

# Status of the National Research Platform (NRP)

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- The gap between those who have and those who can't afford is becoming wider.
- Cyberinfrastructure needs are growing for Education
- The end of Moore's Law is leading to a proliferation of "architectures" ... domain science adoption is at risk.

## Vision of an Open Infrastructure

Horizontally open => institutions can integrate their resources

Vertically open => projects can build on the infrastructure

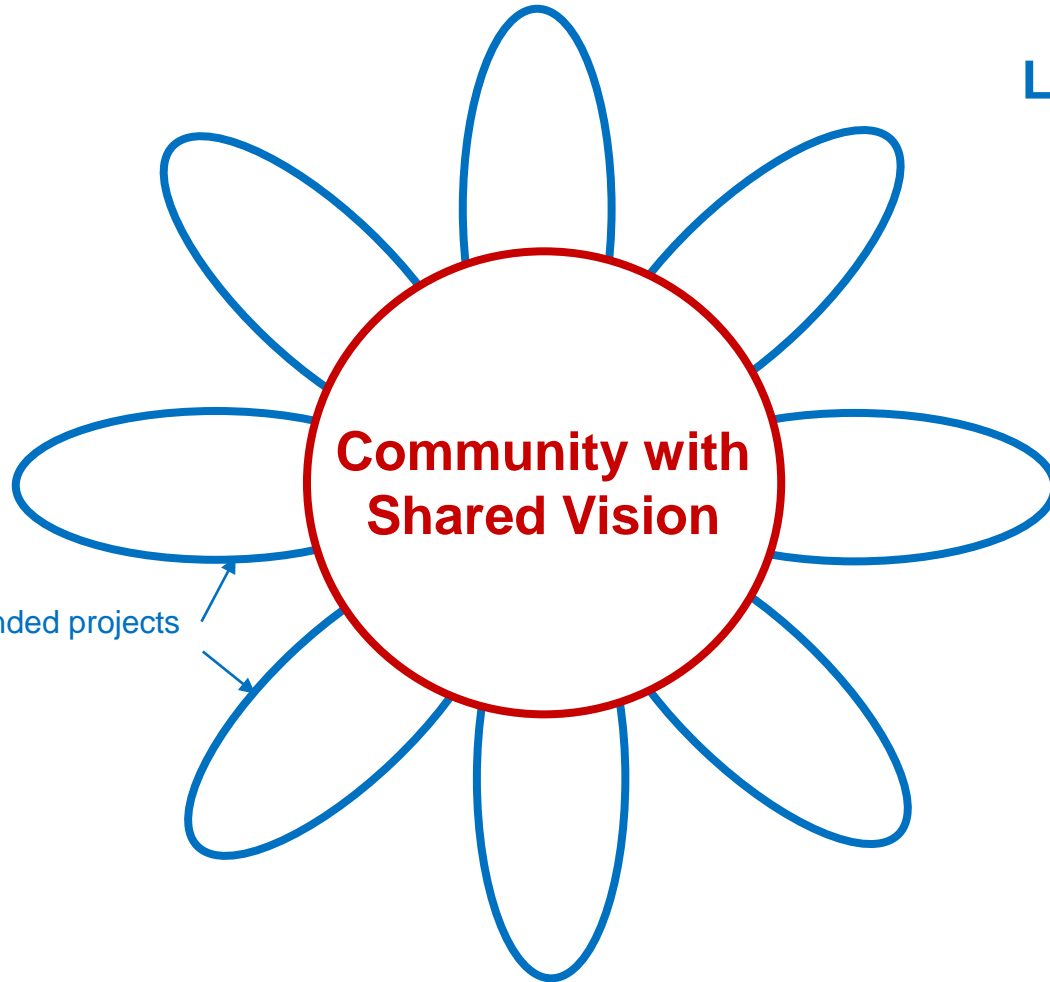
- Create an Open National Cyberinfrastructure that allows the federation of CI at all ~4,000 accredited, degree granting higher education institutions, non-profit research institutions, and national laboratories.
  - Open Science
  - Open Data
  - Open Source
  - **Open Infrastructure**
    - ← Open Compute
    - ← Open Storage & CDN
    - ← Open devices/instruments/IoT, ...?

## Openness for an Open Society



# The Minds We Need

- **Connect every community college, every minority serving institution, and every college and university, including all urban, rural, and tribal institutions** to a world-class and secure R&E infrastructure, with particular attention to institutions that have been chronically underserved;
- **Engage and empower every student and researcher** everywhere with the opportunity to join collaborative environments of the future, because we cannot know where the next Edison, Carver, Curie, McClintock, Einstein, or Katherine Johnson will come from; and



Lot's of funded projects that contribute to this **shared vision** in different ways.

Hardware funded by NSF, DOD, DOE, ...

Petals of this flower include:

Prototype National Research Platform  
PATH

Open Science Data Federation

Open Science Compute Federation

National Data Platform

Pelican

Fusion Data Platform for AI

R&E platforms for multiple campuses

GP-Engine

TIDE

...

Open Infrastructure is “owned” and “built” by the community for the community

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# NATIONAL RESEARCH PLATFORM (NRP)

HOW WE EXECUTE ON THIS VISION

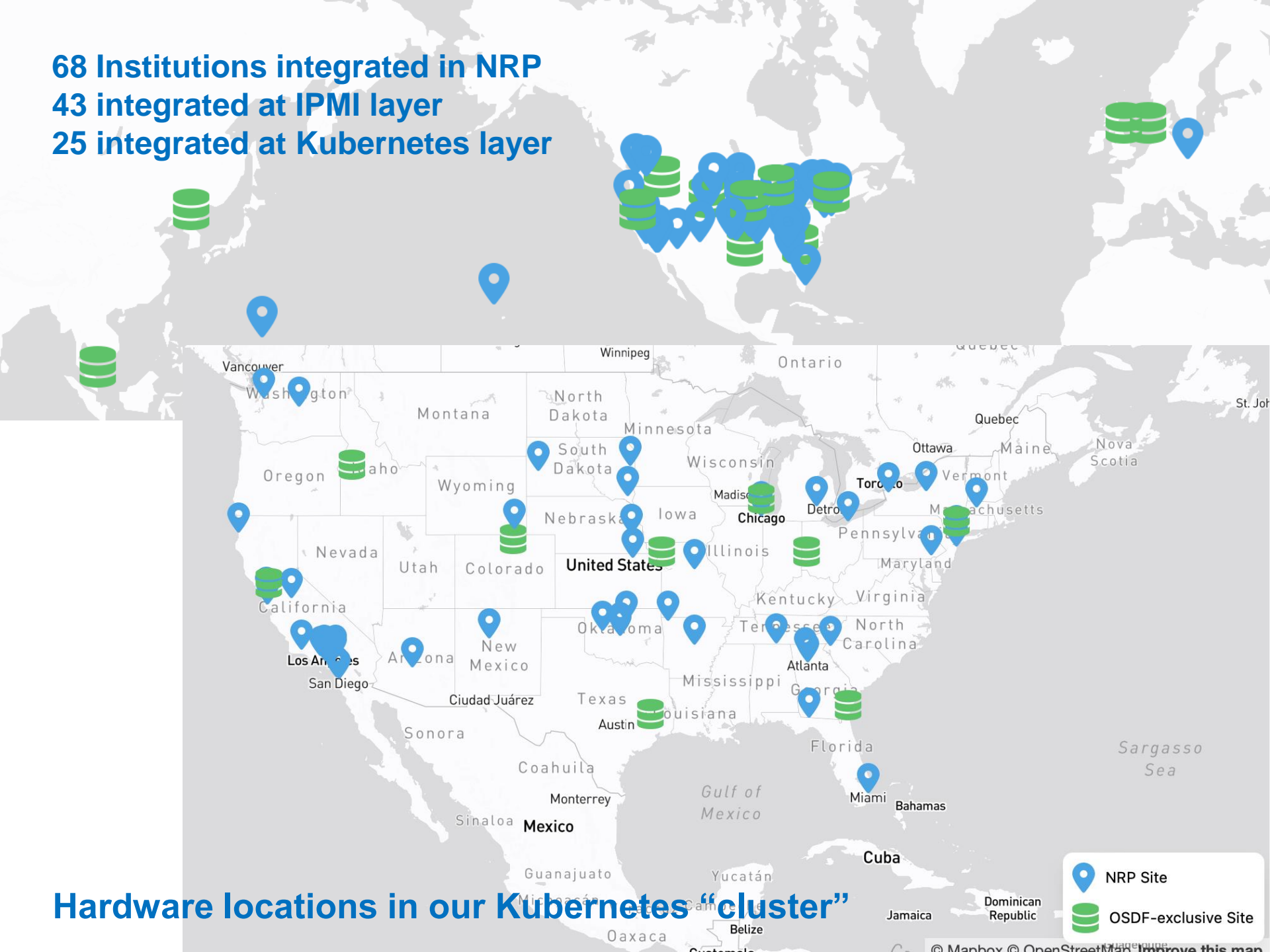
- Depending on effort available and control desired, you can build on NRP both vertically and horizontally at different layers of the stack.





- NRP is a non-local extendable container deployment platform, thus allowing many uses unthinkable for a SLURM cluster in a data center.



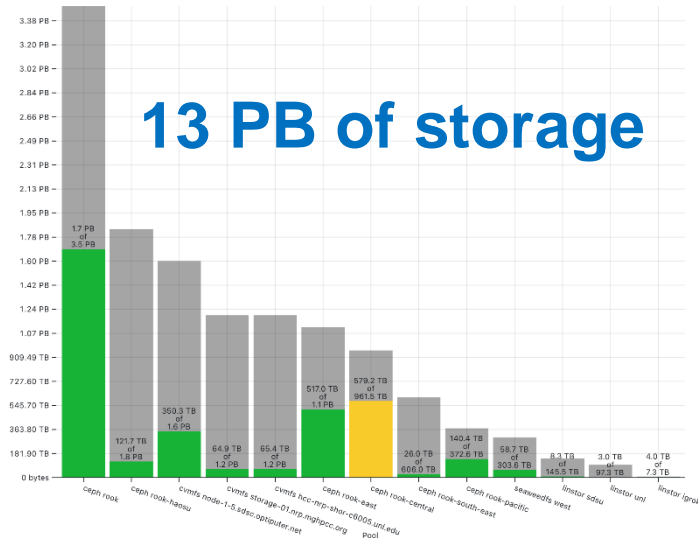
68 Institutions integrated in NRP  
43 integrated at IPMI layer  
25 integrated at Kubernetes layer



Hardware locations in our Kubernetes "cluster"

 NRP Site  
 OSDF-exclusive Site

Type of Accelerator	# of that type in NRP	Type of Accelerator	# of that type in NRP
A100 80G	224	4090	10
A100 40G	2	3090	247
A10	288	2080Ti	152
A40	10	1080Ti	139
A6000	48	Xilinx U55C	32
A5000	6	Other GPUs	104
A4000	32	<b>Total</b>	<b>1262</b>



**In addition, there are 21,070 x86 CPU cores, 7,406 are in nodes that have no accelerators.**

**Our of this total the NSF PNRP award (NSF OAC 2112167) contributes:**

**64 A100 80G  
288 A10  
32 Xilinx U55C  
4 PB of storage**

Data is stored at origins  
and accessed via caches

Annual Average of  
80 files/second accessed  
2.5B total last year

Any Data is Accessible Anytime  
from Anywhere



6 of 16 origins  
19 of 32 caches  
hosted in NRP





# 143 Institutions joining at the batch or storage system layer



Combining all 3 layers, we integrate ~200 institutions across 5 continents

## **Bridging Education & Research by having them co-exist on one platform**

A lot of the smaller campuses care more about educational use than research use on NRP.

**We made education on NRP a special focus of 5NRP  
with sessions on Thursday and Friday**

# Building AI Education on NRP

## ... Two Examples ...

- GP-Engine (NSF OAC 2322218) builds a regional compute cluster across 7 states in the Great Planes Regional Network.
  - Hardware is mostly GPUs, with strong focus on supporting STEM education, especially AI.
- **CENIC AI Resource**
  - Collaboration between California's regional R&E network, NRP, and multiple California State Universities with strong focus on AI education
  - Includes "The California State University System Technology Infrastructure for Data Exploration (TIDE)" (NSF OAC 2346701)
    - The CSU system includes 23 campuses, 21 of which are Hispanic-Serving Institutions.
      - "... most diverse higher education system in America ... provides 50% of all bachelor degrees in California ..."
    - " TIDE creates a pioneering computational core facility within the California State University (CSU) system, focused on ML and AI "



# Select UCSD Courses requiring CI Spring 2023



UCSD operates a modest size cluster (~140) 32-bit GPUs for use in the classroom  
6,502 undergraduates & 1,847 graduate students used this in AY22/23

- Advanced Computer Vision
- Bioinformatics for Immunologists
- Computational Physics: Probabilistic Models/Sim.
- Data Analysis/Design for Biologists
- Data Science/Spatial Analysis
- Deep Learning and Applications
- Intro to Causal Inference
- Neural Networks/Pattern Recognition
- Numerical Analysis for Multiscale Biology
- Robot Manipulation and Control

**AI is accelerating a trend that already existed prior.**  
1/3 of use is easily identifiable AI/ML containers

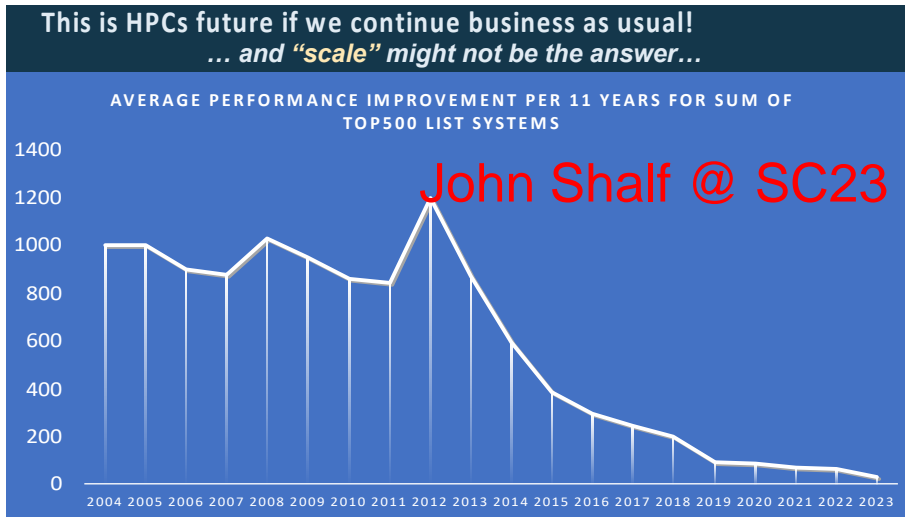
# **NRP brings CS R&D and Domain R&D onto the same platform**

**NRP blurs the lines between "testbed" and "production" CI**

**Create social cohesion to accelerate domain science adoption of new programming paradigms & architectures**

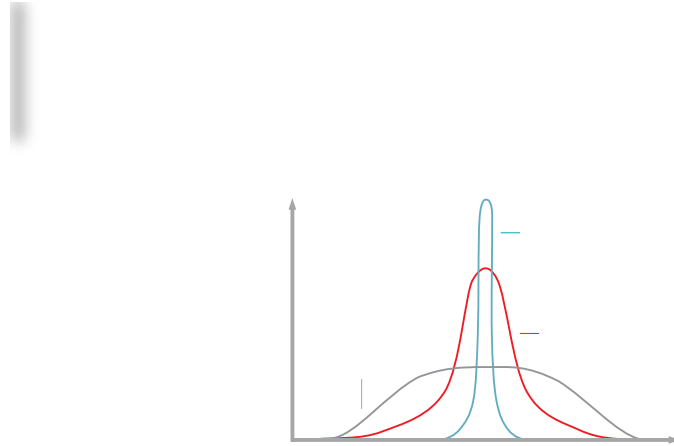


“end of Moore’s law” motivates new architectures



Performance improvements vs time slowed down by  $O(100)$

PI, Tajana Rosing



Mark Papermaster, CTO of AMD

PRISM, a Jump 2.0 project funded by SRC is early user of FPGAs@NRP

NRP supports FPGAs (Xilinx & Intel), P4 switches, NVIDIA DPUs & HGXs

Committed to be a “Playground” of technologies, easily deployed and operated.

- **Programmable computational capabilities emerged in devices of all kinds**
  - Storage devices with embedded FPGAs => "Computational Storage"
  - GPUs on Network Interface Cards => "Data Flow Programming"
  - Programmable switches, down to individual ports => "Programmable Networks"
- We innovate nextGen systems in ATL to solve grand challenges of science
- Innovations made available to all of open science via our Open Infrastructure

**Strategic Objective is to bring CS Research closer to Domain Research in the hope of decreasing time to adoption of new technologies & ideas**

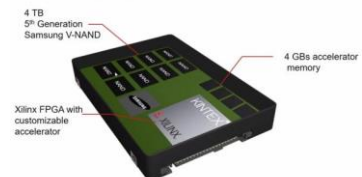
**NVIDIA BlueField DPU**



**P4 programmable switches**



**Xilinx SmartSSD**

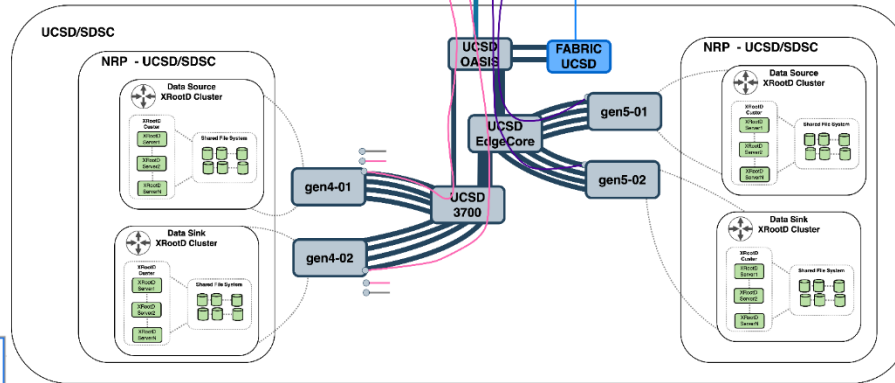
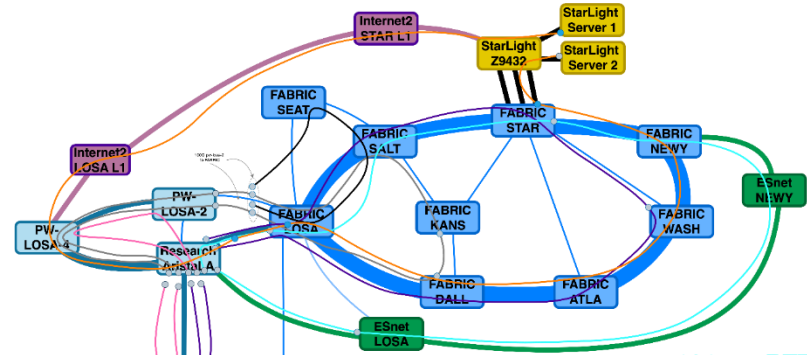




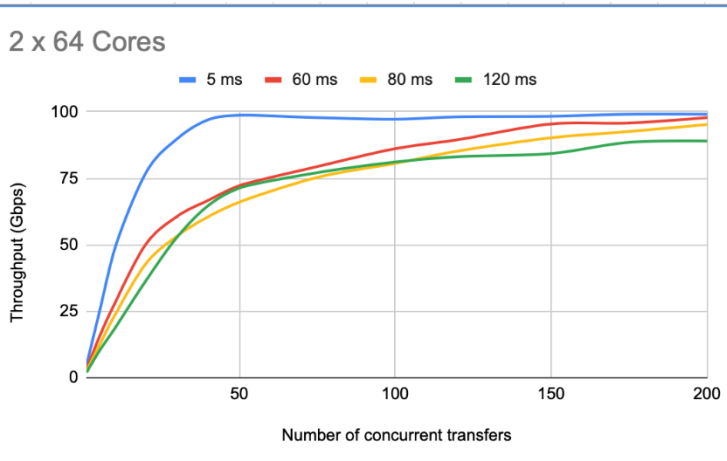
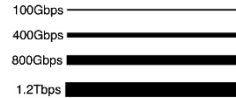
# Example FABRIC-NRP Integration Exercise

Create various RTT loops across FABRIC, NRP, ESnet, CENIC, StarLight, Internet2

All begin & end on NRP@SDSC



- 131 ms RTT
- 122 ms RTT
- 108 ms RTT
- 80 ms RTT
- 58ms RTT
- 6 ms RTT



Started using this testbed for measurements yesterday.

- **NRP has a very ambitious vision**
  - Horizontally open
    - Today about 3x # of GPUs total than what was part of Cat-II PNRP award
      - PNRP award started testbed operations phase on 3/27/23
  - Vertically Open
    - We have built the “Open Science Data Federation” on top of NRP,
    - ... and are starting to build “Fusion Data Platform for AI” on top of NRP
    - ... and are starting to build elements of the National Discovery Cloud for Climate on top of NRP (Pelican, National Data Platform, NCAR integration, ...)
  - “Playground” for CS R&D on the same platform as “Production” system for Domain Scientists
- **Education increasingly requires significant CI**
- We are off to an excellent start ... but there is lot’s more to come over the course of the next 5 years.

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