



INTERNET.
2



NEXT GENERATION INFRASTRUCTURE



SAACC 2019

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Next Generation Infrastructure Project Update

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NGI Background: **Five Community drivers for services:**

- ***Research Community: Support emerging science infrastructure requirements***
 - Consider instrumented, integrated allocation of 100G+ capacity for research applications – in partnership with regionals
- ***Research Community: Deliver software-driven infrastructure***
 - More easily integrate with E-2-E science workflows and support API's/orchestration/automation for 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 Connect Services***
 - Continue to enable cloud connect including enhanced self-service portal support
- ***Regionals: Respond to requests to increase capacity offered***
 - Raise capacity offered for core services: peering, research, cloud and general R&E

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NGI Background: **Community Discussion Evolution**

- ***Initial projects underway, First RFP released, additional planning has begun...***
 - Investments in interconnect, management network underway
 - “Open Line System” Optical Upgrade RFP released 12/5, Due 2/1
 - Service models and design for layer 2/3 to be completed in 2019
 - Automation/software scoping beginning
- ***What is critical are the guiding principles***
 - Ecosystem approach
 - Experimentation
 - Target research

Guiding principles

Ecosystem approach

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

Experimentation

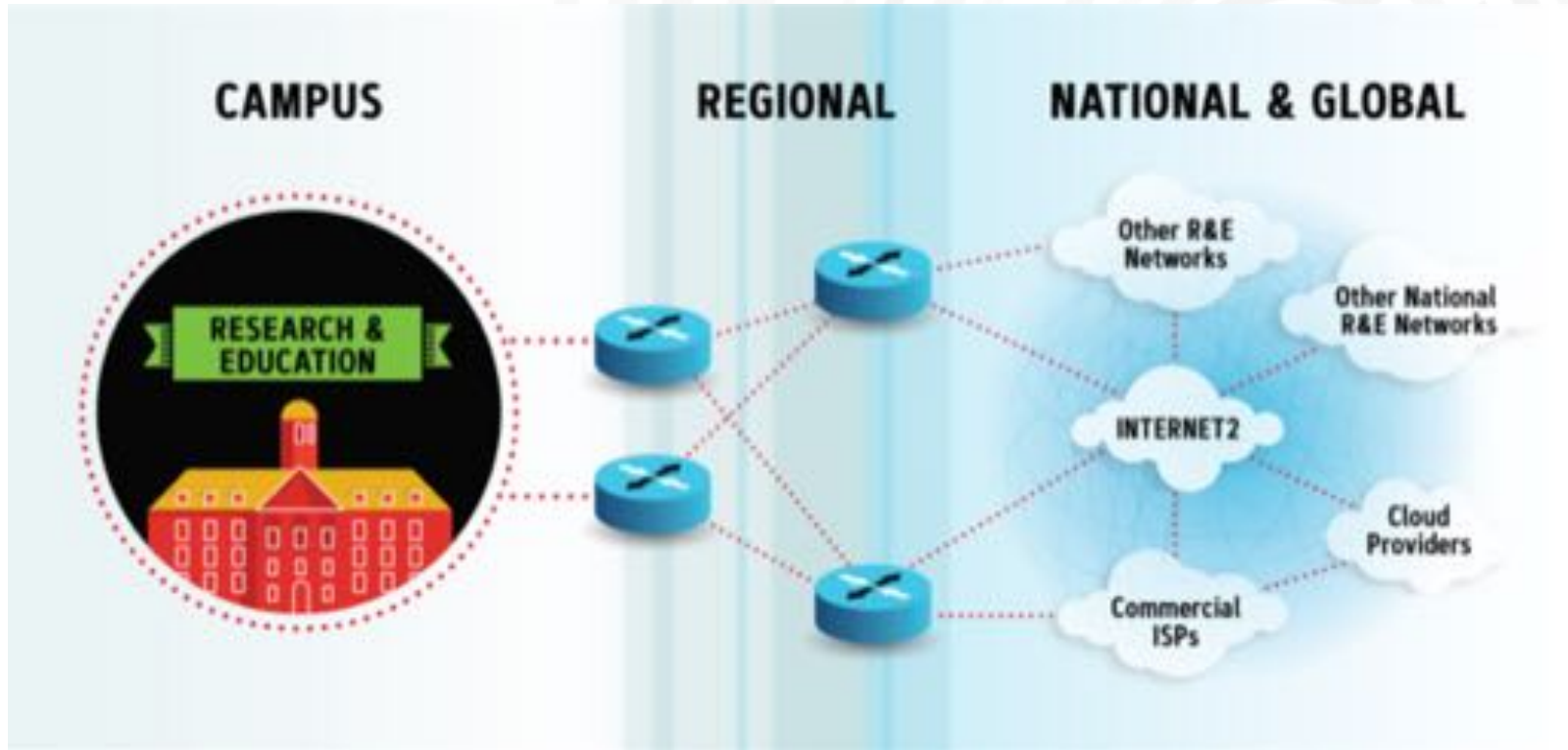
- Try stuff, short term commit
- No impact on current production service

Target research end users

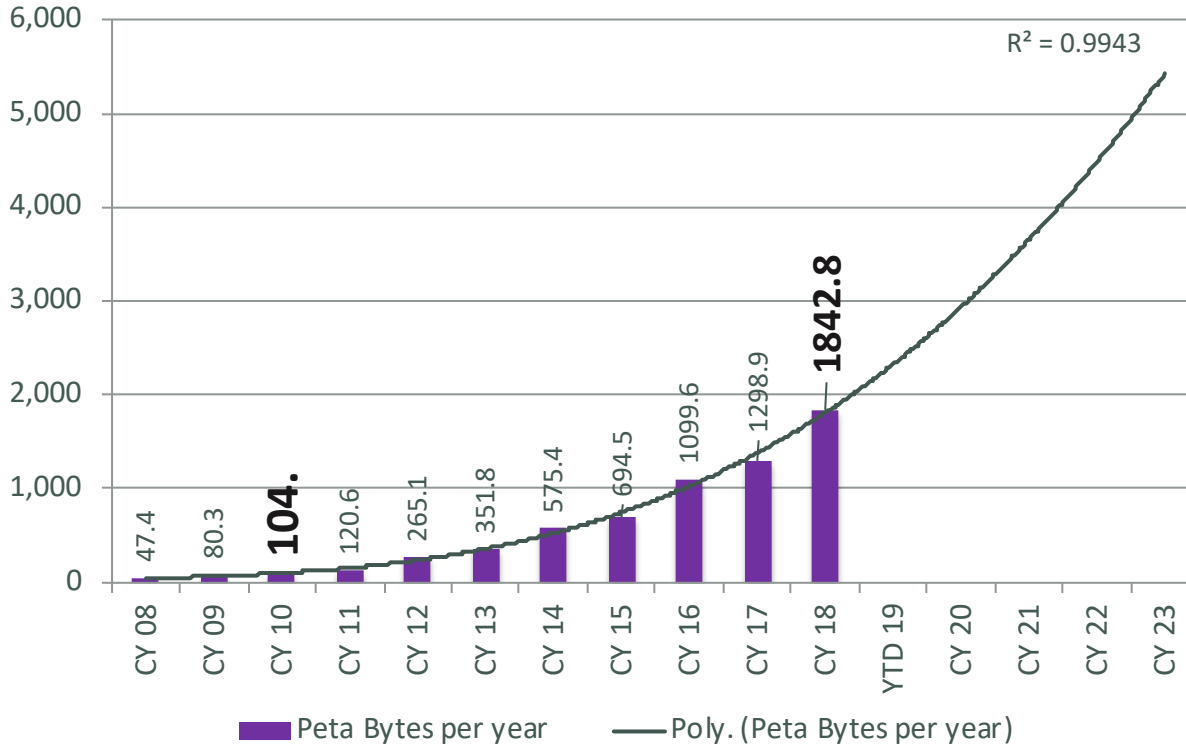
- Push service delivery edge close to user

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Research and Education Network Ecosystem



Internet2 Network Total PetaBytes Carried Per Year (Calendar Year)



NGI Driver:

**Reset scale
Economies
To Support
Massive Growth**
(at similar total operating costs)

- All words ever spoken by humans over all time are estimated at 5 xB.
- During 2018, overall backbone capacity was augmented by nearly 20% with 15 new 100G links coming on line to augment the existing 80 100G backbone links.

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NEXT GENERATION INFRASTRUCTURE

WHY Now: An example with NGL Optical Line System

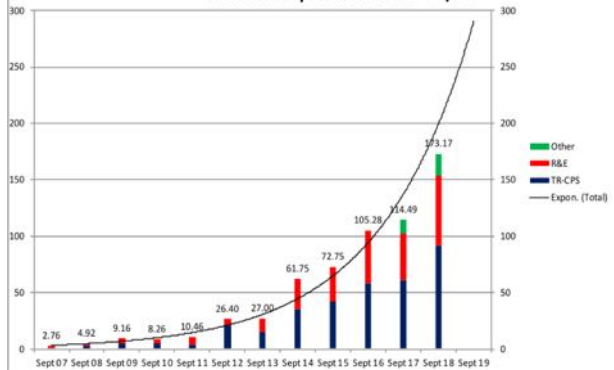
- Smaller Form factors – Less space = less colocation cost
- Power utilization is much lower – less power = less power cost
- Approaching accelerating growth in capacity needs in next 5 years

To provide more value with flat budgets, we need to leverage the new efficiencies to drive out cost, which funds capacity

Enhanced Circuit Pack Cost (per end)



Historical September Totals - PB/Mo



OCI/OCLD
c 2011
100G line side
3-slots
363 watts



400G MOTR
c 2018
400G line side
1-slot
140 watts



CFP2-DCO
c 2018
200G line side
Pluggable
19 watts

NEXT GENERATION INFRASTRUCTURE

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



Being Agile -- wins to date and insights on future timings

- Our approach has changed away from a single plan, towards a single program with multiple sub-projects.
 - Data driven; timely and iterative decision making along a multi-year path
 - Still looking for economies of scale on the two major platform decisions, but less linear overall plan
 - Tends to support the increased complexity of activities and allow faster decisions
- Early activity:
 - Cloud Connect Portal/OESS 2.0
 - Interconnection 100G platform and capacity increases
 - Increase in cloud exchange/peering capacity



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NGI: *Interconnection Upgrade (Underway 4Q-18 to 1Q-19)*

Interconnects Internet2 members to cloud and commercial peers at 7 locations across the country

- Procured hardware to upgrade the two largest sites to move peering ports from dozens of 10G to 48 x100G
- Reclaimed 100G hardware will move to the other 5 interconnection sites
- Enables upgrades of our fastest growing hardware
- New Hardware costs 1/6 the cost per 100G of current platform, 1/3 less maintenance costs

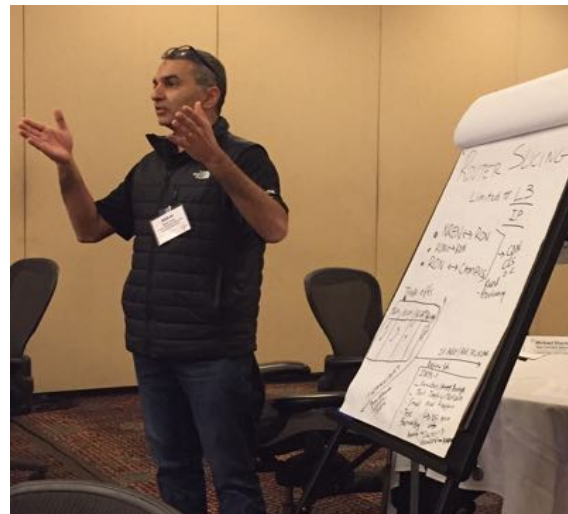


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NGI: *Community Pilots, Experiments and Reports*

➤ Progress on Experiments & Pilots in 2018

- Router Slicing Working Group Report (KanREN, LEARN, OneNet, Internet2)
- Future Routed Services Working Group Report (many!)
- "Voyager" Optical Pilot Readout (NYSERNet)
- Cloud Orchestration Experiments (OSHEAN, RENCi)
- (NRP) National Research Platform Pilot (Internet2, GPN, LEARN, CENIC, NYSERNet, KINBER)
- Eastern Regional Network Collaboration (many!)
- Alien Wavelength Pilot (NJEdge, NYSERNet, SCInet)

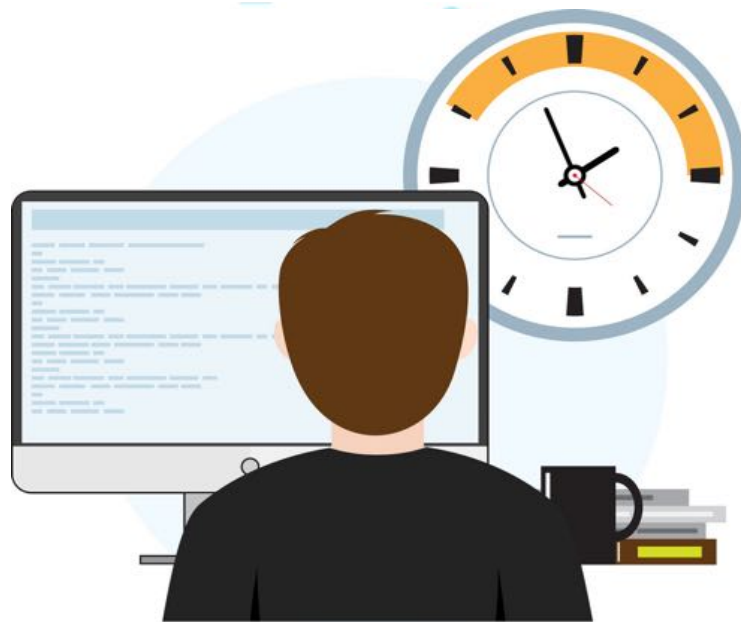


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NGI: *Software, Systems, Automation*

New opportunity to automate operations & service delivery; reduce time to service; enable sharing

- Released cloud-connect portal (OESS 2.0) - Added self-service cloud provisioning to Amazon and Google Direct connect & API features that reduce time to results and enable infrastructure sharing
- Demonstrated new telemetry-based path control at TechEX with Arista Networks



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NGI: *Optical Photonics Investment (2019 Activity)*

Underlying photonic transport system for nationwide community wavelength sharing

- Implement new smaller hardware that has greater distance & greater capacity technology
- Find efficiencies
- RFP released week 12/5/18, responses due 2/1/19



- >50 ghz / 35 Gbps
- Disaggregated
- Programmable
- Efficient

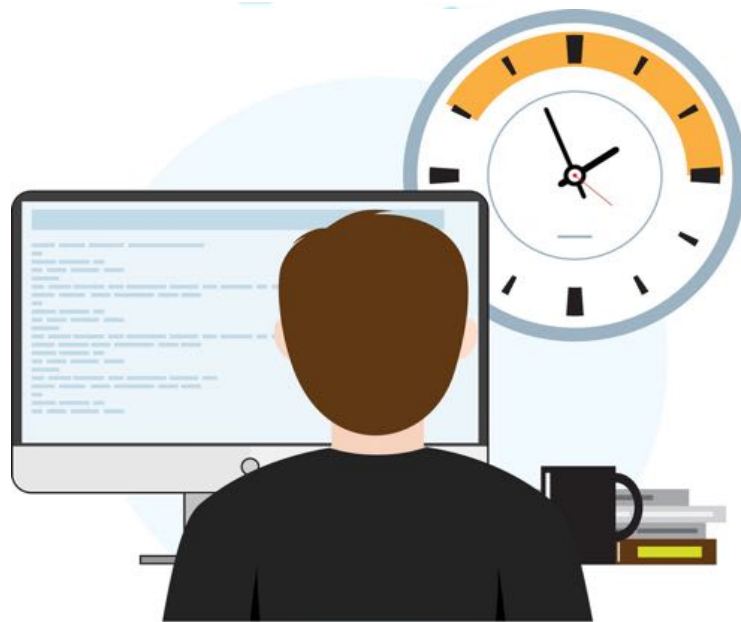


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NGI: *Other Service Improvements*

New opportunity to automate operations & service delivery; reduce time to service; enable sharing

- Continued Cloud Connect Pilot



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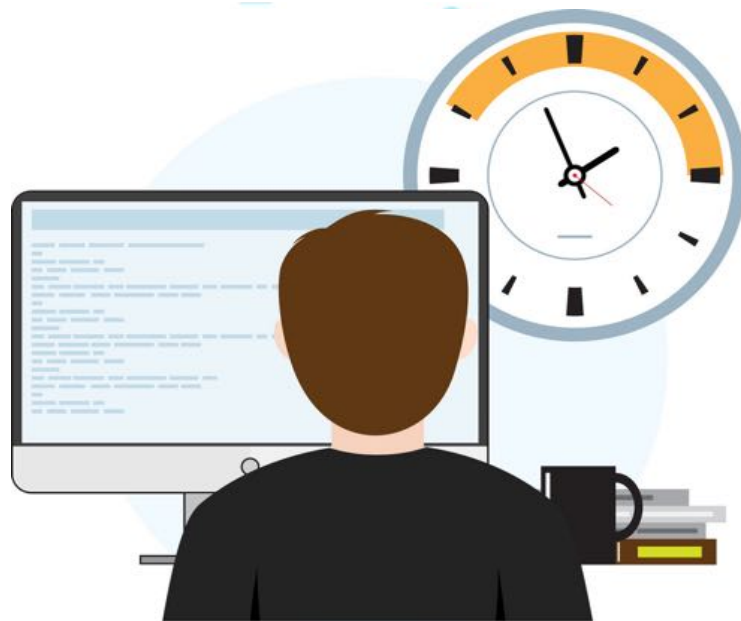


Next Generation Infrastructure 2019 and Beyond

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NGI: *Software, Systems, Automation*

- Automate internal processes & automate configurations for consistency, rapid delivery
- Add self-service & API features that reduce time to results and enable infrastructure sharing
- Update measurement, analytics and operational transparency tools
- Provide leading network security capabilities that enable and also protect science workflows
- 2019 Activity: Testbed to begin to model these activities in conjunction with Packet Network Development

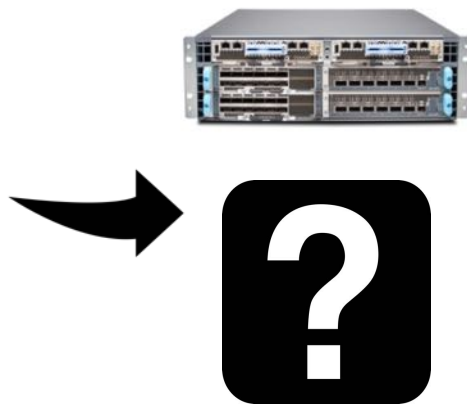


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NGI: *Programmable Packet Platform*

*Underlying system for community packet services
at approximately 35 sites across the country*

- Introduce more deeply programmable and virtualizable (shareable) network elements
- Allow bandwidth increase to connectors and address demand for capacity & potential sharing
- RFI underway, will be issued after Global Summit
- RFP in mid 2019.
- Transition is TBD



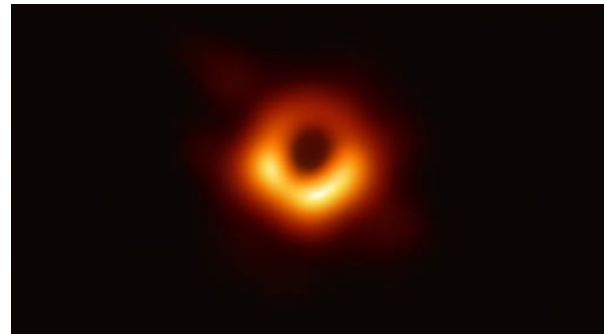
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NGI: *Future support*

- Internet2 will support 400G on its national backbone, with first segments rolling out in 2020. Some segments will start at 800G.
- User-Specific Telemetry, Self Service Portals, Cloud Integration and “making Internet2’s infrastructure feel like you built your own custom network” are all part of the plan in coming years.
- Cloud Interconnection - We will have Terabits of Layer3 cloud connections and 100’s of gigabits of “direct connect” L2 access as well.
- Whether it is dedicated wavelengths, or leveraging L2 or L3 VPN’s and the resiliency of the network, we can support LSST.

NGI: *Still a long way to go*

- The newly released image of a black hole took years of work, collaboration of more than 200 scientists, and also required 1,000 pounds of hard drives (5 petabytes of data)
- The Mauna Kea Observatory in Hawaii might have generated about 700TB of data (one-seventh of the total),
- Shipping those drives from Hawaii to MIT (~5,000 miles) works out to ~112 gigabits per second
- <https://www.extremetech.com/extreme/289423-it-took-half-a-ton-of-hard-drives-to-store-ehs-black-hole-image-data>



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