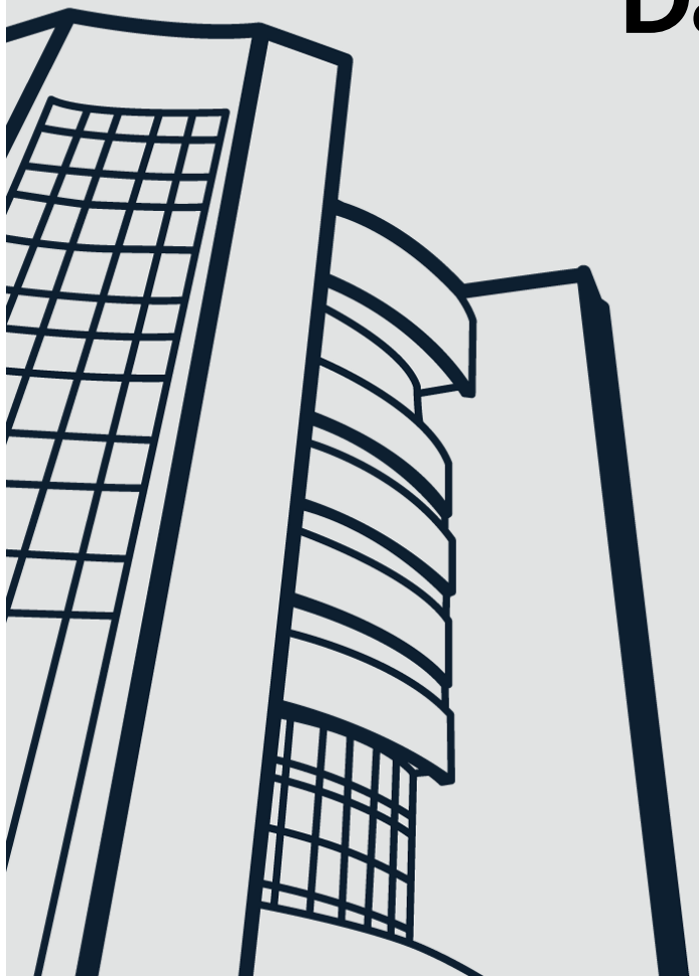
국가와 국민을 위한
데이터 생태계 중심기관 KISTI



Data Sharing Infrastructure across Northeast-Asia Supercomputing Centers(A3) for Open Science
(HEP, KEK, and Spring-8 etc)

KISTI/KREONET
Jeonghoon Moon
16th Jan 2025

KiSTi 한국과학기술정보연구원
Korea Institute of Science and Technology Information
www.kisti.re.kr

Contents

[1] Global trends of infrastructure for Open Science
– Global Computing & Data sharing Infrastructure (NRP/GRP/ANAN APRP/IRI)

[2] Open Science in Korea
– ScienceDMZ & Research Platform

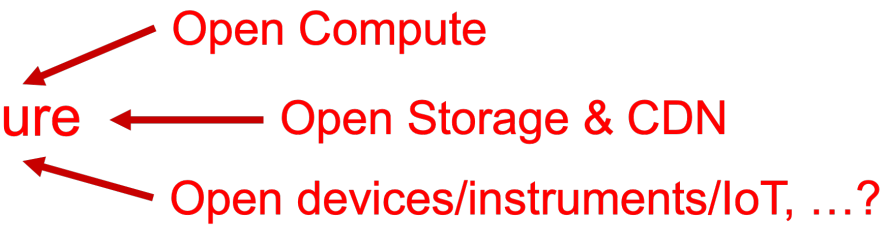
[3] Korea, China, and Japan New collaboration international project
– A3 Foresight Program

Global Computing & Data sharing Infrastructure

[1] NRP, GRP, APRP, KRP
[2] IRI ABA

Long Term Vision

- 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



Openness for an Open Society

Source by Frank Wurthwein/SDSC/UCSD

NRP

[1] National Research Platform

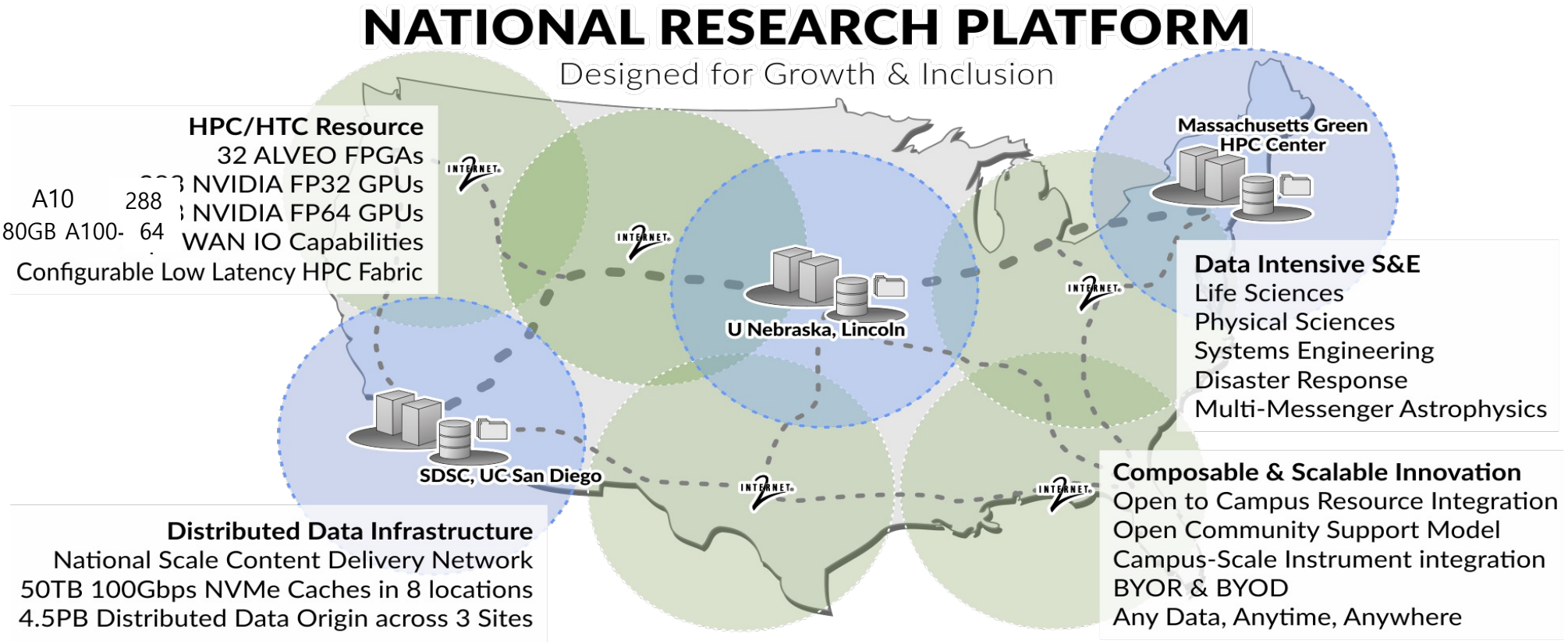
- **The National Research Platform** (NRP)
  - It is a partnership of more than 50 institutions, led by researchers and cyberinfrastructure professionals at UC San Diego, supported in part by awards from the National Science Foundation.

- **NRP is the name of the set of programs, facilities, and policies that are designed for distributed growth and expansion.**
  - NRP's primary computation, storage, and network resource is a ~300 node distributed cluster called ***Nautilus*** that will grow significantly by the end of 2022. Nautilus hosts many network testing data transfer nodes including ones used by the Open Science Grid (OSG).

- **Nautilus is a powerful nationally distributed computer system**
  - With CPUs, GPUs, and FPGAs, in two types of subsystems ("high-performance FP64/FPGA" and "FP32-optimized"), specialized for a wide range of data science, simulations, and machine learning or artificial intelligence, allowing data access through a federated national-scale content delivery network.

NRP
NATIONAL RESEARCH PLATFORM

National Research Platform Prototype for national scale



5 year project with $4.8M hardware & $6.45M people

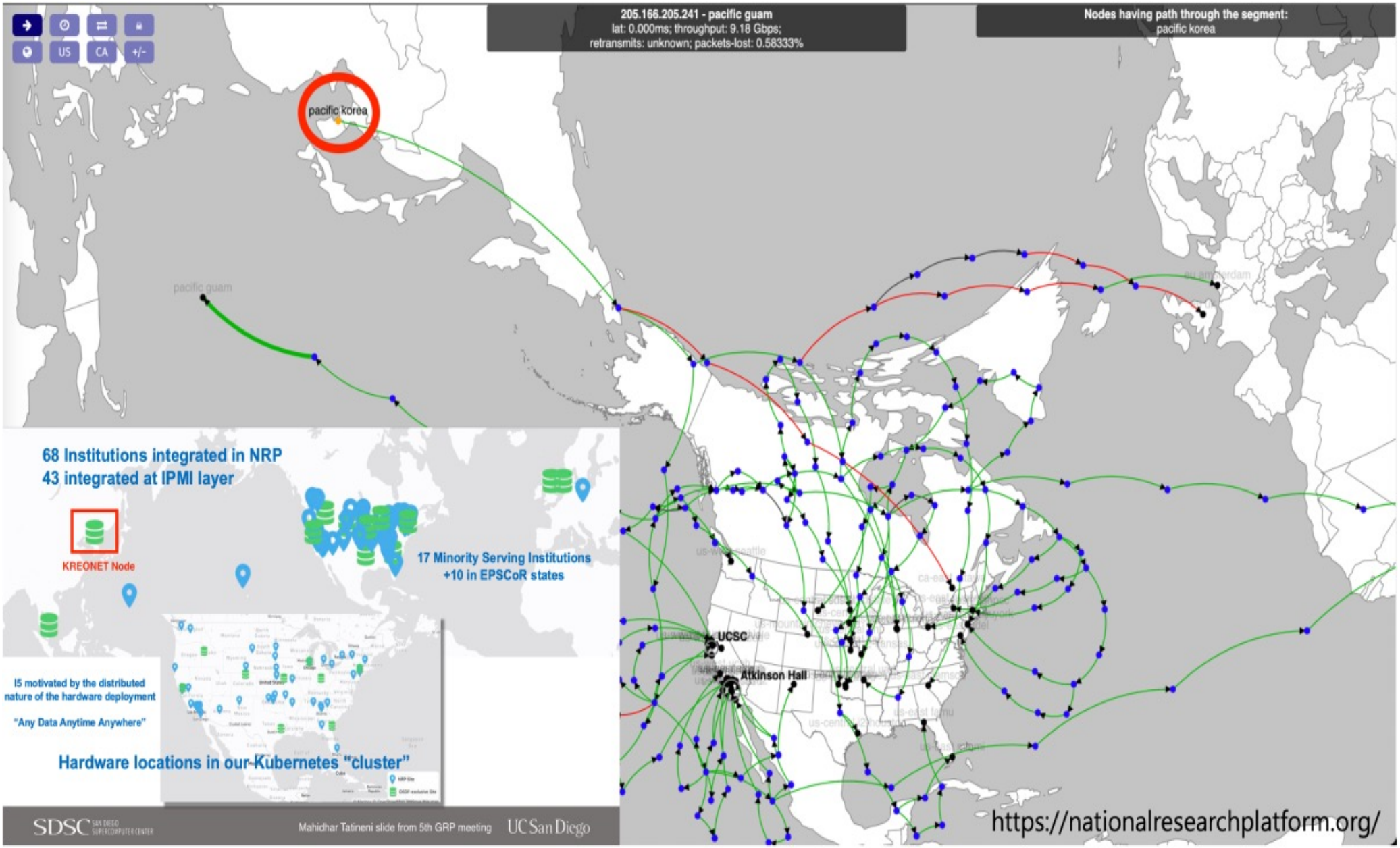
Supports Nautilus, and thus the core NRP infrastructure

Promises to go beyond "PRP" functionality

PI = Wuerthwein; Co-PIs: DeFanti, Rosing, Tatineni, Weitzel

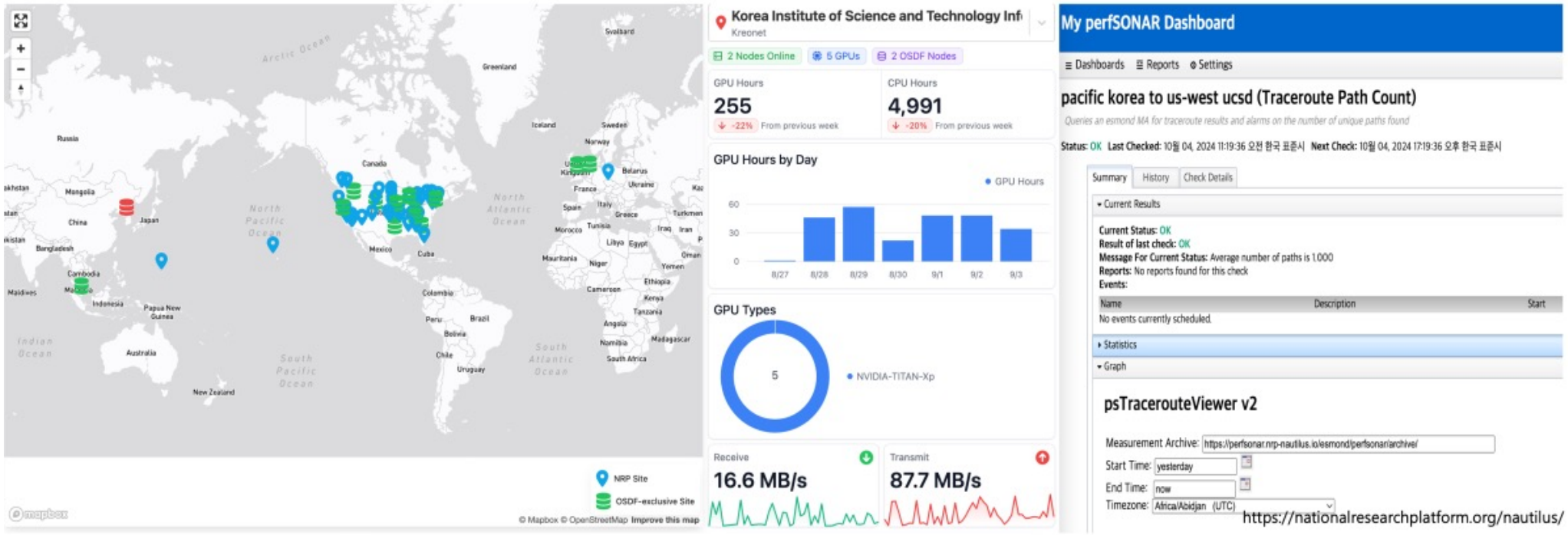
Funded as NSF 2112167

National Research Platform



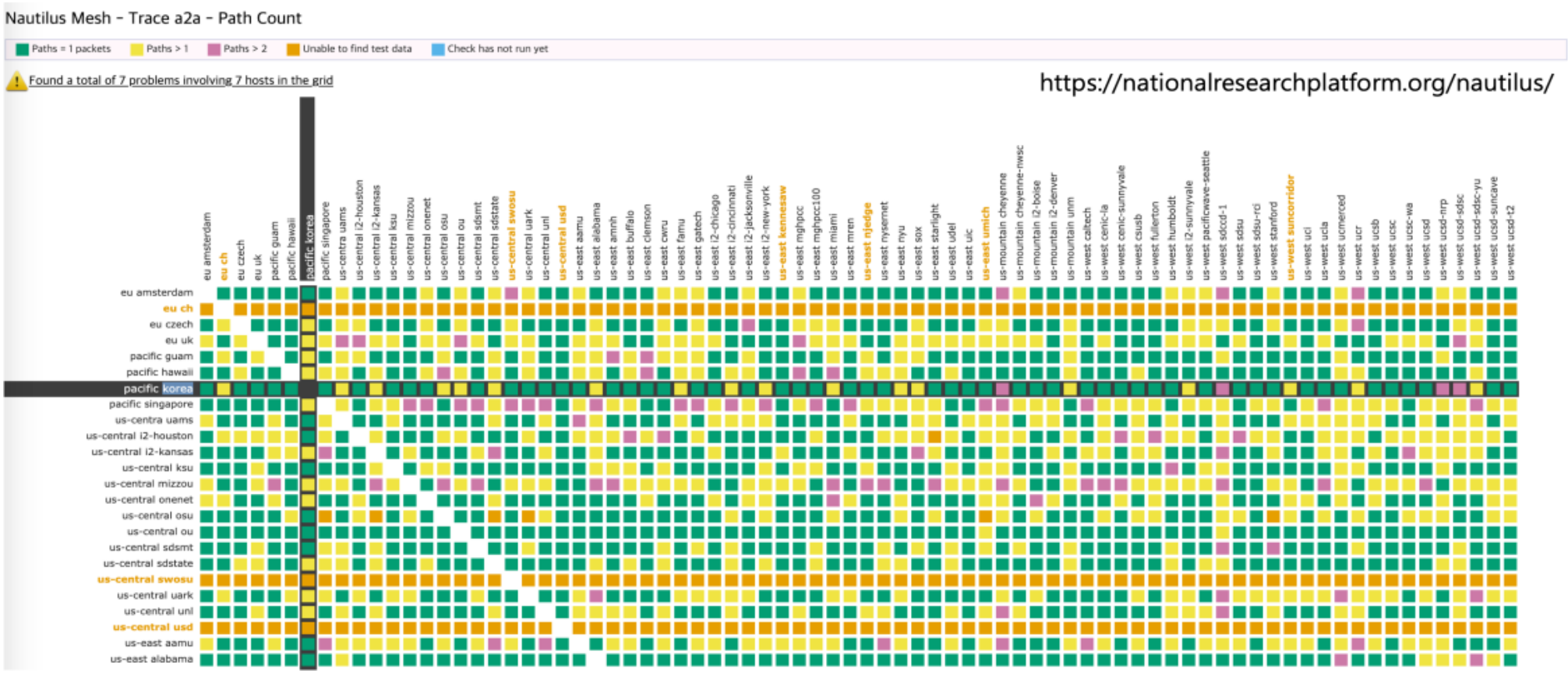
National Research Platform status

- Current status of KISTI nodes(donated 2 node to the NRP platform)
  - GPU base node, CPU base node
- System monitoring by Prometheus/Grafana
- Usability & Network ststus
- Type of the node – GPU, CPU, Memory, Storage



National Research Platform status

- KISTI donated 2 node to the NRP platform
  - GPU base node, CPU base node
- Network monitoring via Maddash by PerfSONAR: 78 sites for global
- Monitoring Matrix color
  - Green/Yellow/Orange/Pink
- Network performance Monitoring
  - 24 hours and 365 days performance guarantee



GRP

[1] Global Research Platform

Global Research Platform (GRP)

- The Global Research Platform (GRP) is an international scientific collaboration
  - To create one-of-a-kind advanced ubiquitous services that integrate resources around the globe at speeds of gigabits and terabits per second.
  - Focuses on design, implementation, and operation strategies for next-generation distributed services and infrastructure to facilitate high-performance data gathering, analytics, transport, computing, and storage, at 100 Gbps or higher.
- GRP has partners in North America, Asia, Europe, and South America to customize international fabrics and distributed cyberinfrastructure to support data-intensive scientific workflows.
  - Americas' Research Network (AmRP), North/South/Latin America
  - Asia Pacific Research Platform (APRP), APAN, Asia Pacific
  - MREN Research Platform (MRP), Midwest Research & Education Network, Midwest, USA
  - National Research Platform (NRP), USA



APAN APRP

[1] APAN(Asia Pacific Advanced Network) APRP(Asia Pacific Research Platform) WG

APAN APRP(Asia-Pacific Research Platform) WG

- **Since 2018 APRP WG initiated at APAN 45th 2018 in Singapore**
  APRP – Asia Pacific Research Platform Working Group
  APAN meeting held 2 times in a year

- **Objectives**
  APRP WG develops technologies to provide data-intensive science (HEP, Astronomy, Earth ScienceAI, Bio, Climate/Weather, Agriculture) environments and various computing resources by linking distributed HPC systems and establishing a stable big data highway system based on NREN in the big data era, and promotes related research collaboration in the Asian region.
  - Promote **Distributed & Shared HPC ecosystem in the Asia-Pacific**.
  - Engage **APAN members and ASEAN countries**
  - Towards the setting up an **Asia Pacific Research Platform (APRP)** and **become a part of a Global Research Platform**

- **Executive member**
  Chair : Jeonghoon Moon, KISTI, Korea
  Co-Chair : Andrew Howard, NCI, Australia
  Secretary : Asif Khan, Qatar Univ. Qatar

- **Asi@Connect 5th Call project by TEIN*CC**
  Title : A High bandwidth distributed HPC (1st April 2022 – 31st July 2023)

- **A3 Foresight Program Project by A3 Countries NRF**
  Title : Data Sharing Infrastructure across Northeast-Asia Supercomputing Centers for Open Science (1st Aug. 2024 – 31st Jul. 2029, 5 Years)

APAN 58th Meeting & APRP WG session



- **APAN 58th APRP Meeting**
  - Held at Islamabad in Pakistan(26th Aug. to 30th Aug. 2024)

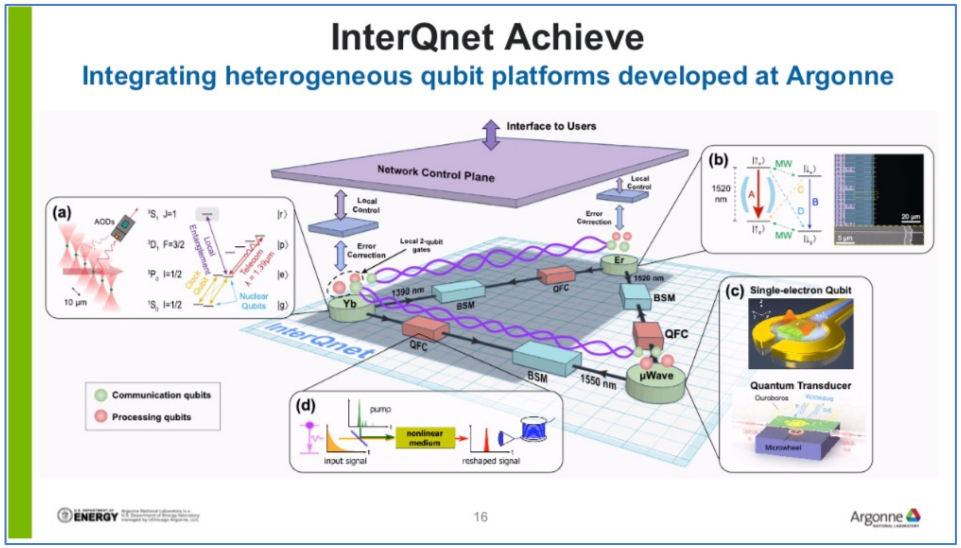
- **Session Information**
  - Session 1: Keynote Speech and Technical Part, Chair: Jeonghoon Moon, 0900 – 1030
  - Session 2: Application and Country Update Part, Chair: Andrew Howard, 1100 - 1230
    10 Presentations from 6 countries
  - Keynote Speech: Quantum Network by Dr. Raj Kettimuthu (ALN/US)
  - Presenters: 10 presentations, 6 countries
  - Keywords: Big data, A3 Foresight Program, New Project, DMC/Cloud of NCI, Inter Data Center, Apply for Agriculture, Bio-Science, AI-Science, PERN, etc

Session 1

Session1, 0900-1030 GMT +5(PK time), 28th Aug. Chair: Jeonghoon Moon(KISTI/KR)		
1	0900-0903	Introduction of APRP WG and sessions (Jeonghoon Moon/KISTI/KR)
2	0900-0918	FNAL's High-Speed Networking R&D Efforts for the HL-LHC (Asif Raza/Fermilab/US)
3	0918-1010 (Keynote)	INTERQNET: A systems approach to realize a scalable quantum network (Raj Kettimuthu/ANL/US)
4	1010-1025	NDeX Project: Inter data centers big data transfer (Kiwook Kim/KISTI/KR)
5	1025-1035	Data Sharing Infrastructure across Northeast-Asia Supercomputing Centers for Open Science (Jeonghoon Moon/KISTI/KR)

Session 2

Session2, 1100 - 1230, GMT +5(PK time), 28th Aug. Chair: Andrew Howard(NCI/AU)		
1	1100-1115	Australia Country Update and NCI future works (Andrew Howard/NCI/AU)
2	1115-1130	Introduction of PERN and activities(Ahmed Naeem/PERN/PK)
3	1130-1145	AI research activities of Sukkur-IBA Univ. in PK (Ghulam Mujtaba/Sukkur-IBA Univ.PK)
4	1145-1200	EBC-K project in MY(Nor Asilah/UPM/MY)
5	1200-1215	HPC & Bioinformatics activities(Asif Khan/Perdana Univ./MY)
6	1215-1230	Research Platform and apply for Agriculture fields (Kihyeon Kim/KISTI/KR)

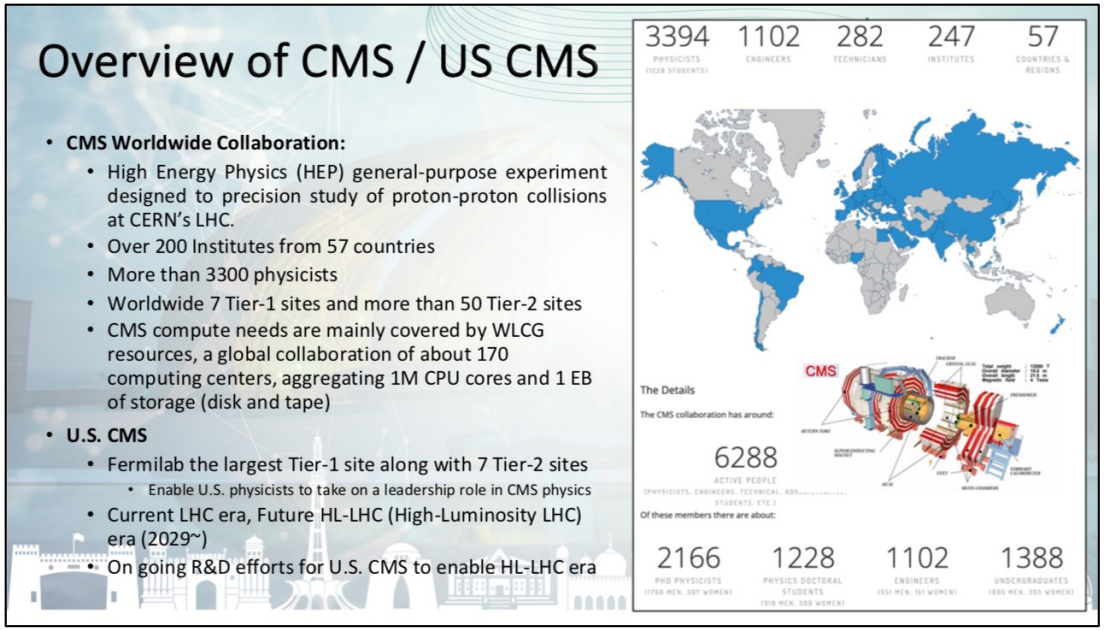


Keynote Speech: Overview of Quantum Networking Technologies and Ongoing Quantum Networking Research at Argonne(Rai Kettimuthu/ANL/US)

⇨

FNAL's High-Speed Networking R&D Efforts for the HL-LHC era (Asif Raza/ FermiLab/US)

⇦



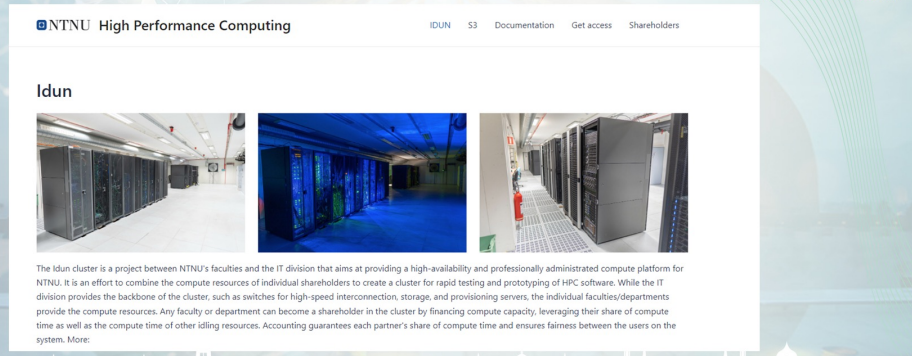


Extra Budgetary contribution from Korea (EBC-K 2024) Project(Nor Asilah/UPM/MY)

⇨

Summary of Sessions

Available Computational Resources for Training and Testing AI Models

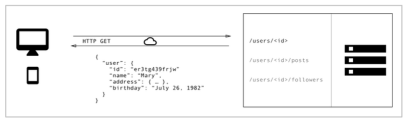


Introduction to NDeX(Kiwook Kim/KISTI/KR)

4. Agricultural Big Data Research Platform Linkage Plan

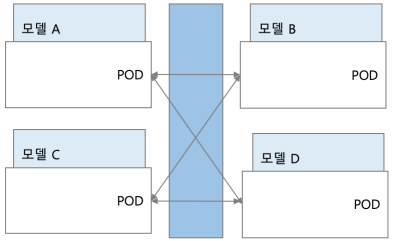
- **Platform Composition Plan (Draft)**
  - Platform and SW Configuration for Container and API Networking Processing
  - Container Control/Management -> Kubernetes Open Source SW
  - Model Management -> Harbor
  - Data Management -> Ceph
  - (Option 1) API Networking -> Self-made API Protocol
  - (Option 2) DevOps/MLOps -> Dizest, Argo, Mlflow

API Networking Protocol Development



Rest API-based Protocol
Pipelining/Ensemble Linkage between Models

(Option 1) API Networking Protocol Creation

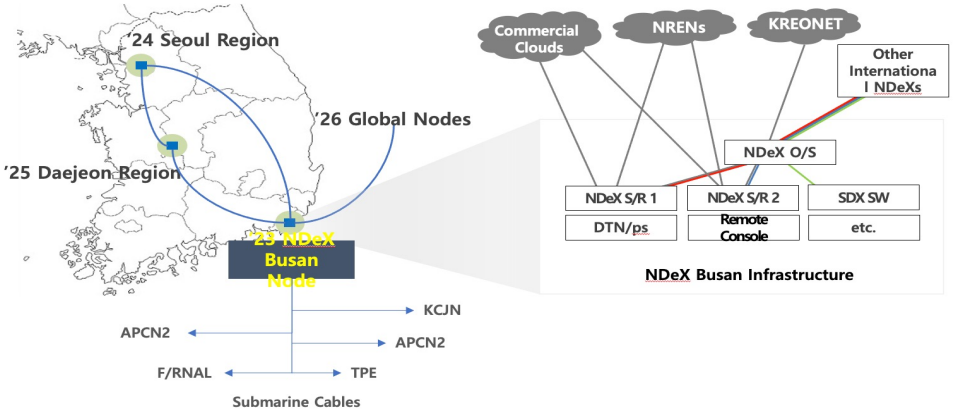


18

AI Research Activities@Sukkur-IBA University (Ghulam Mjtaba/Sukkur-IBA Univ/PK)

Building Distributed NDeX Infrastructures

- NDeX Regional Node Establishment Plan
  - '23 : Completed pilot node in the Busan metropolitan area.
  - '24 : New node to be built in the Seoul metropolitan area.
  - '25 : Additional node planned for the central region of Korea.



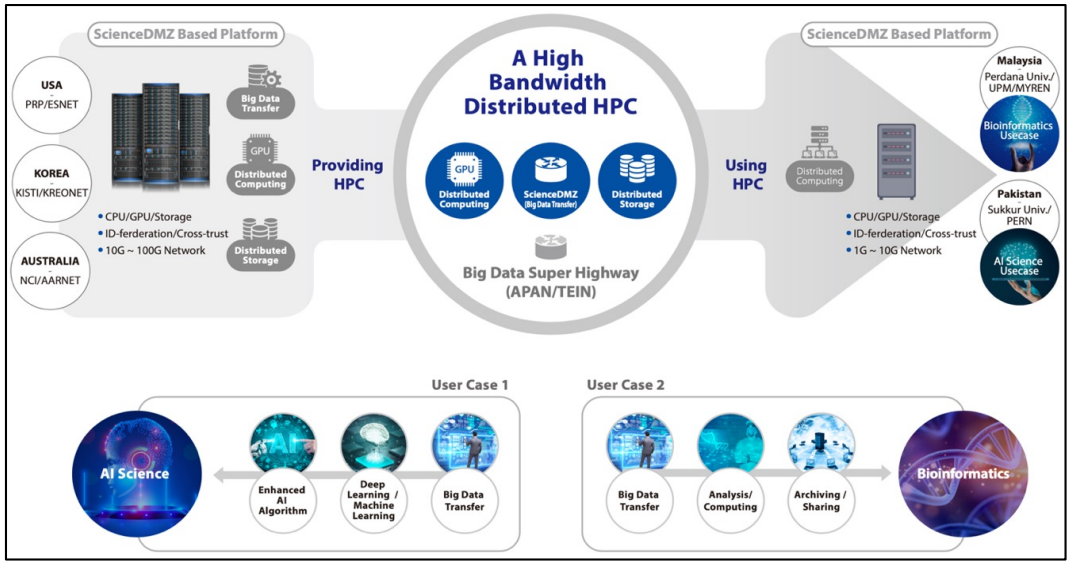
Big Data Research Platform (Kihyeon Kim/KISTI/KR)

Asia-Pacific Research Platform setup@UPM/Malaysia

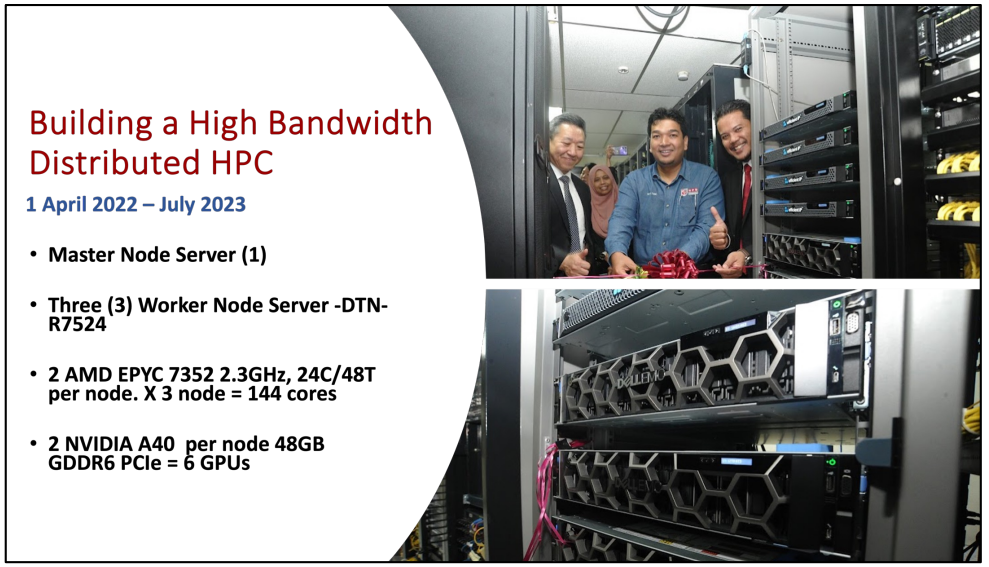
- Asia-Pacific Research Platform setup complete at UPM of Malaysia(Feb. 2024)
- Test running for various Applications (refer. Table)
  - APRP platform is being tested and used by Jupyter/Python users.
  - There are about 5 categories of the application areas

No.	SW	Time (days / hours) (Laptop with 1 processor)	Time (days/hours) (Max core available are 48 cores)	Reduce to
1.	Gromacs	3 months (90days)	With 48 cores	9 days
2.	Pythons	15 hours	With 24 cores	2 hours

- Open plan to APRP WG members (Pakistan, Nepal, Sri-Lanka and Thailand)
- Share the computing resources with KR, AU, JP, SG etc



Architecture of APRP



APRP setup@UPM

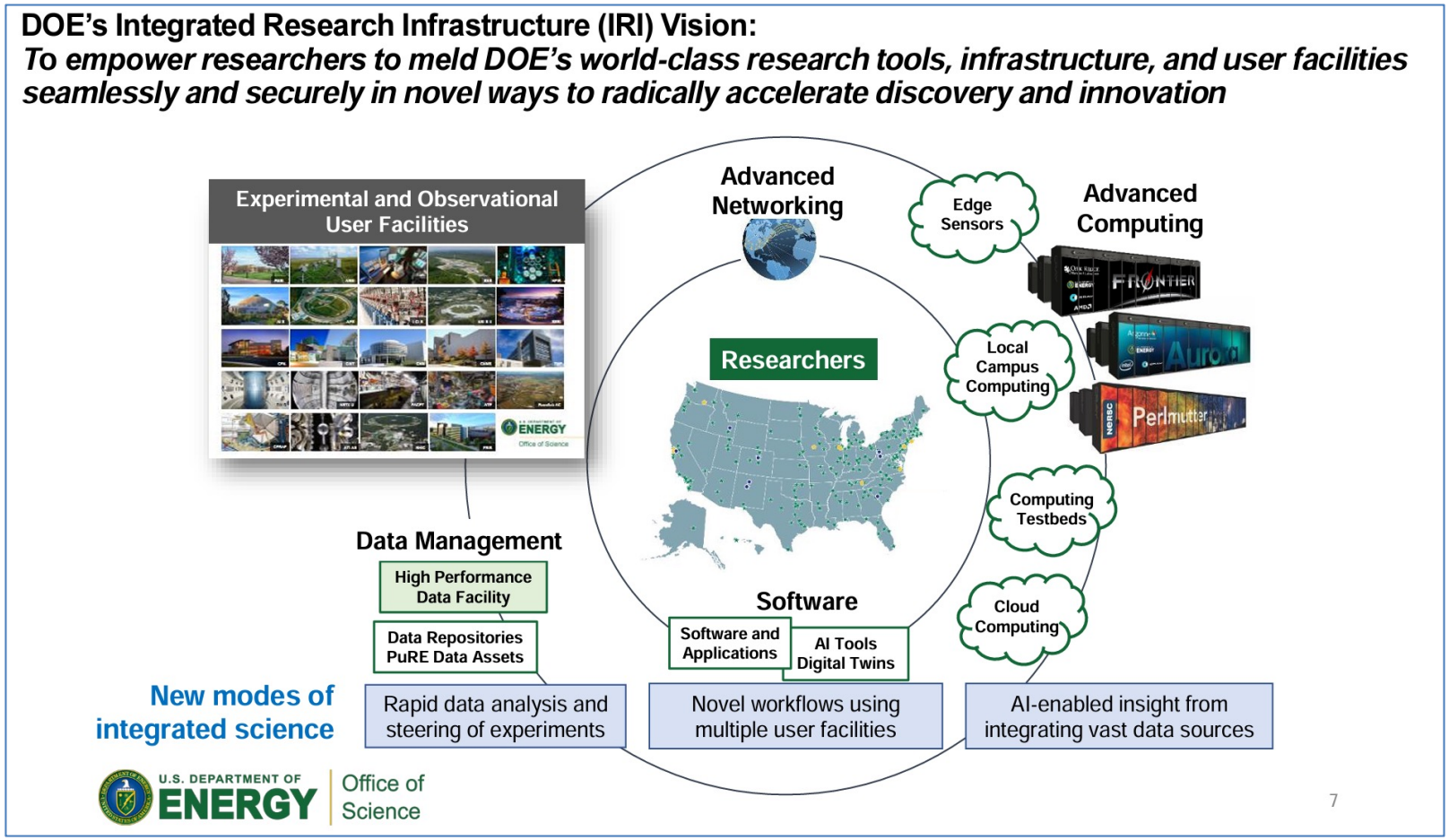
IRI ABA

[1] IRI ABA (Integrated Research Infrastructure Architecture Blueprint Activity)

IRI ABA, ASCR

- DOE's IRI Vision : To empower researchers to meld DOE's world-class research tools, infrastructure, and user facilities seamlessly and securely in novel ways to radically accelerate discovery and innovation. **"Simple and powerful"** is the core keyword: researchers will benefit from an operational environment that is intuitive and simple to use yet extraordinarily powerful in accelerating discovery.

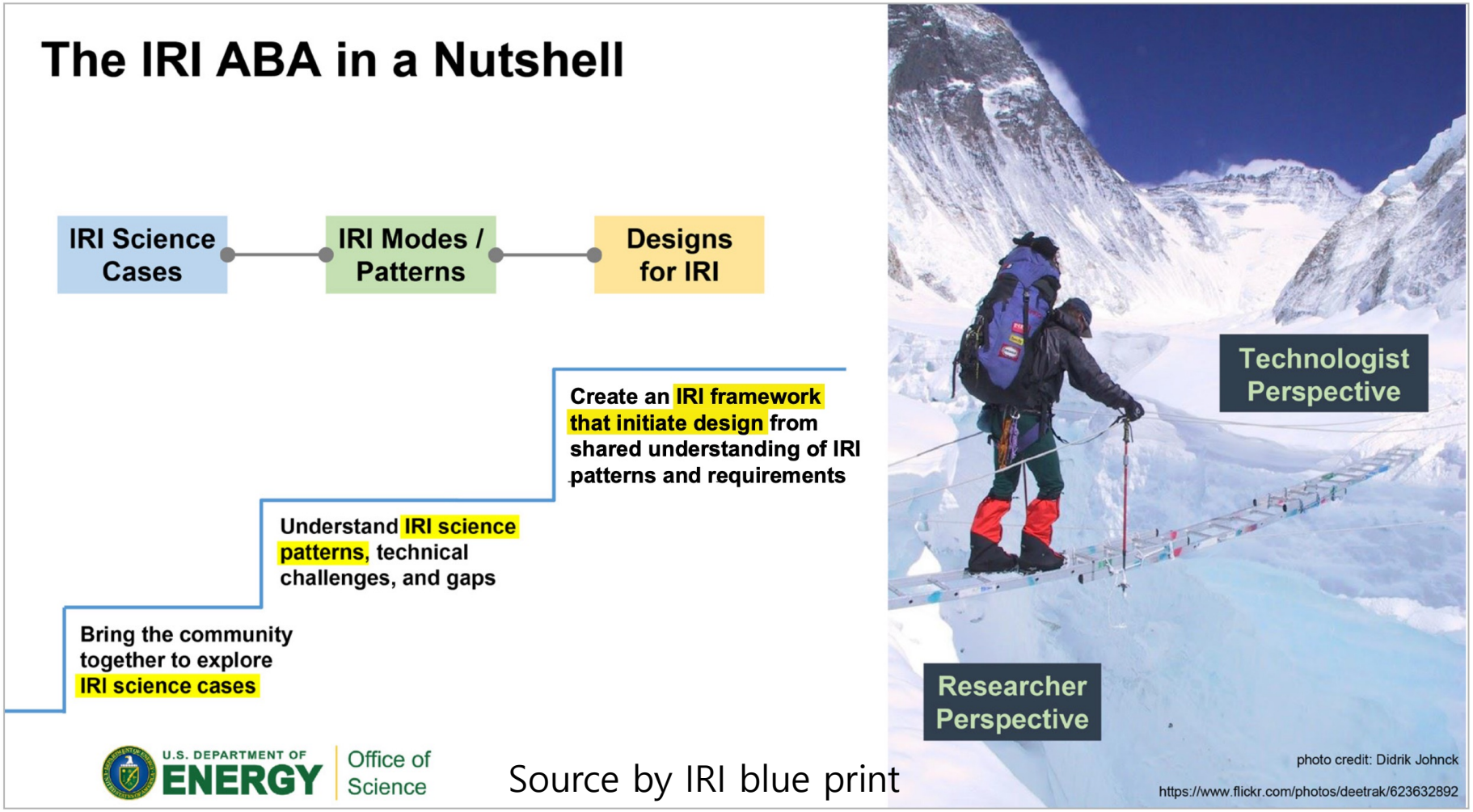
- In 2022, SC leadership directed the **Advanced Scientific Computing Research (ASCR)** program to conduct the **Integrated Research Infrastructure Architecture Blueprint Activity (IRI ABA)** to produce a reference framework to inform a coordinated, SC-wide strategy for IRI.



Source by Ben Brown Director, Facilities Division, Advanced Scientific Computing Research (ASCR)

IRI ABA

- **IRI Science Cases** - Bring the community together to explore IRI science cases
- **IRI Models/Patters** - Understand IRI science patterns, technical challenges, and gaps
- **Designs for IRI** - Create an IRI framework that initiate design from shared understanding of IRI patterns and requirements



Source by IRI blue print

KRP

[1] Korea Research Platform

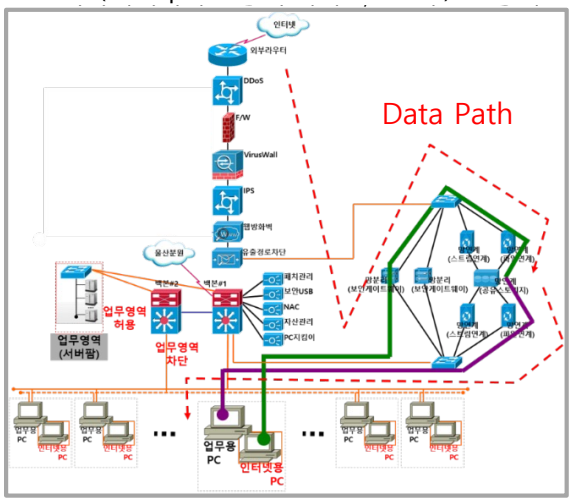
Why ScienceDMZ

Research trends changed to Data Intensive Science

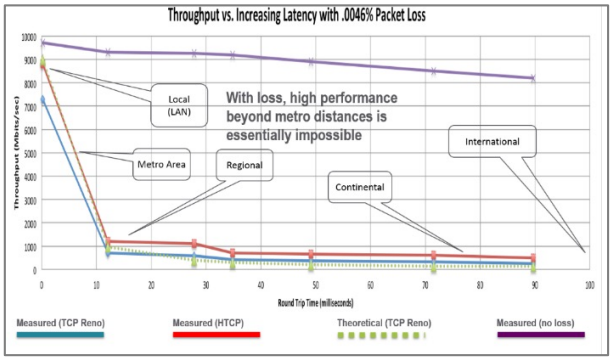
Big data super highway



Data path is a very complicated
(7 steps to enter the inside)

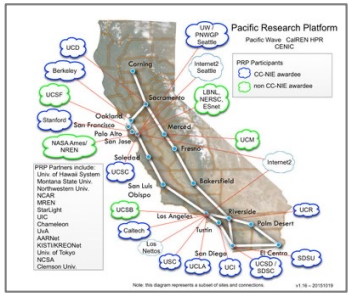


Packet loss problems

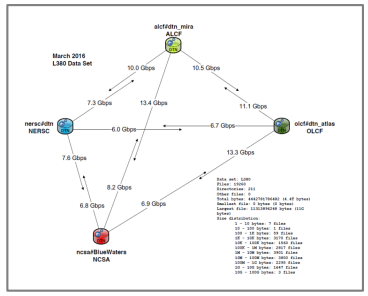


☞ 0.0046% packet loss make a huge performance down

ScienceDMZ Examples



USCENIC
PRP Proejct, connecting Science Big Data sources with ScienceDMZ (Calit2)



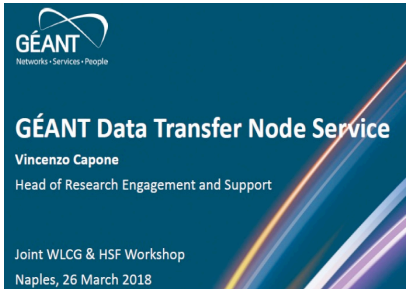
US/ESNET
ESNet connecting Supercomputers with ScienceDMZ (ESNet)



US/Fermilab
DTN as a Service for BigData Express(iCAIR)



US/NCAR
ESNet trying to integrate ScienceDMZ to NCAR RDA (ESNet)



Europe/GEANT
EU trying to Implement ScienceDMZ on GEANT (GEANT)

KREONET become a Science Big Data Super Highway

- ScienceDMZ launched by Esnet at 2010, Basis of PRP/NRP Architecture and Design

Network Architecture (zero friction)

Data Transfer Nodes (DTN/FIONA)

Performance Monitoring (perfSONAR)

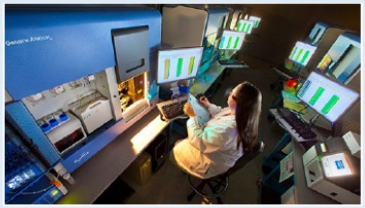
Science DMZ

- ScienceDMZ: Accelerates Science Research
- Partnering on Science Engagement and Technology Adoption

Super Facilities



Big Data &Supercomputer



Big experimental Facility

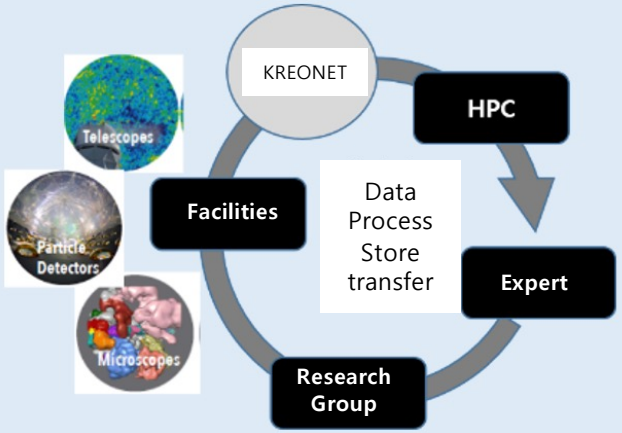


Big data producer

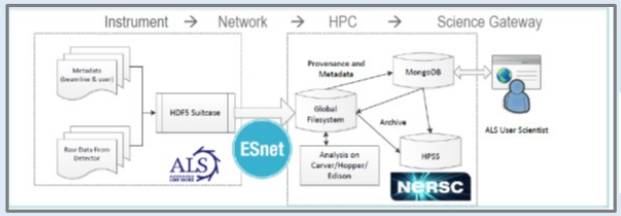
Changing Research environment

Machine Learning
+
Online Data
+
HPC Computing

Requirement for Research Network in Korea



Bridge role between Supercomputer and experimental facilities



Role model of Esnet and NERSC

LSST (Large Synoptic Survey Telescope)

100Giga Big Data Transfer Demonstration "a remarkable 99.7 Gbps on the 100Gbps path between Dallas and Daejeon"

- **LSST Data Flows to KISTI and KASI**

  During the course of the LSST and AmLight SC18 demonstrations, data from the telescope site in Chile arrived via AmLight at both the KISTI and Caltech booths in Dallas, where it was mirrored and carried across SCinet, Starlight, KRLight and KREONet2 to DTNs at KISTI and KASI in Korea, as shown in the figure below. Using Caltech's Fast Data Transfer (FDT) application, throughputs of 58 Gbps were achieved across the 60 Gbps path from the telescope site to the KISTI booth, and a remarkable 99.7 Gbps on the 100 Gbps path between Dallas and Daejeon.

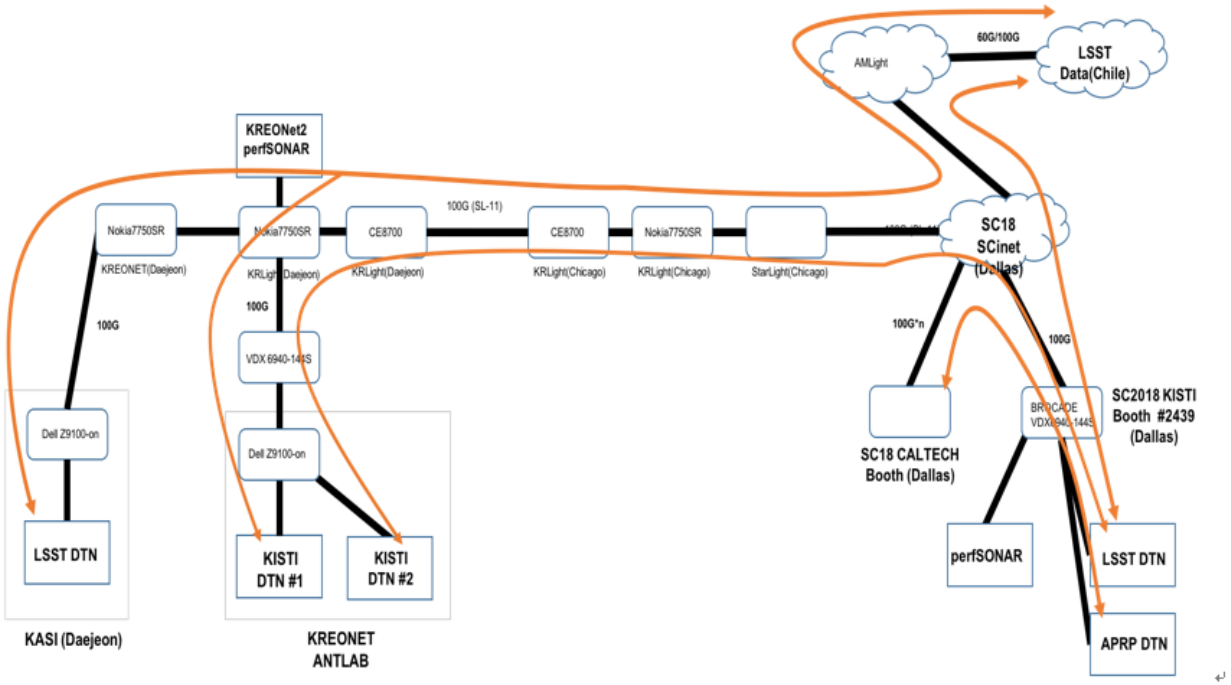
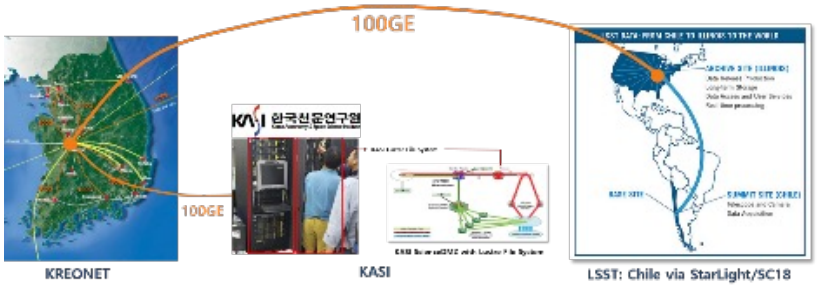


Figure 1 Data flow paths among the LSST telescope site, the KISTI and Caltech booths, and KISTI and KASI in Korea during the SC18 demonstrations



For more information on

Global Petascale to Exascale Science Workflows Accelerated by Next Generation Software Defined Network Architectures and Applications

Government Laboratory, Network & Technology Industry Partners

ESnet	www.es.net
Lawrence Berkeley Nat'l Lab	www.lbl.gov
Internet2	www.internet2.edu
CENIC	www.cenic.org
Pacific Wave	pacificwave.net
AmLight	www.amlight.net
SCinet	
Starlight	www.startap.net/starlight/
USC	
Northeastern	
PRP	http://prp.ucsd.edu/
Yale	www.yale.edu
Colorado State	
Fermilab	
CERN	
KISTI	http://www.kisti.re.kr/eng/
TIFR	
Michigan	
RNP	www.rnp.br
ANSP	www.ansp.br
UNESP	http://www.unesp.br/international/
REUNA	
CenturyLink	www.centurylink.com
2CRSI	www.2crsi.com
Arista	www.arista.com
Cisco	www.cisco.com
Echostreams	www.echostreams.com
Intel	www.intel.com
Mellanox	www.mellanox.com
Dell	www.dell.com
Pica8	www.pica8.com

Korea Research Platform (KRP) for Domestic

- Since 2015, Global partner of PRP project
- Since 2018, Leading of APAN APRP WG
- Since 2021, Expanding to 7 Korea National Research Institute
- Since 2022, Asi@Connect Project/TENI*CC for international
- Since 2024, A3 ForeSight Program Project by A3 countires NRF

National Scale

Establish a high-reliability & high-speed transfer system without boundaries between participants

☞ For 25 Korea National Research Institutes & 4 University of Advanced Science & Technology

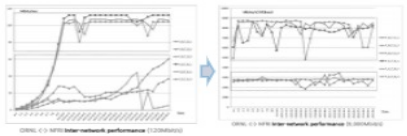


Key elements

- Borderless single domain transfer performance level
  - ☞ Esnet ScienceDMZ level
- A Unified authentication system without boundaries

Example of Nuclear Fusion Research

Improve transfer performance about 75 times after ScienceDMZ deploy
☞ To expand the national scale



HPC over HPN

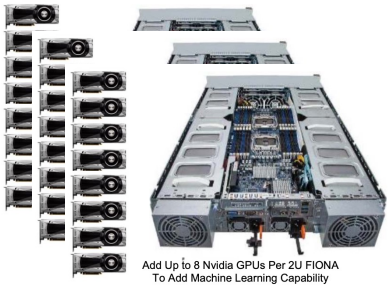
- Korea Research Platform expanding to 25 National Research Institutes
- HPC(Supercomputer, Cloud, Storage) over HPN and global federation

HPC over HPN: A High bandwidth distributed HPC

Korea Research Platform (1G ~ 100Gb/s)

Faster workflow with big data

GPU-DTNs



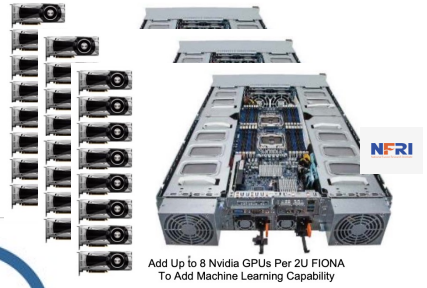
DATA center

Nurion



KISTI Supercomputer

GPU-DTNs



DATA center

A3 Foresight Program Project

[1] Consortium of A3 countries
[2] Data Sharing Infrastructure across Northeast-Asia Supercomputing Centers for Open Science
[3] Strategies and Key technologies

Overview of A3 Foresight Program Project

- **Main Title**
  - Data Sharing Infrastructure across Northeast-Asia Supercomputing Centers for Open Science

- **Sub Title(Korea Part)**
  - Research on building a high-bandwidth distributed HPC based on high-compression metadata of AI technology

- **Participants :** Korea, Japan, China

- **Duration :** Aug. 2024 – Jul. 2029 (5 Years)

- **Budget :** Korea(264,000$), Japan(347,000$), China(562,000$) = 1,173,000$

- **PI and Co-PI**
  - Hidetomo Kaneyama: RIKEN/Japan
  - Yutong Lu: NSCC-GZ(Sun Yat-sen Univ.)/China
  - Jeonghoon Moon: KISTI/Korea

Overview of A3 Foresight Program project Korea side

- Title : Research on building a high bandwidth distributed HPC environment on AI-based HCMD(High Compression Meta-Data)
- Host Institute: KISTI/KREONET Center by NRF in Korea
- Duration : 1st August 2024 – 31st July 2029
- Budget : 350,000,000 Won for 5 years
- Lead & Participants
  - PI: Jeonghoon Moon
  - Participants Researchers
    - Kiwook Kim
    - Kihyeon Kim
    - Jaeseung Kwak
    - Dongkyun Kim

The A3 Team

- **NSCC-GZ, Sun Yat-sen University**
  - PI: Yutong Lu **卢宇彤**
  - Professor, Director





- **R-CCS, RIKEN**
  - PI: Hidetomo Kaneyama **金山 秀智**
  - Expert Technician





- **KISTI**
  - PI: Jeonghoon Moon **문정훈**
  - Principal Researcher

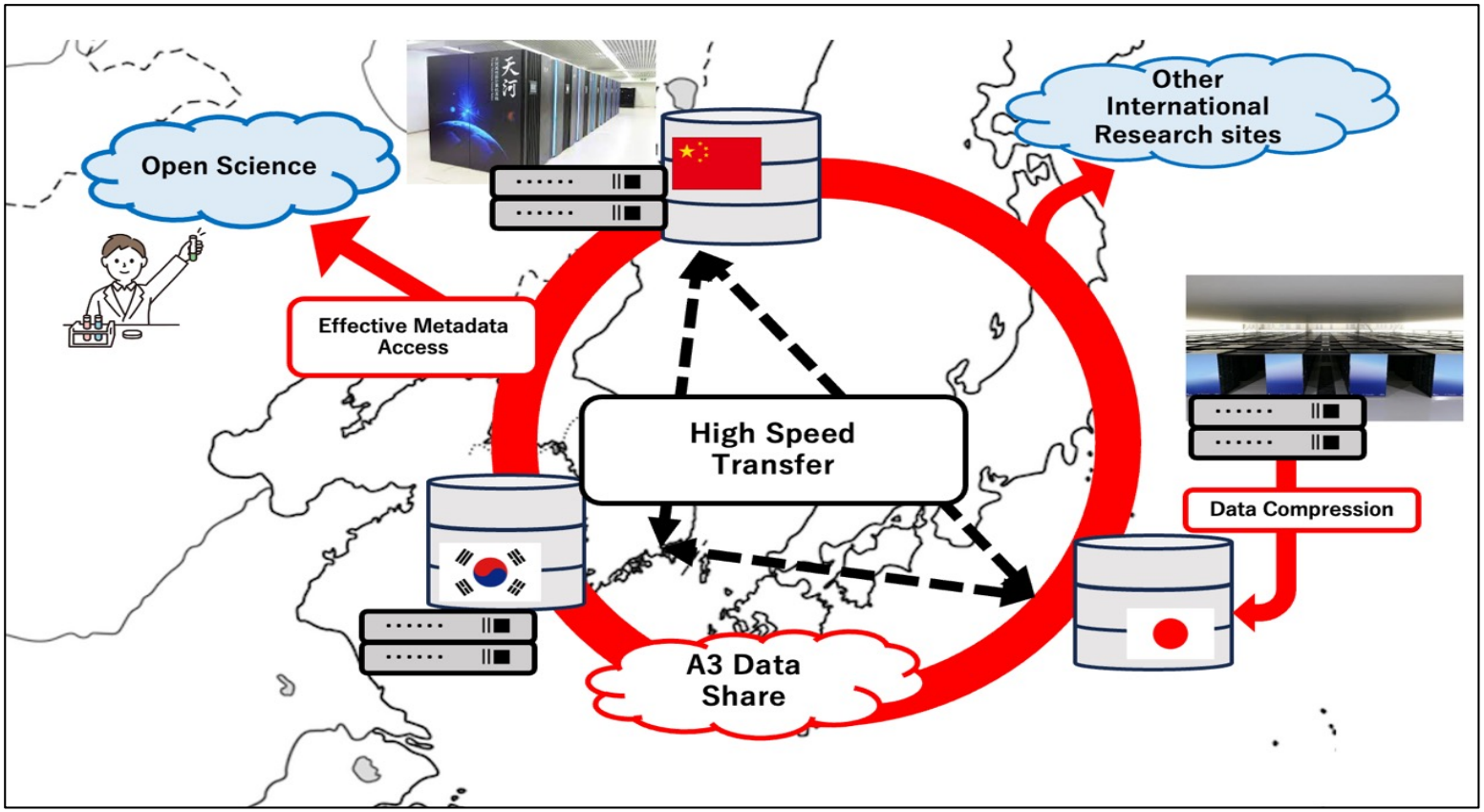




A3 Foresight Project - Objective

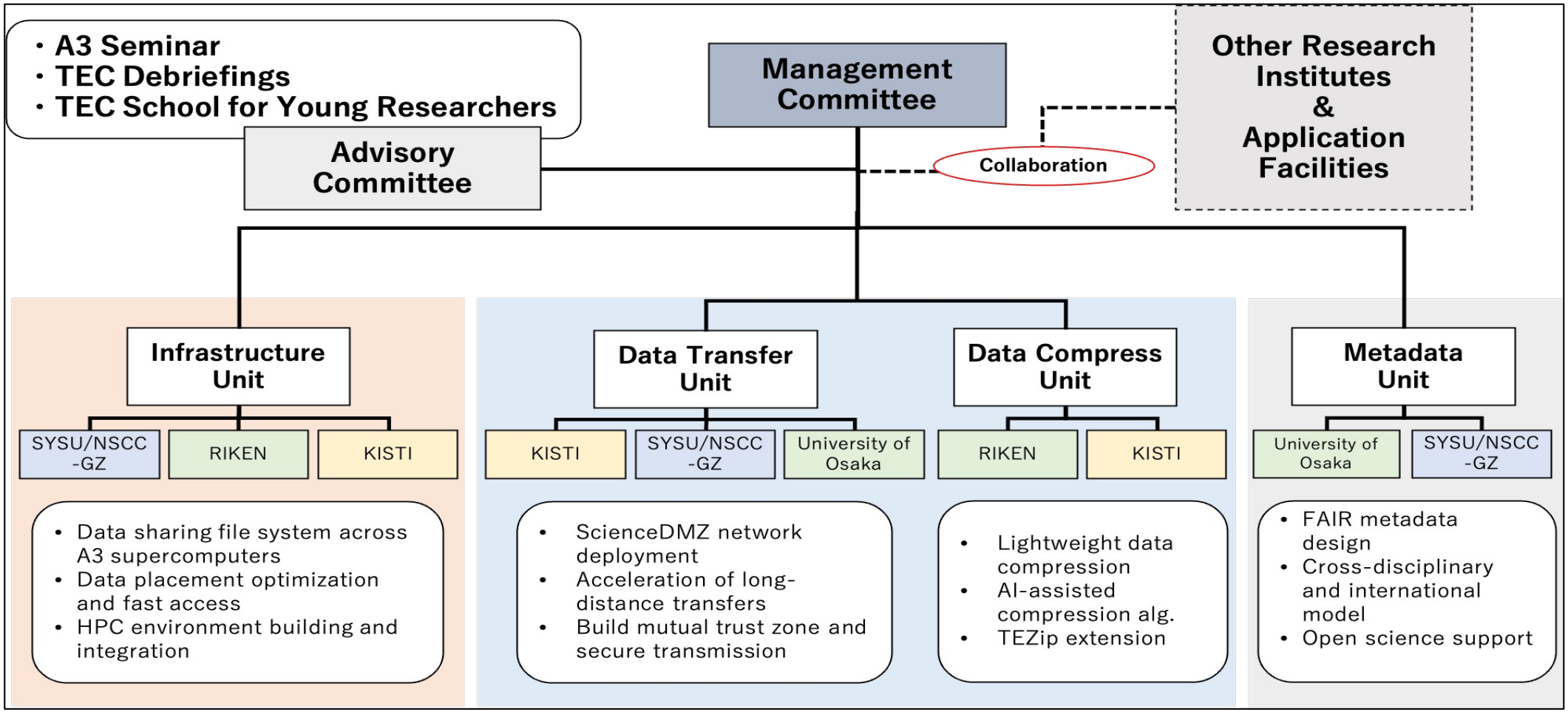
Objective:

According to the Boundless advancement of science and technology through LLM (Large-Scale Language Model) and Advancement of science and technology without boundaries through open science, **this project aims to lead the development of an advanced research environment (system and element technology) for the utilization and sharing of research data and to establish an infrastructure for sharing advanced research data between Korea, China, and Japan.**



Strategies – 4 Units

- **Strategies (Divide into 4 Units)**
  - Unit 1: Infrastructure Unit (Leading by China: NSCC-GZ , KISTI, RIKEN)
  - Unit 2: Data Transfer Unit (Leading by Korea: KISTI, NSCC-GZ, Osaka Univ)
  - Unit 3: Data Compress Unit (Leading by Japan: RIKEN, KISTI)
  - Unit 4: Metadata Unit (Leading by Japan: Osaka Univ., NSCC-GZ)



Key Technologies of Units

- **Strategies (Divide into 4 Units)**

  - **Unit 1: Infrastructure Unit(Leading by China - NSCC-GZ , KISTI, RIKEN)**
    - Data sharing file system across A3 supercomputers
    - Data placement optimization and fast access
    - HPC environment building and integration

  - **Unit 2: Data Transfer Unit(Leading by Korea - KISTI, NSCC-GZ, Osaka Univ)**
    - ScienceDMZ network deployment
    - Acceleration of long-distance transfers
    - Build mutual trust zone and secure transmission

  - **Unit 3: Data Compress Unit(Leading by Japan - RIKEN, KISTI)**
    - Lightweight data compression
    - AI-based compression algorithm
    - TEZip extension

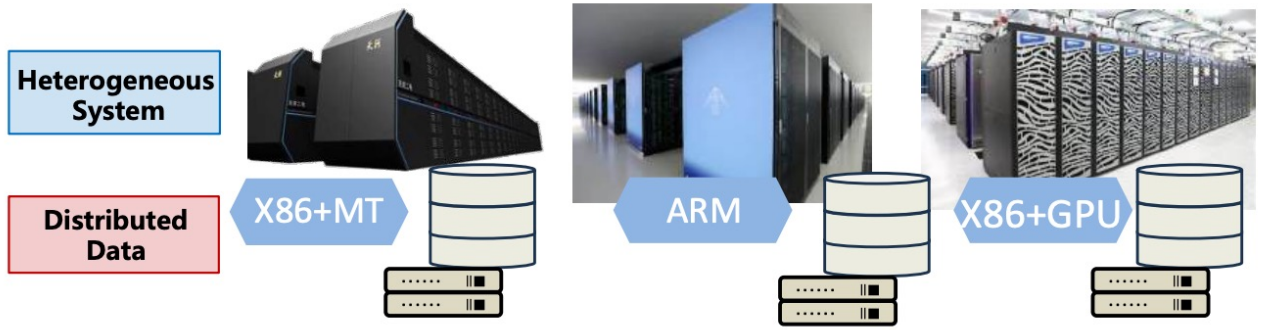
  - **Unit 4: Metadata Unit(Leading by Japan – Osaka Univ., NSCC-GZ)**
    - FAIR metadata design
    - Cross-diciplinary and international model
    - Open Science support

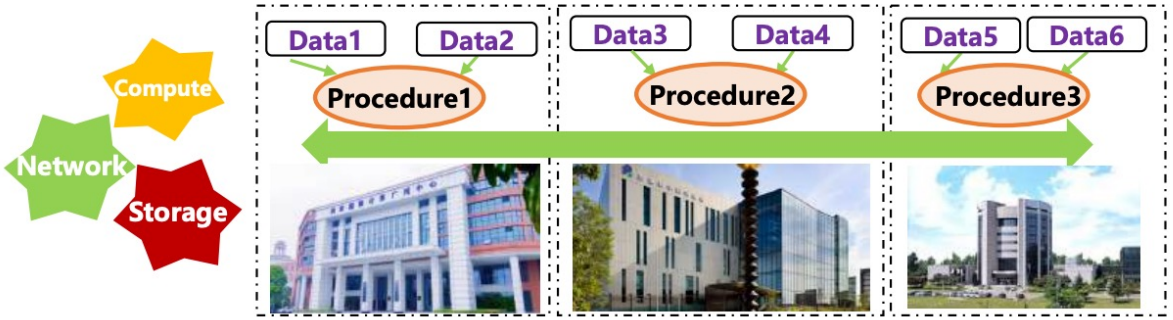
The Challenges

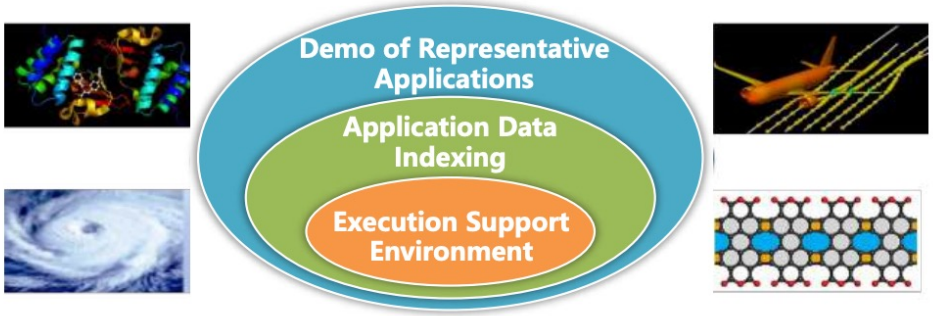
Fusing and Managing Geographically Distributed Data

Effective Long-distance Transfer and Sharing

Coordinated Processing of Cross-region Applications

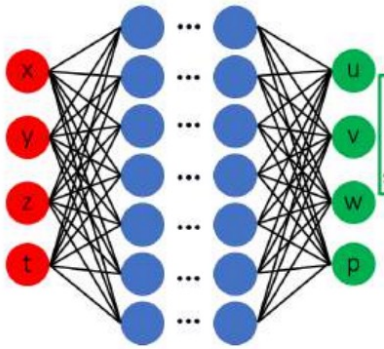






HPC+AI for Science and Engineering

Actively transforming scientific computing landscape



Naviers-Stokes loss

$$\frac{\partial \rho}{\partial t} + \frac{\partial \rho u}{\partial x} + \frac{\partial \rho v}{\partial y} + \frac{\partial \rho w}{\partial z} = 0$$

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} + \frac{1}{\rho}\frac{\partial p}{\partial x} - \frac{1}{Re}\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right) = 0$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} + \frac{1}{\rho}\frac{\partial p}{\partial y} - \frac{1}{Re}\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} + \frac{\partial^2 v}{\partial z^2}\right) = 0$$

$$\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z} + \frac{1}{\rho}\frac{\partial p}{\partial z} - \frac{1}{Re}\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} + \frac{\partial^2 w}{\partial z^2}\right) = 0$$

Experimental data loss

$$\|\vec{V} - \vec{V}_{exp}\|^2 = 0$$

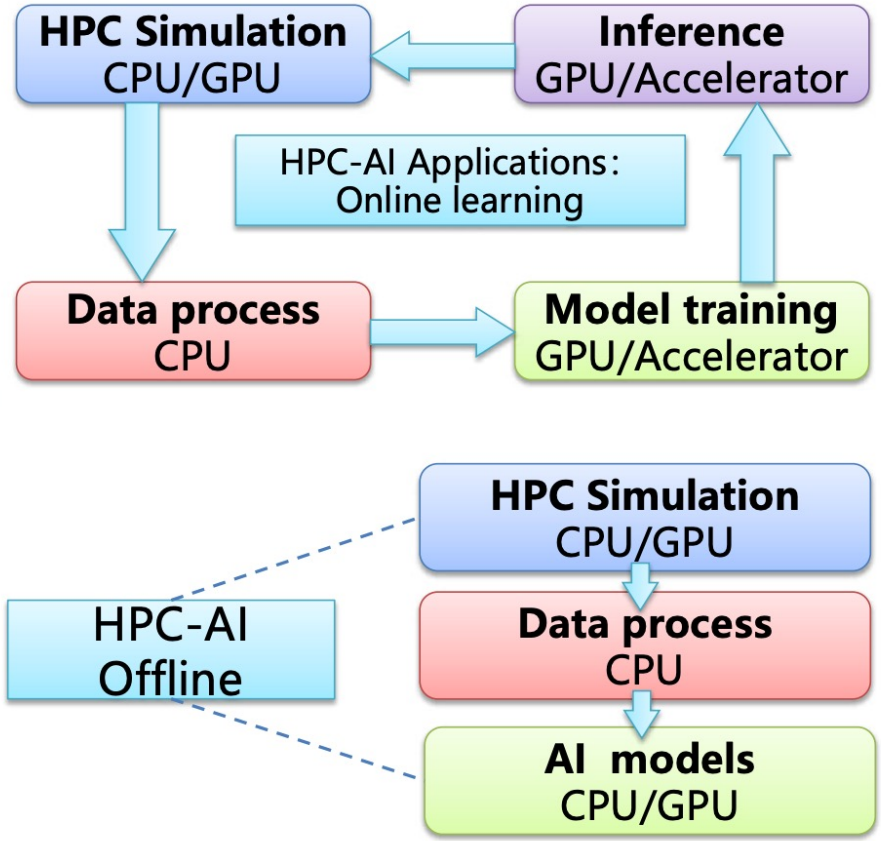
AI4SCI





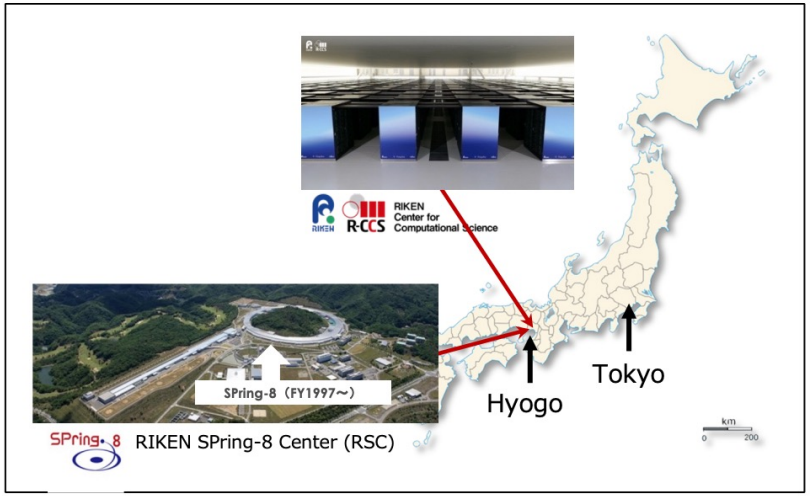


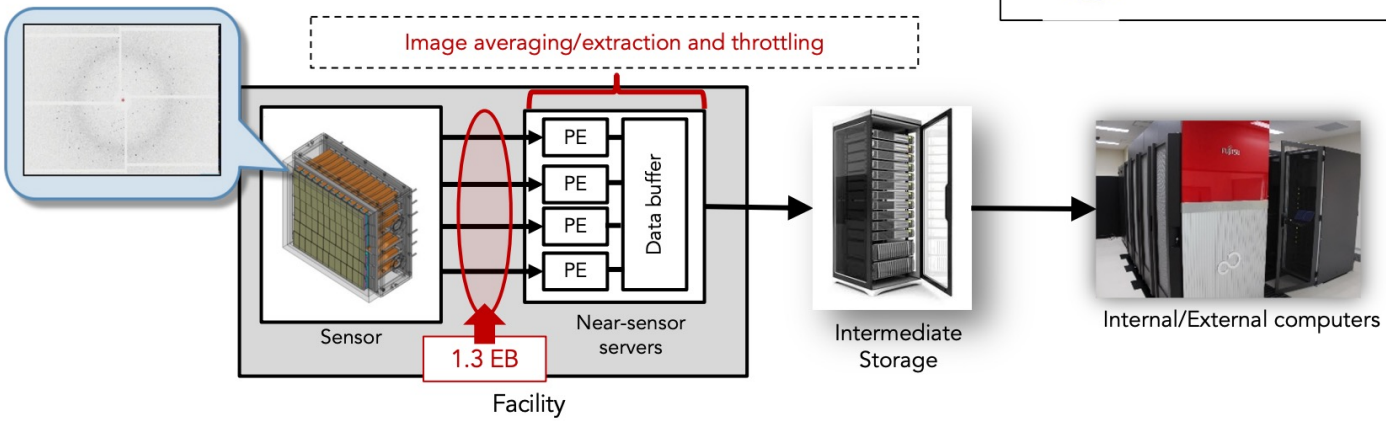
HPC



Big Data Transfer and management

- **RIKEN operates SPring-8 large synchrotron radiation facility**
  - Located in the same Hyogo prefecture as R-CCS' Fugaku
- **Big data generation at SPring-8 facilities**
  - In 2017, SPring-8 public beamlines (26 BLs) generated 320 TB/year
  - In 2025, with the next generation detector (CITIUS), the facility is projected to generate 100-400PB of data per year
- **Data transfer is a first-step for data analytics**
  - Such data generated by sensors need to be transferred to internal/external computers for the further analysis





Due to the large size, transferring data from a sensor to a computer and managing it is challenging.

Data transfer service in SACLA (SPring-8 Angstrom Compact Free Electron Laser)

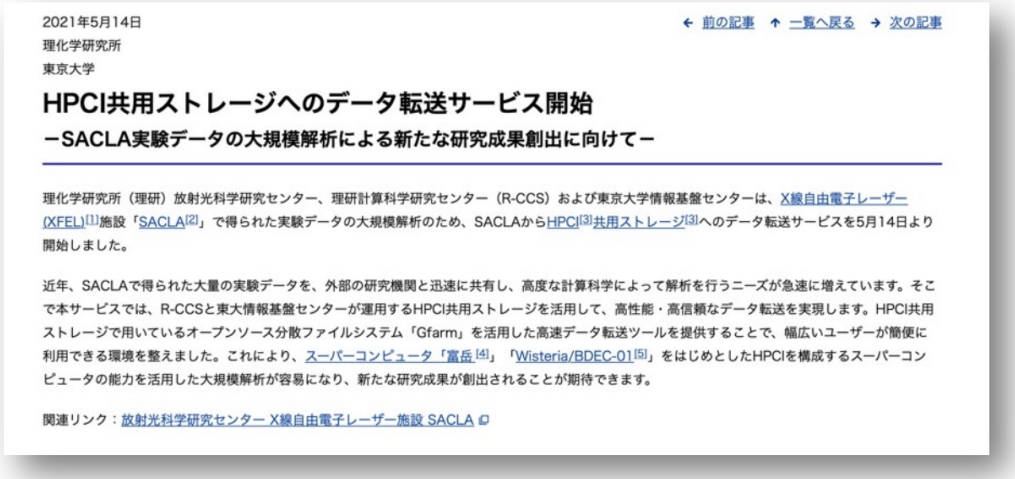
- **We lauched data transfer service from SACLA to “HPCI shared storage” in 2021**
  - “HPCI shared storage” is a geograpycally distributed storage shared by Japanese supercomputing centers including Fugaku

SACLA HPC:
Data Transfer Service to HPCI Shared Storage



Source (May 14, 2021): http://xfel.riken.jp/users/bml09-1.html

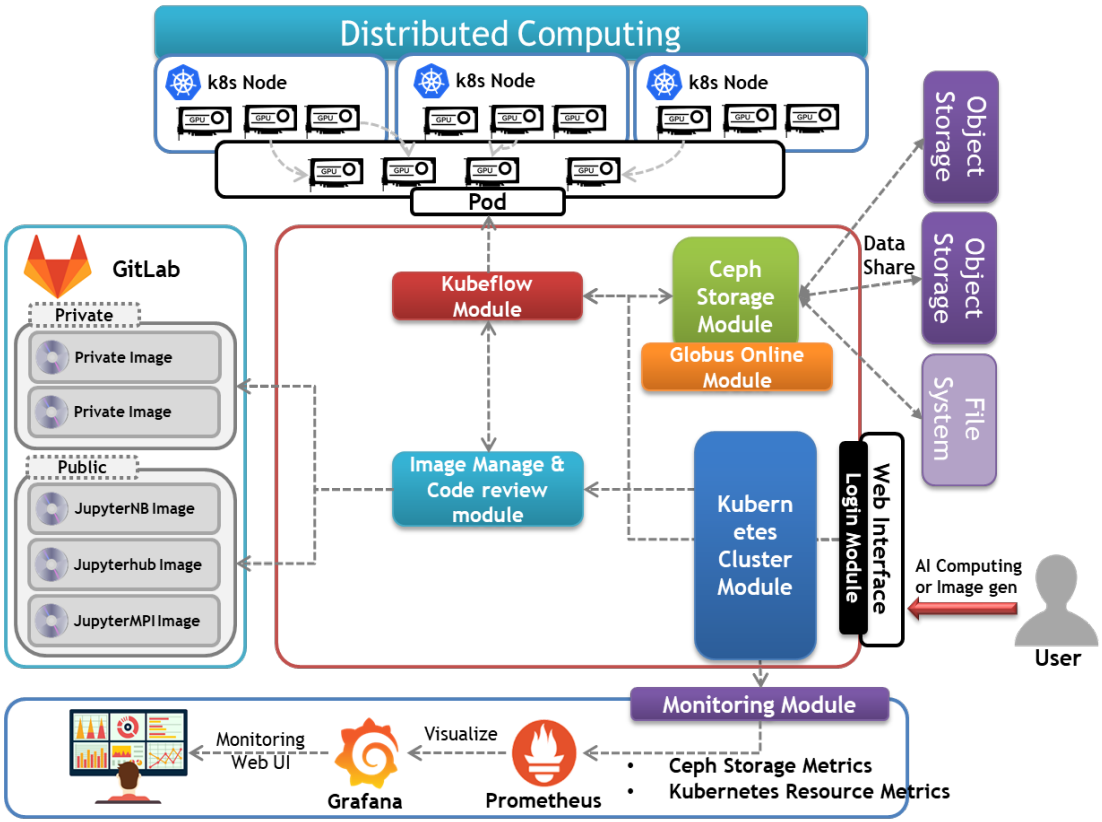
Data Transfer Service to HPCI Shared Storage
Toward the creation of innovative achievement through SACLA



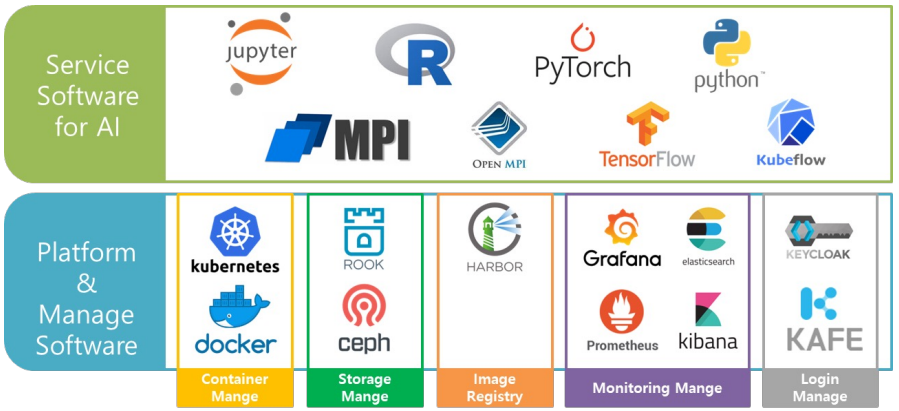
Source (May 14, 2021): https://www.riken.jp/pr/news/2021/20210514_1/

We have been working on data compression to improve this data transfer service

- **Building a platform to manage CPU/GPU computing resources, including storage**
  - Building a platform to manage CPU/GPU computing resources, including storage by Kubernetes
  - Kubernetes servers specification
  - Using open source



Asia-Connect Platform Architecture

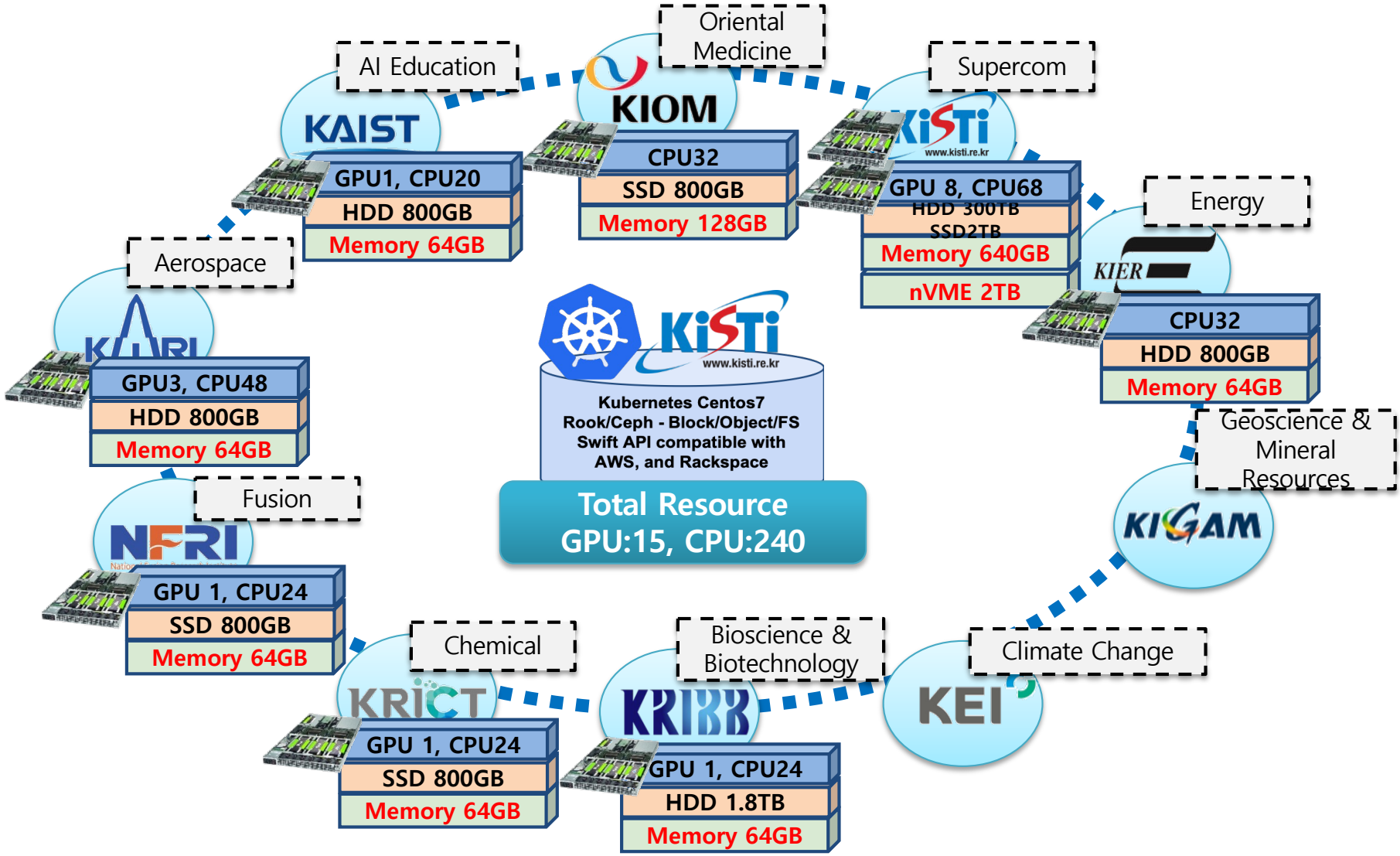


Using Opensource on Platform

Server Role	GPU	CPU	Memory	Storage	Network
Master Node	No GPU	Intel(R) Xeon(R) Gold 6226R CPU @ 2.90GHz 32-Core Processor	DDR4 251GB	HDD 480GB	1GB
Pakistan Node	NVIDIA A40 1GPU	AMD EPYC 7502 32-Core Processor	DDR4 188GB	SSD 960GB NVMe 960GB	1GB
Malaysia Node	NVIDIA A40 1GPU	AMD EPYC 7502 32-Core Processor	DDR4 188GB	SSD 960GB NVMe 960GB	1GB
Storage Node	No GPU	AMD EPYC 7402 24-Core Processor	DDR4 188GB	HDD 58TB	100GB

Kubernetes Servers Specification

- **Big data super-highway between Korea research institutes(Based on K8S)**



Conclusion

Future plan & Conclusion

For the first year of the A3 project

- **Korea → Japan → China**
  - KISTI-Osaka Univ. and then KISTI-Japan-China

- **Survey network connectivity**
  - A3 Countries NREN's path guarantee
  - Network performance test

- **Building a big data super-high way**
  - Deploy ScienceDMZ
  - Setup the network monitoring environment

- **Deploying 3rd applications**
  - Big data transfer from Fermilab to the A3 Countries
  - Sharing big data for Spring-8, KEK, and HEP
  - Establishment analysis AI model for big data



THANK YOU

