDN"
- An emerging idea of software control



Now:

- OpenFlow-> P4, NetConf, Yang, etc
- Many Orchestrators and Controllers
- X86 / Merchant Silicon
- Router Slicing

- Disaggregation
- Cloud View – maybe network devices are really just like generic servers in a distributed data center?



http://packetpushers.net/simplified-approach-sdn-network-disaggregation/

What's Changed : Software Driven Everything

- Increasingly, networks are defined in software
- Large data centers and enterprises are leading move to server-based Network Operating Systems: Google, Facebook, Amazon
- Software, through automation tools is centralizing configuration and provisioning
- Software, through AI and Machine Learning also increasingly automating analysis and prediction

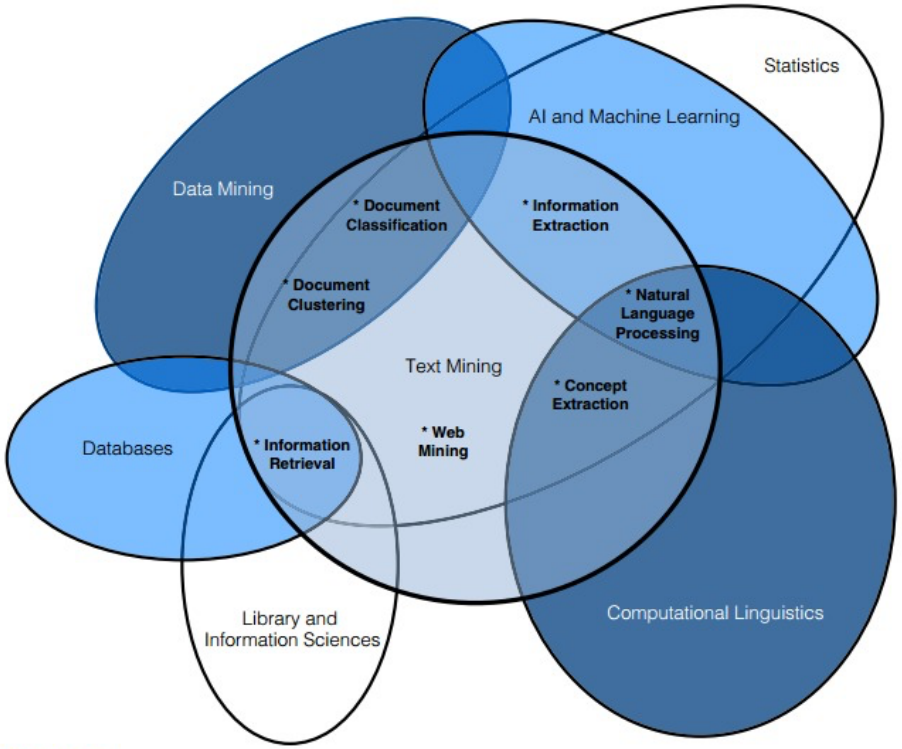


FIGURE 2.1
A Venn diagram of the intersection of text mining and six related fields (shown as ovals), such as data mining, statistics, and computational linguistics. The seven text mining practice areas exist at the major intersections of text mining with its six related fields.

What's Changed : Big Science Collaboration

Convergence of physical and life sciences – needs data-intensive computing

- Convergence comes from the sharing of methods and ideas by chemists, physicists, computer scientists, engineers, mathematicians and life scientists across multiple fields and industries. *Source: http://www.convergencerevolution.net/2016-report/*

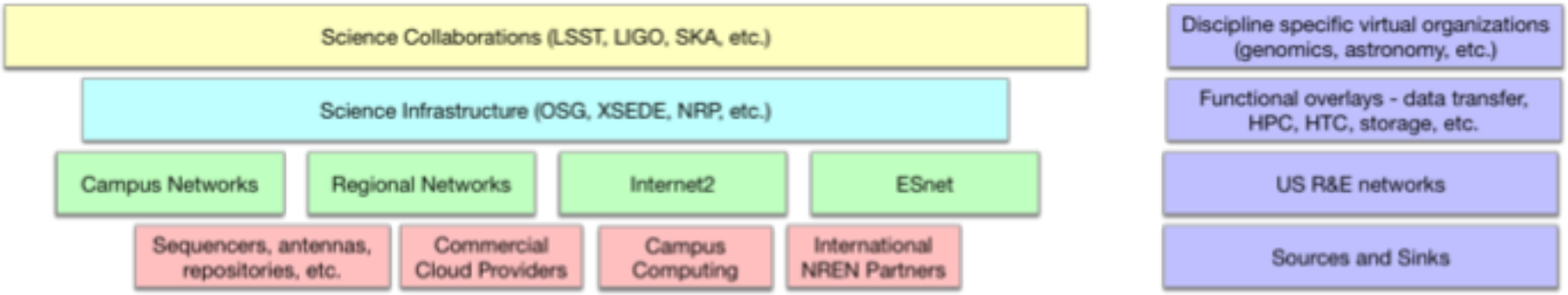
Large scale data collection by global science collaborations - "virtual observatories"

- National Ecological Observatory Network
- National Center for Biotechnology Information
- Ocean Observatories Initiative
- International Virtual Observatory Alliance

Science infrastructure drivers

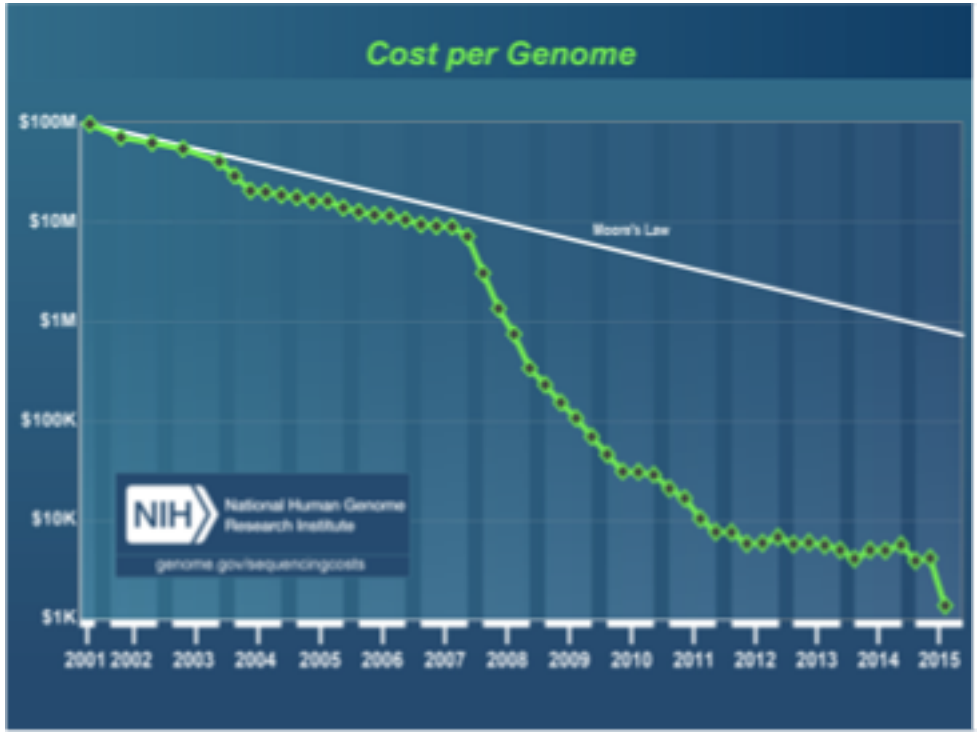
Ecosystem-wide services

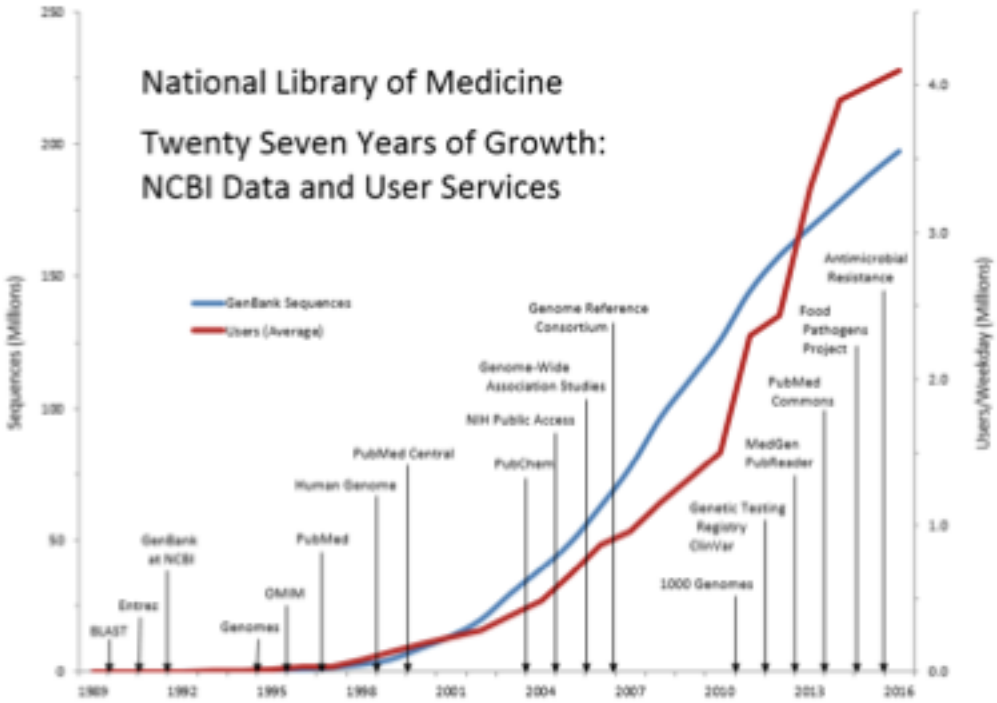
- From a network infrastructure investment perspective – these are often overlays
  - We've been supporting various overlays for years – GENI, XSEDE, etc.
  - To the science users, these are the infrastructure – and they rely on the network ecosystem, to support their unique needs
- Understanding nuances of workflow in the overlays helps us plan for:
  - Aggregate packet flows, caching schemes, cloud service access needs, on-campus storage needs, etc.

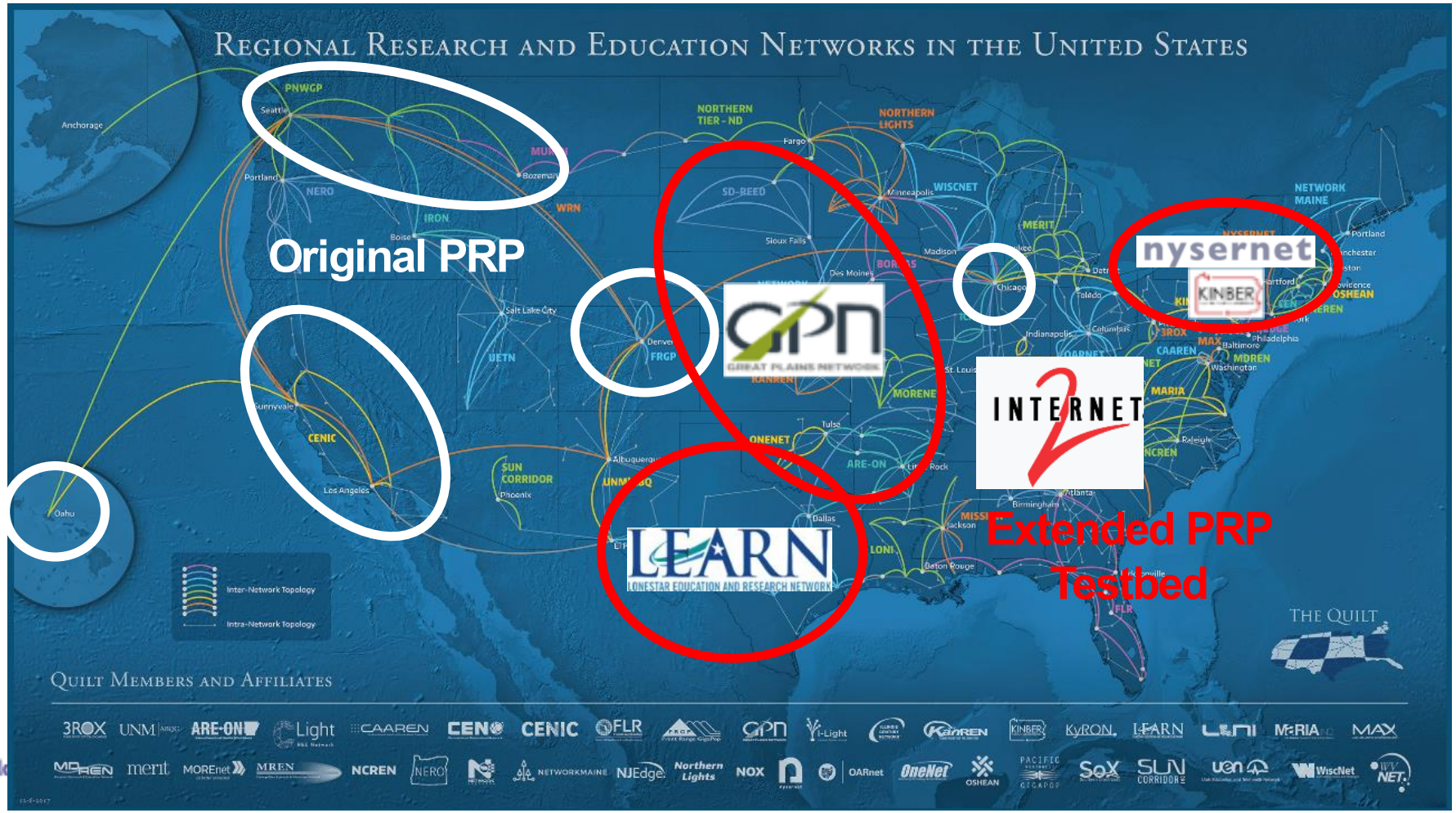


Collaborative Computational and Data-Driven Science

- Advances in scientific technology has driven an exponential grown data



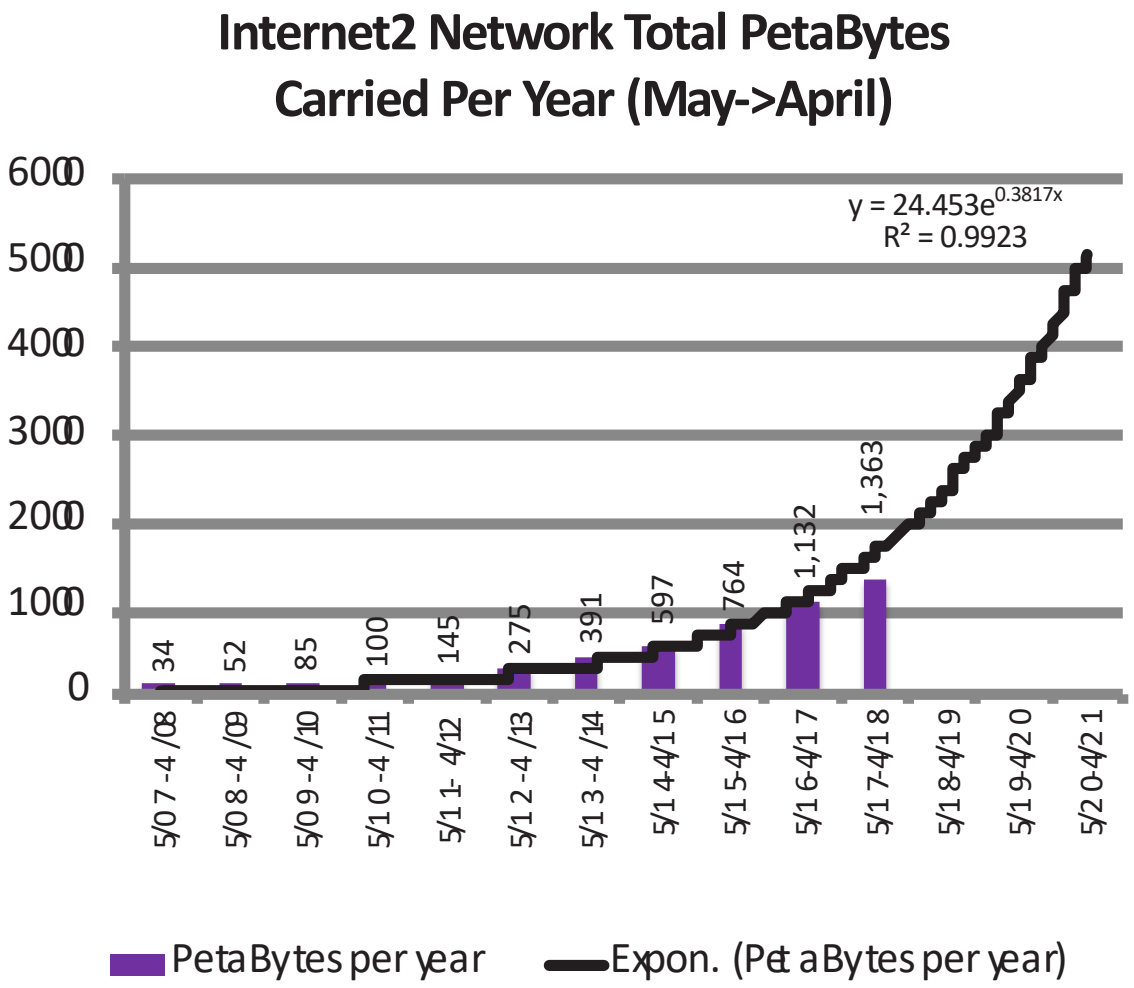




ESnet
CENIC
SDSC
CITRIS BANATAO INSTITUTE
it2

These trends require thought and enabling efforts by network operators:

- Tighter end-to-end collaboration
- Better standardization and/or adoption of interdomain norms
- New Skills and Tools-> Software
- Significantly improved capacity
  - Reduction of (unnecessary) duplicate infrastructure
  - Improved cost/bit ratios



Planning Themes:

- "Age of Cloud Scale"
- Security
- Open *Network* Systems
- Software Driven Everything
- Big Science Collaboration

"… an era marked by extreme and pervasive compute and data, with dramatic changes in the scale and nature of cyberinfrastructure requirements."

"… witnessing dramatic changes in technologies and resources, resulting in unprecedented computational and data processing capabilities and scales; the deployment of high-bandwidth/low-latency networks at the campus, regional, national and international scales; the increasing availability and capabilities at the network edge; and more."

"… view cyberinfrastructure more holistically as a spectrum of computational, data, software, networking, and security resources, tool and services, and computational and data skills and expertise that collectively can enable new discoveries across science and engineering. "

Manish Parashar – NSF OAC Director – Dear Colleagues Letter 04/18/18

Community Discussion Evolution: Pivot to Active Planning

- Community has been actively discussing a shared future with community leaders, particularly researchers and regional networks since 2016.
  - RECINNS
  - Series of Principal Meetings with Regional Networks
- Pilots/Proof of Concepts - ongoing and insightful
- Detailed, phased, planning can begin based on current known needs, while further input continues to be generated and integrated
  - Move forward “open line system” photonic-layer sharing and I2 upgrade in 2019.
  - Move to more detailed planning for layer 2/3 and automation/software later in 2018 and position to begin those implementations as soon as 2020.
- Internet2 can continue to work with the community for alignment before the next series of major investments (L2/L3) are submitted for budget beginning in April, 2019.

Guiding principles

Ecosystem approach
- Focus on joint service delivery model - campus, regional, Internet2

Experimentation
- Try stuff, short term commit
- No impact on current production service

Target research end users
- Push service delivery edge close to user

Five Community drivers for services improvements:

- Research Community: Support emerging science infrastructure requirements
  - Consider instrumented, integrated allocation of 100G+ capacity per connector for research applications
  - Examples – National Research Platform, Eastern Regional Research Platform, etc.
- Research Community: Deliver software-driven (API) infrastructure
  - More easily integrate E-2-E workflows, research and support big science applications
- Campus & Regionals: Additional end-to-end and infrastructure sharing
  - Reduce duplicative investment in new capital as well as operating expenses
- Campuses & Regionals: Cloud Access Services
  - Continue to enable cloud-access including more self-service portal support
- Regionals: Respond to requests to increase capacity offered per $
  - Consider removing the TR-CPS “cap” from 20G to 100G per connector, offer NRP solution

Core Requirement Areas:

Internet2 Infrastructure Service Portfolio

- Optical Spectrum & Wavelength Services
- Packet Platform
- Programmable Research Overlay
- Custom Platform Support
- Build Your Own Colocation Services

Cross Cutting Requirements

- Supporting of Research
- Automated & Programmable
- Cloud & Peer Connected
- Embedded Security Services
- Regional/National Integration
- Infrastructure Sharing
- Global Reachability
- Measurement Services
- Research Data Services

Research Community: Support emerging science infrastructure requirements

- Consider allocating dedicated bandwidth in the ecosystem for science infrastructure implementations
  - Optimized for research flows
  - Abundant Bandwidth
  - Highly Instrumented
  - Secured
  - API and Self-Support Enabled
- Tied to Research Engagement for workflows, applications, architectural and other support structures

Scientists need to do publishable science, not delve into networking/IT support. Therefore, an effective national partnership will need cyberinfrastructure experts working with scientists at their interface and understanding the desired scientific outcomes, rather than viewing the technology as an end to itself. –NRP Workshop Final Report

The ideal goal is a consistent, scalable, and simple national connectivity approach for provisioning and supporting the complex and evolving specialized needs of collaborative research across the R&E institutions and shared Cyberinfrastructure facilities. – Rick Tutthill and Chris Misra, UMass Amherst, RECINNS paper

… continuing to innovate in developing and implementing advanced networking architecture and technology required by data intensive science domains will be an important theme. - Joe Mambretti – MREN

Research Community: Deliver software-driven (API) infrastructure

- Determine community needs for API & telemetry
  - Private API's like NSI/AutoGOLE
  - Standards API's like MEF ENNI
  - Thoughts on API's regional/campus orchestrators may need
  - Logs, Flow and other telemetry for infrastructure sharing
- Implement small prototype in Q4 2018/Q1 2019 for testing and experimentation
  - Seek regional and campus collaborators

Developing a programmability model for the core network to also become more flexible, allowing relinquishing of control over the network substrate to the end users and going beyond simple bandwidth on demand API. – Mark Johnson & Ilya Baldin – RECINNS Paper

Having access to a programmable WAN is important not only for testbeds but also for a number of emerging applications. – Joe Mambretti, MREN – RECINNS Paper

We would like to see connectivity that can be ordered and provisioned via API and internet portals to eliminate the delays associated with the traditional submission of a service order to obtain a virtual cross connect or to have a VLAN provisioned – Emory University Cloud Research Story

Campus & Regionals: Additional end-to-end and infrastructure sharing

- Call for participation in Optical Route Sharing
- Consolidation / Virtualization of Routers/Switches
  - And service arrangements to deliver services on some else's hardware
- Development of tools for provisioning, operations and management in a federated environment

"There can be no sacred cows. We must challenge the assumption that network ownership [must remain] as we currently understand it and [allow for it to] give way to new models." – Paul Schopis – RECINNS Paper

From an ecosystem perspective, it is important to optimize our collective investment and not spend more on services or architectures than is necessary and prudent. Our national interests are best served when Internet2 AND the regional networks are successful. - From Guiding Principles created at 2016 Tempe Regional Principal's Meeting

the Internet2 infrastructure should migrate to a model that is more of a platform enabling development by external communities than an infrastructure providing a fixed, predefined set of services. – Joe Mambretti, MREN & Starlight, RECINNS Paper

Campuses & Regionals: Cloud Access Services

- Leverage investment in R&E networks for economies and cost control
- Deeper interconnection of R&E infrastructure and commercial cloud providers
  - Capacity
  - Security
  - Private Networking
  - Resiliency
- Offer common API's, portal, architectural frameworks and best practices to R&E to ease adoption and multi-cloud migration

… support for access to the cloud is necessary. These services are not just for academic enterprises, but also for researchers. – Michael Lambert, PSCC, RECINNS Paper

One of the challenges we have seen … is being able to secure robust and reliable private cloud connectivity… We would like to see an offering where we can leverage private cloud connectivity including 10G or multiple 10 Gb ports that also could meet the reliability and diversity requirements of a highly available data center... – Emory University Cloud Connect Research Story

Direct connectivity into cloud providers is key as compute resources in the cloud will need to be able to access on-premises file storage, license servers, and other resources in a quick and secure manner in order to maintain a consistent user experience. – Adam Smith, Georgia Tech, Cloud Research Story

… problems encountered… are typically associated with high egress charges to remove data from the commercial cloud…. It would be a huge incentive to move more scientific computing into the cloud if Internet2's interconnects with the big commercial clouds are unmetered. – Nancy Wilkins-Diehr, SDSC, Cloud Research Story

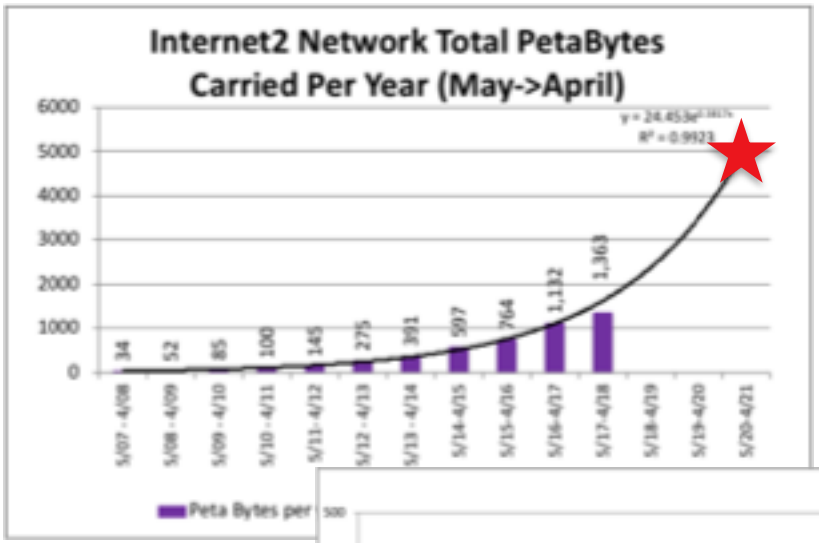
Regionals: Respond to requests to provide increase capacity

- Consider what the next Internet2 “port offering” looks like post upgrade
  - Hybrid of locally and backhauled services?
  - Higher B/W single port options (400G?)
  - Consider economic efficiencies of leveraging community assets such as inter-regional peering and commodity capacity when developing resiliency plans.
- Seek to raise TR-CPS availability to at least 100G for connectors
- Seek to dedicate bandwidth to research applications such as National Research Platform and others

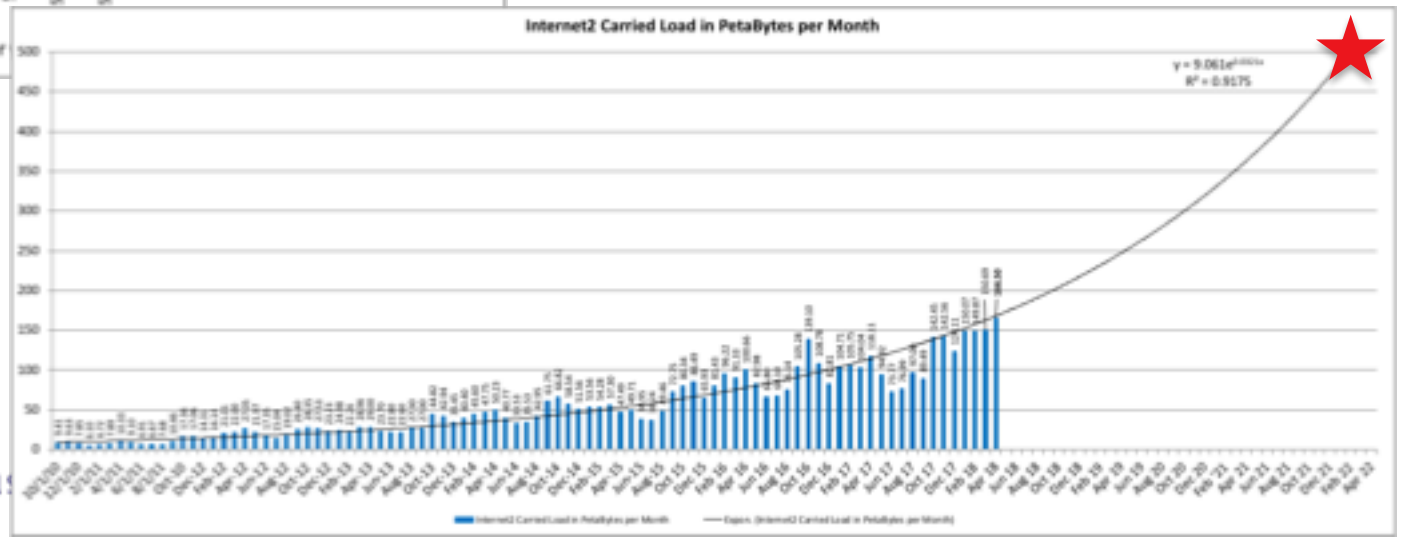
Today’s R&E environment is changing rapidly. Traffic demand is growing, and fulfilling that demand with current technology platforms is becoming increasingly difficult to accomplish affordably. – RECINNS Summary Paper.

These are challenging economic times for every institution and finding ways that we can collaborate to leverage strengths across the community in pursuit of our common goals will help us provide great services, control costs, and keep us all focused on the important elements of our respective portfolios.
– Chris Sedore – Nysernet – RECINNS Paper

Internet2 Economic Drivers through 2021



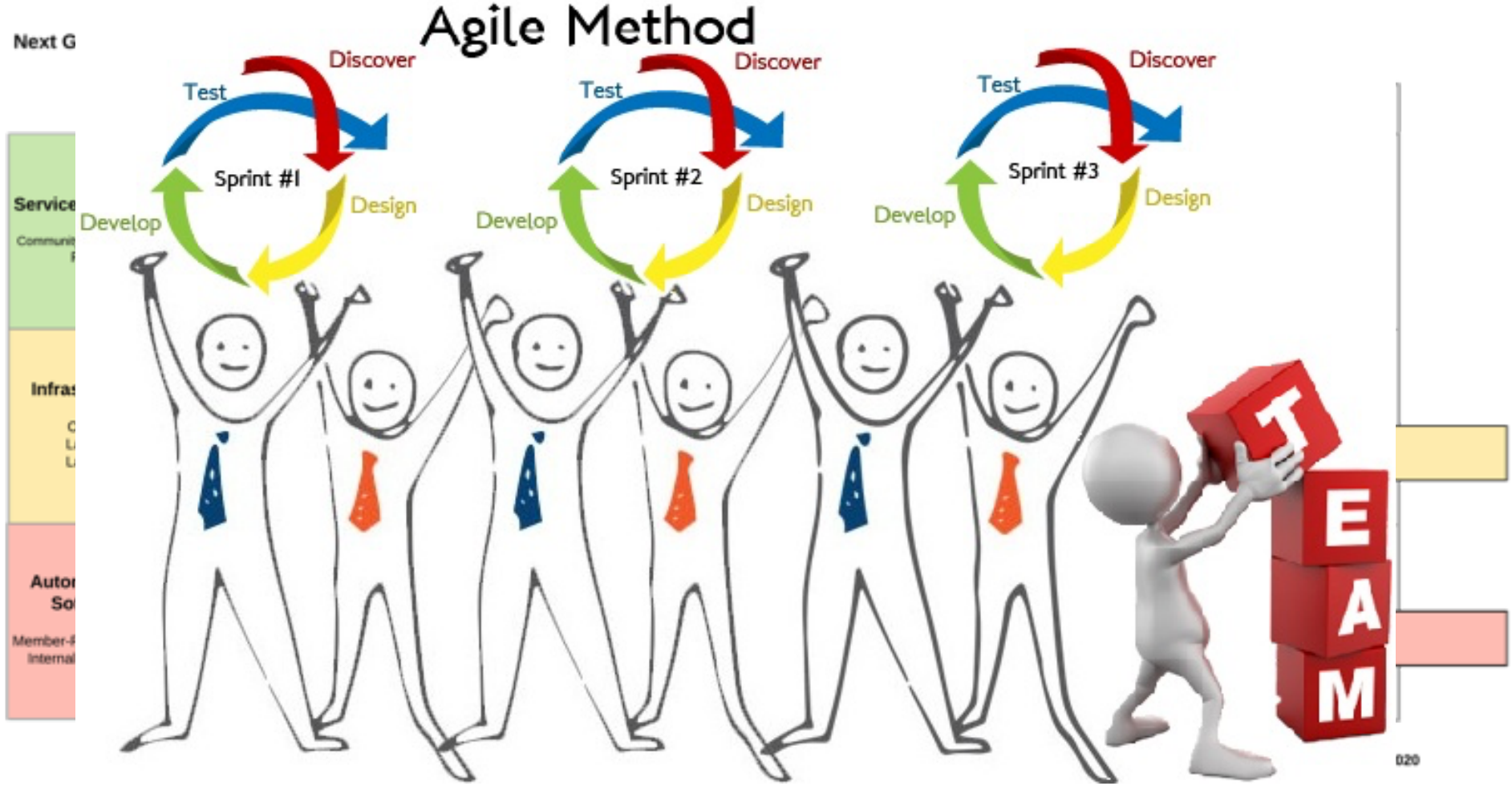
- Substantial utilization growth is good but is creating unsustainable cost growth at tail end of current platforms
  - Internet2's platforms will be 10+ years old in 2020
  - New equipment provides more bandwidth per dollar & space.
  - We are at the tail end of current 2009/10 platform efficiency
- Internet2 should strive to offer connectors a substantial "bandwidth bump" within the existing service model.



Three Potential Investment Areas supporting service improvements:

1. Optical ***photonics portion of Layer 1***
    1. Underlying photonics systems have a 10+ year life, but ours lacks support for >200G wavelengths and "open line system" add/drop nodes and software capabilities that allow current standards.
    2. This sub-project includes just the photonics layer and NOT the transponders.
2. ***Router/switch*** topology rework and upgrade of remaining devices
    1. In consultation, we will look for opportunities to partner and reduce the footprint from 44+ routers
    2. We will then look for higher density, lower cost, smaller footprint devices via open RFP.
    3. Finally, we will look at opportunities to add capacity and to integrate/replace/reconsider optronics in the routers or in replacement of current transponders (while reusing many transponders we already have.)
3. A new Investment area would include ***software and automation***:
    1. Add "zero touch" provisioning for regionals and researchers to support their own virtual networks.
    2. Increase programmability and virtualization to allow integration with research applications.
    3. Support other software enabled features like measurement, security, telemetry in virtual networks

A potential program timeline for community discussions and Internet2 upgrades:



Organizing the Program: Elements of Planning

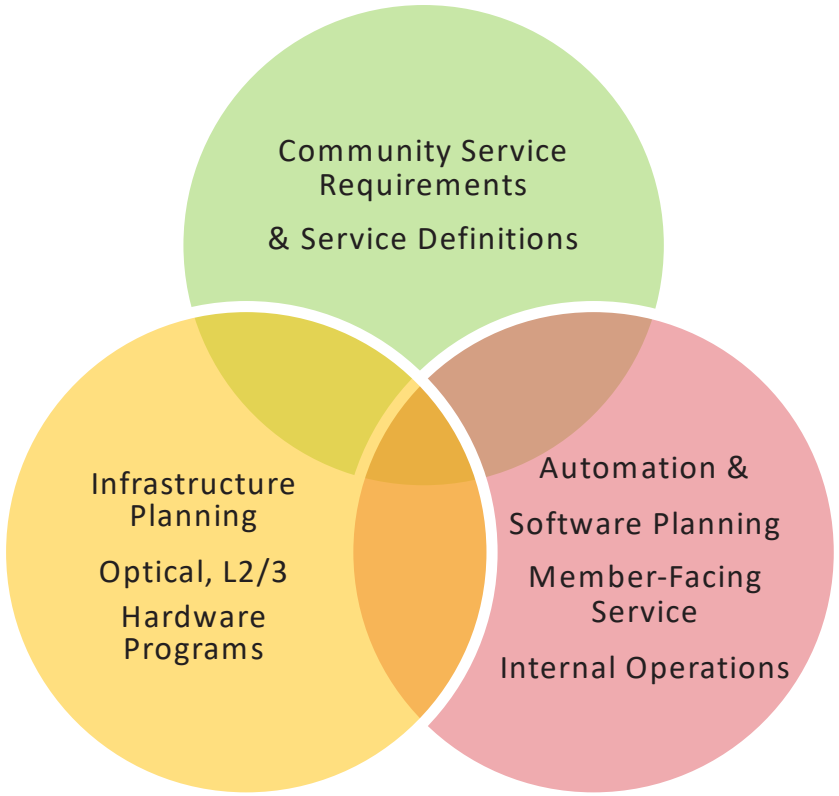
We are proposing 3 teams begin to refine the community input we have received in to actionable plans beginning in July 2018:

Community Service Requirements
Organizing now; will present "what we have heard" and begin to propose and iterate a service portfolio with the community for the service requirements the design will need to fulfill.

- This becomes the goalposts for the other two teams.
- Will be responsible for overall value, cost and service balance of project

Infrastructure Planning
Organizing beginning in July 2018 as the requirements phase matures after Global Summit, will research current technologies and begin technical planning, possible RFP's & pilots

Automation & Software Planning
Organizing beginning in July 2018 as the requirements phase matures after Global Summit, will research current technologies and begin development & integration planning , possible RFP's & pilots



Discussion