Trusted CI Webinar Series

Title: SPHERE - Security and Privacy Heterogeneous Environment for Reproducible Experimentation

Presenters: Dr. Jelena Mirkovic & David Balenson (USC-ISI)

Host: Jeannette Dopheide

Slides: https://tinyurl.com/5n6nev4z

The meeting will begin shortly.

Participants are muted. Click the chat button to ask a question.

This meeting will be recorded.

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TRUSTED CI
THE NSF CYBERSECURITY CENTER OF EXCELLENCE

Mid-scale RI-1 (M1:IP): SPHERE - Security and Privacy Heterogeneous Environment for Reproducible Experimentation

University of Southern California Information Sciences Institute,
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Presented by: Jelena Mirkovic, PI <mirkovic@isi.edu> and

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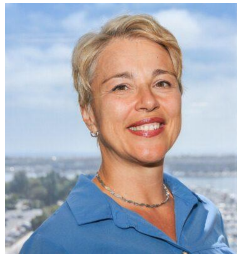
SPHERE Project Team



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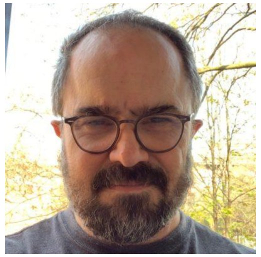

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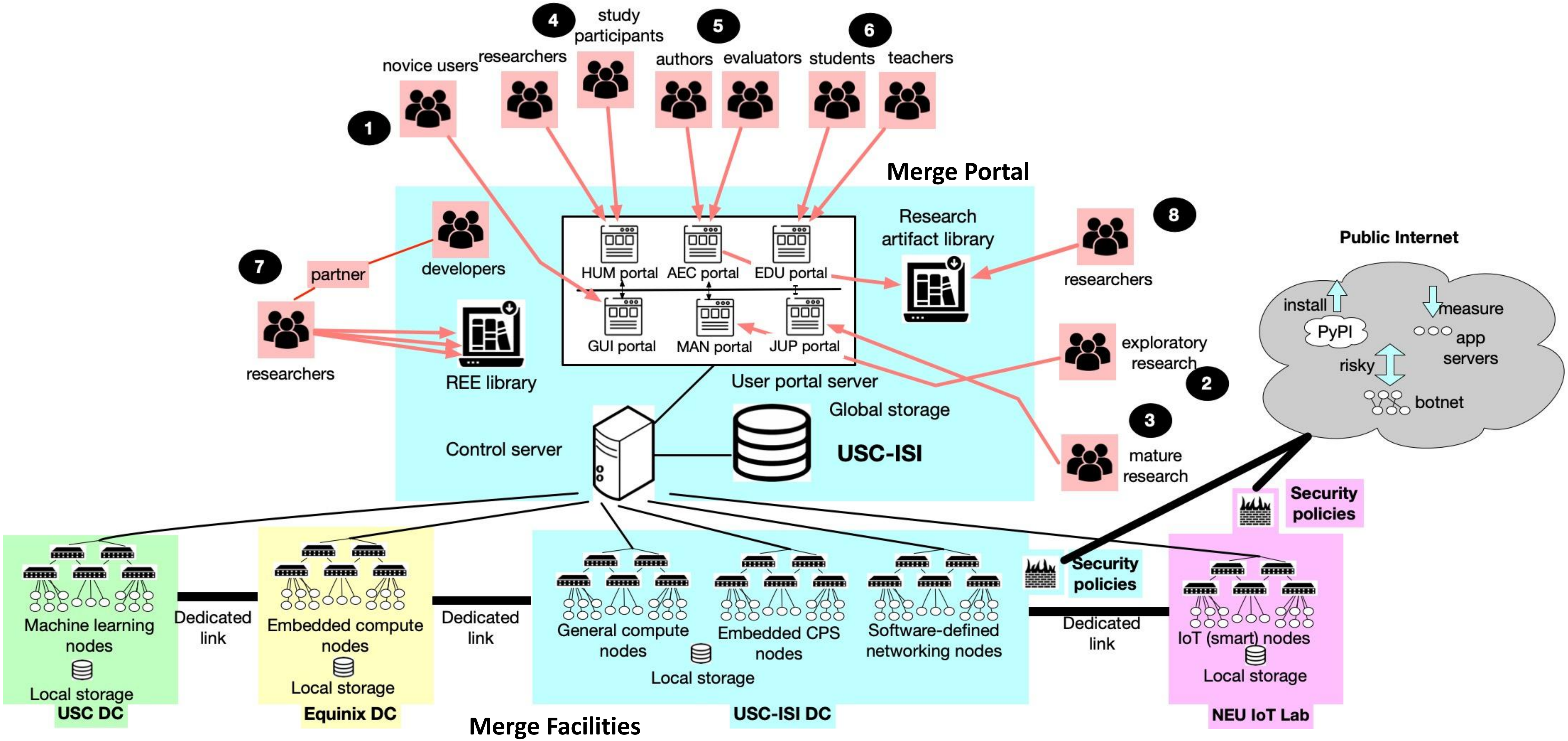
Motivation and Need

- **Motivation:** Cyber threats affect every aspect of our daily lives, critical infrastructure, science, and government. Research solutions are simplistic, piecemeal, and opportunistic, and slow to reach the market
- **Community need:** Common, rich, representative research infrastructure, which meets the needs across all members of the community and facilitates reproducible science

vertical progress, integrated research
more sophisticated solutions

- **Proposed:** SPHERE research infrastructure
  - Heterogeneous resources to meet 90% of research needs in the community
  - Multiple user portals to meet the unique needs of different classes of users
  - Processes/incentives for the community to create representative experimentation environments (REEs) on SPHERE
  - Integrated reproducibility support and processes/incentives for stakeholders to share/reuse research artifacts

SPHERE High-Level Architecture

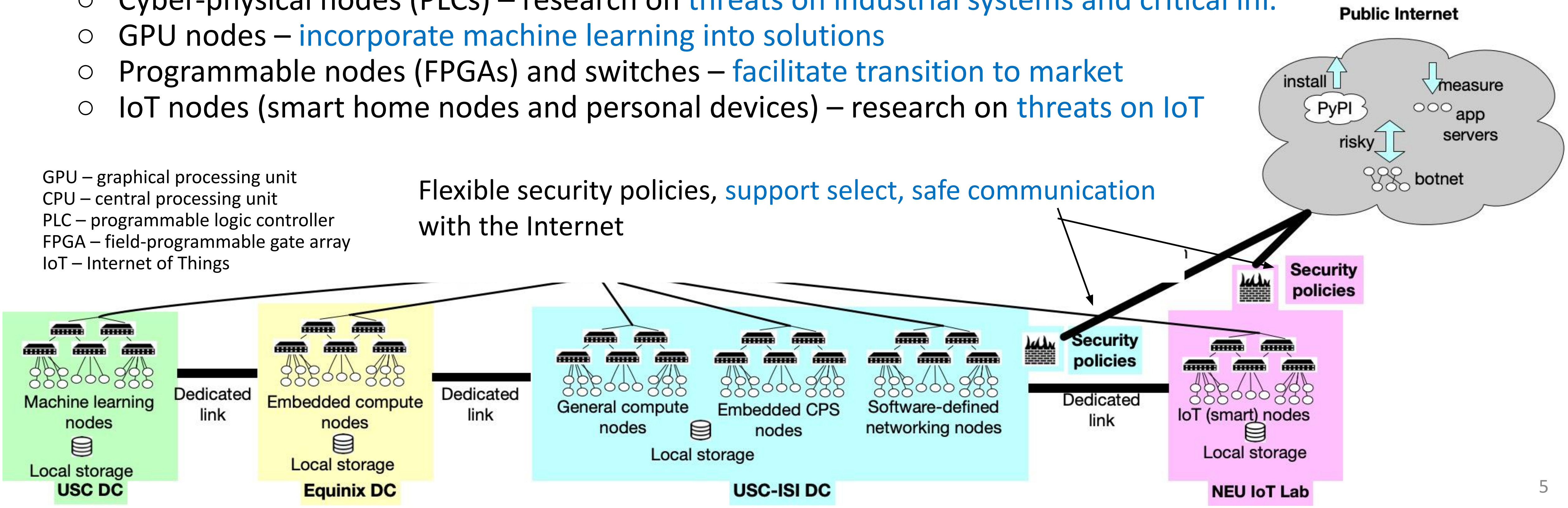


SPHERE Multiple Types of Resources

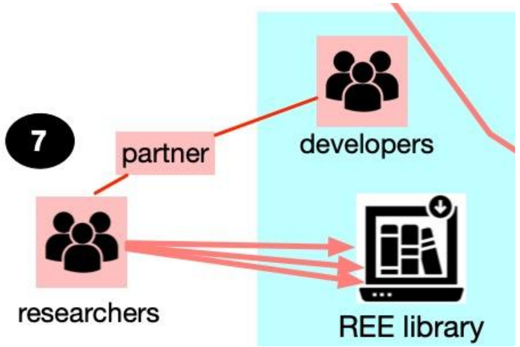
- **Multiple** types of resources, needed for **emerging cybersecurity and privacy research**:
  - General compute nodes with trusted computing technology – research on network, cloud computing and system threats
  - Embedded compute nodes (e.g., in phones, tablets, etc.) – research on distributed threats, threats on distributed computing, attacks on specific CPU architectures
  - Cyber-physical nodes (PLCs) – research on threats on industrial systems and critical inf.
  - GPU nodes – incorporate machine learning into solutions
  - Programmable nodes (FPGAs) and switches – facilitate transition to market
  - IoT nodes (smart home nodes and personal devices) – research on threats on IoT

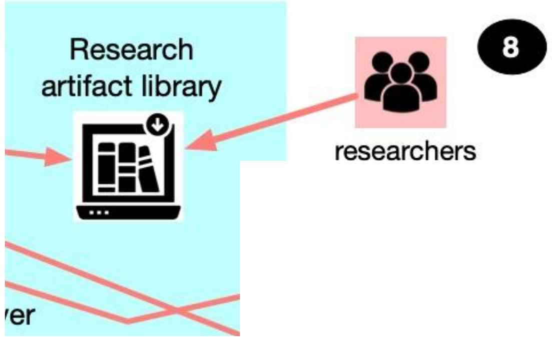
GPU – graphical processing unit
CPU – central processing unit
PLC – programmable logic controller
FPGA – field-programmable gate array
IoT – Internet of Things

Flexible security policies, support select, safe communication with the Internet



SPHERE REEs and Research Artifacts





Representative Experimentation Environments (REEs)

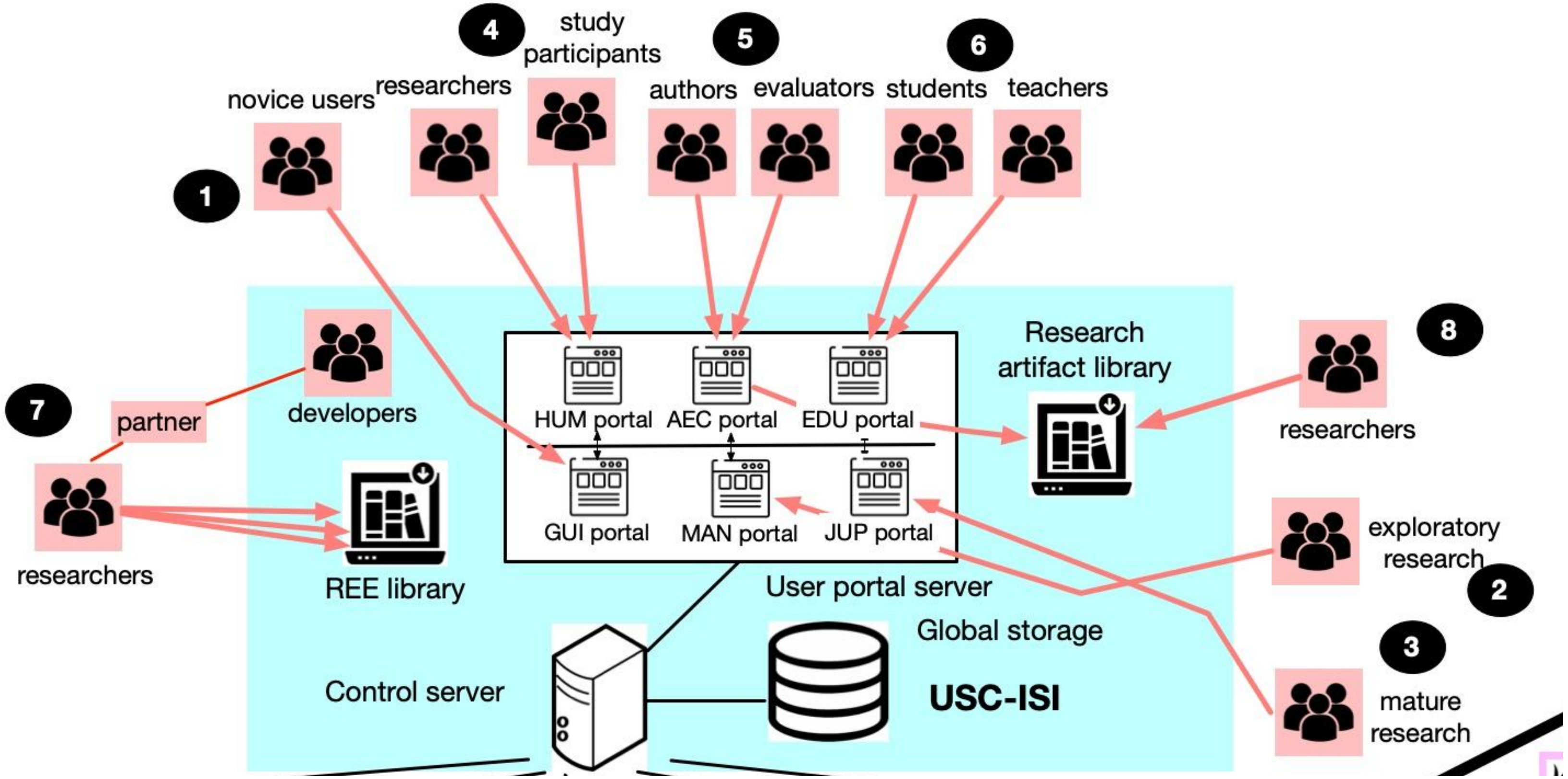
- Make research more relevant, vertical and sophisticated
- “Standard” for experimentation in each CS&P area
- Integrated by their authors into SPHERE (funded)

Research Artifacts

- Make research more vertical and reproducible
- Acquired via partnership with artifact evaluation committees (AECs)
- Integrated by their authors into SPHERE as part of artifact evaluation for a conference

CS&P – cybersecurity and privacy
AEC – artifact evaluation committee

SPHERE Portals



- Multiple user portals, supporting different types of users and use modalities
  - Manual, scripted, and GUI-only use support exploratory, mature, and novice research
  - Dedicated support for AECs, education, Internet measurement, and human user studies

GUI – graphical user interface
AEC – artifact evaluation committee

SPHERE History

- **Over the past 20 years:** USC-ISI designed, built and operated DETERLab
  - 389 research project teams from 278 institutions, and involving 1,042 researchers from 205 locations and 46 countries
  - 230 classes from 147 institutions and helped educate more than 20,000 students
- **2019:** Merge software for testbed control and management
  - Built w/ modern open-source tools for large-scale, high-fidelity, robust experimentation
  - Merge has run several of our testbeds for the past four years – DCOMP, Searchlight, RedStar and modernized DeterLab
- **Modernized software and hardware:** via NSF CCRI grant 2019-2022 and ARO DURIP grant 2019-2021
  - 48 new nodes, 6 new switches, Merge software, user transition
- Modernized DETERLab will become the first seed to grow SPHERE as part of its general compute enclave

SPHERE Unique Research Capabilities

SPHERE RESEARCH INFRASTRUCTURE

- **Relevance:** Experiments with emerging technology and specialized hardware, not currently available to many researchers, support 90%
- **Realism:** Experiments that combine different hardware devices to create realistic scenarios
  - e.g., IoT nodes with GPU nodes and programmable switches to filter attacks
- **Reproducibility:** Experiments on common RI, with extensive support for artifact sharing and reuse, facilitate vertical development
- **BPC:** Different experimentation portals cater to users with different abilities and interests, lowering barrier to entry
- **Impact:** Faster pace of innovation in CS&P and faster technology transition to practice, enabling U.S. to become the global leader in this area

IoT – Internet of Things
GPU – graphical processing unit
CS&P – cybersecurity and privacy

SPHERE Team Background

SPHERE RESEARCH INFRASTRUCTURE

- **DeterLab:** the only public cybersecurity testbed for **18 years**

389 research groups
1K researchers
237 classes
20K students

- Additional testbeds for formal eval. of DARPA programs
- **Merge:** mature testbed management software, running all three testbeds

ported to 4 partner institutions

- **Mon(IoT)r:** largest private IoT testbed and datasets

560 downloads

- Prior NSF funding: **SEARCCH** (reprod.), **DEW** (reprod., usab.), **DeterLab modernization** (RI)
- Many publications on experimentation, reproducibility, IoT privacy
- Founded **CSET workshop**, led NSF-funded **CEF study**, organized **CEF 2022** and **Cybersecurity Artifacts 2022** workshops, pioneered use of testbeds in education

IoT - Internet of Things
CSET – Cyber Security Experimentation and Test, running for 16 years
CEF – Cybersecurity Experimentation of the Future

SPHERE Research Value

- Transform CS&P research from piecemeal, opportunistic to integrated; and from reactive to proactive
- Enable reproducible experimentation that is easily and remotely accessible to all U.S. researchers
  - Especially benefits underserved researcher populations (evidence from DeterLab)
- Students from MSIs and HBCUs recruited for paid internships
- Work with AECs to transform the research process and host artifacts
- REEs and artifacts will lead to increase in publications and data products

CS&P – cybersecurity and privacy
MSI – minority serving institution

HBCU – historically black colleges and universities
REEs – representative experimentation environments
AEC – artifact evaluation committee

SPHERE Societal Benefits

SPHERE
RESEARCH INFRASTRUCTURE

- Faster pace of innovation in CS&P and more mature solutions on the market
- Protect scientific infrastructure and society from various threats: ransomware, data theft, data corruption, supply chain attacks, denial of service, etc.
- Produce larger, more diverse, better educated and prepared CS&P workforce
- Help integrate CS&P solutions into new and emerging technologies before they get widely deployed

CS&P – cybersecurity and privacy

SPHERE Community Outreach

- Presentations, posters, and other activities at major conferences
  - Major cybersecurity conferences: NDSS, S&P, USENIX Security, CCS, ACSAC
  - NSF events: RIW, SaTC PI meeting, Cybersecurity Summit
  - Other conferences: IoT, CPS, HPC, etc.
  - Underrepresented communities: Tapia, Grace Hopper, SACNAS NDiSTEM
- Engage researchers via surveys and interviews
  - Google form at https://bit.ly/SPHERE-Needs-Survey
  - No more than five minutes, six open-ended questions
  - Anonymous and can skip questions
- Adjust SPHERE development to meet community needs

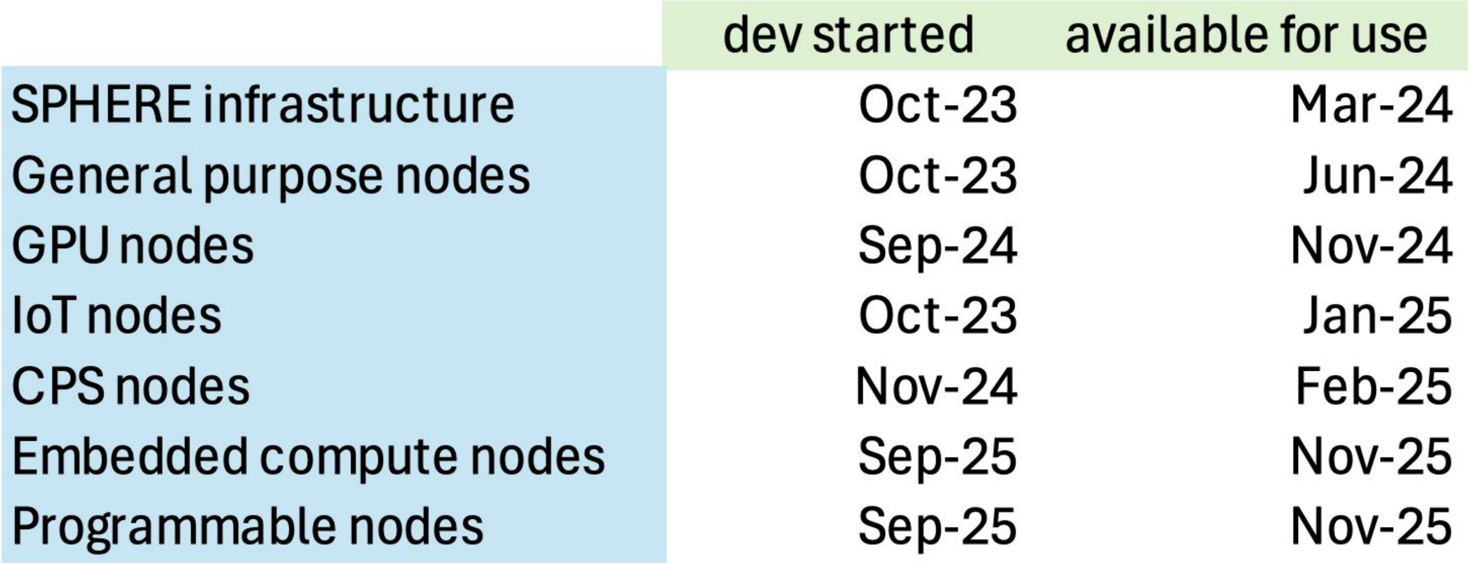
bitly

NDSS – Network and Distributed System Security
S&P – IEEE Symposium on Security & Privacy
CCS – ACM Conference on Computer & Communication Security
ACSAC – Annual Computer Security Applications Conference

RIW – Research Infrastructure Workshop
SaTC – Secure and Trustworthy Cyberspace
SACNAS – Advancing Chicanos/Hispanics & Native Americans in Science
NDiSTEM – National Diversity in STEM

Become a SPHERE Beta User

- Help us grow and improve before we open to larger audience
- Get access to cool new hardware and features
  - Log in remotely via browser, create custom topologies of general purpose VMs (control VM resources, network topology, bandwidth and delay)
  - Access nodes via SSH w/ sudo privileges
  - Experiment directly on nodes or via Jupyter notebooks
  - Able to reach into the Internet, can also support incoming connections
  - Chat-based user support

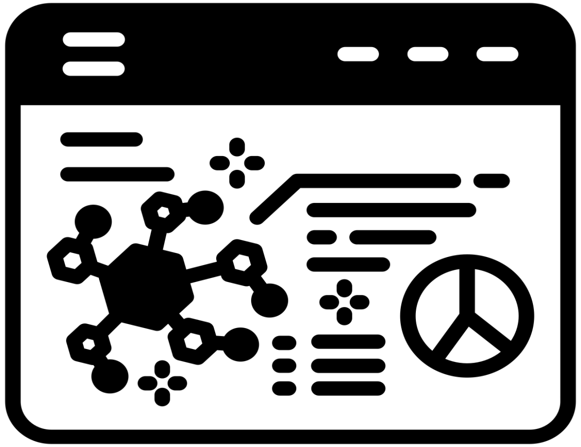


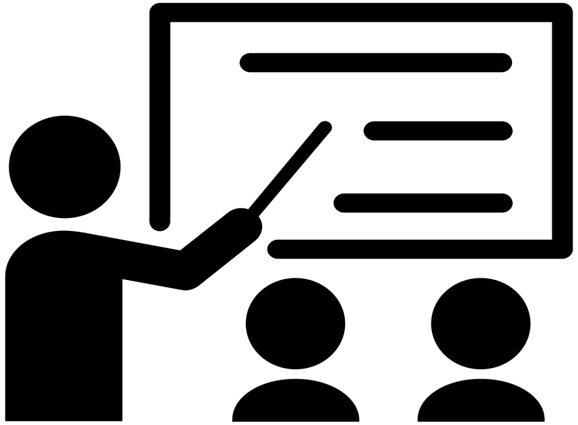
	dev started	available for use	
SPHERE infrastructure	Oct-23	Mar-24	
General purpose nodes	Oct-23	Jun-24	* old nodes available now
GPU nodes	Sep-24	Nov-24	
IoT nodes	Oct-23	Jan-25	
CPS nodes	Nov-24	Feb-25	
Embedded compute nodes	Sep-25	Nov-25	
Programmable nodes	Sep-25	Nov-25	* NICs available Fall 2024

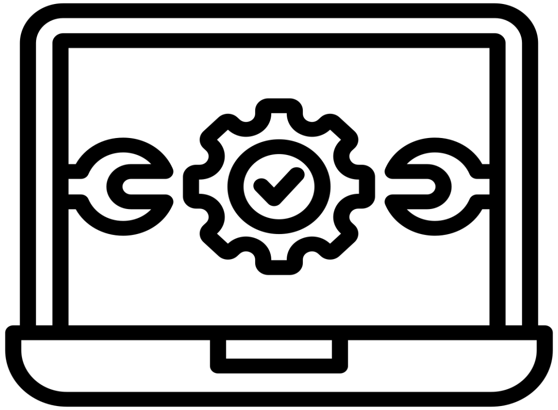
How You Can Help with SPHERE

Promote and leverage SPHERE at your institutions!

- Researchers can use SPHERE to conduct new, innovative research
- Faculty and students can use SPHERE for educational purposes
- IT staff can use SPHERE to test, and evaluate new solutions and technologies







Thank you!

https://sphere-project.net

contact@sphere-project.net

SPHERE

RESEARCH
INFRASTRUCTURE

Questions?

Click on the chat icon to type a question

Community Updates

- Next Webinar: May 20th @ 11am Eastern
  - Topic: NSF Research Infrastructure Guide
  - Speakers: Mike Corn (NSF)
  - **webinars@trustedci.org**
- Trusted CI NSF Cybersecurity Summit (Oct 7-10th) @ Pittsburgh, PA
  - Student Program: Call for applications coming soon!

About the Trusted CI Webinar series

To view presentations, join the announcements mailing list, or submit requests to present, visit: **trustedci.org/webinars** or email **webinars@trustedci.org**

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