Proposed SPHERE Demonstrations for SC26 Network Research Exhibition

The SPHERE project proposes a live, multi-site demonstration showcasing SPHERE's unique capabilities for cyber-physical systems (CPS), IoT experimentation, and bring-your-own-device/testbed (BYOD/BYOT) integration across distributed research infrastructure. The demo will highlight how SPHERE enables flexible, scalable, and interconnected experimentation spanning remote facilities, SCInet infrastructure, and portable edge deployments.

Demonstration Overview

The proposed SC26 exhibit will feature a set of demonstrations running across SPHERE enclaves and SCInet-connected compute resources. The goal is to showcase SPHERE's distinctive strengths:

- CPS and IoT enclave experimentation
- Multi-facility orchestration
- BYOD/BYOT integration
- Dynamic deployment of lightweight SPHERE facilities
- Real-time data movement and analytics over high-performance networking
- Integration with FABRIC

The demonstrations will generate live data from distributed CPS and IoT experiments, stream the data across wide-area networks to SCInet-connected resources, and perform real-time machine learning and visualization at the conference booth.

CPS and IoT Enclave Demonstrations

SPHERE's CPS and IoT enclaves will run experiments that produce telemetry and operational data in real time. Separate demonstrations may be shown for CPS and IoT environments, or combined into a unified workflow illustrating coordinated multi-enclave experimentation.

Potential CPS demonstrations include physical process control scenarios such as the "miniwater" testbed currently under development at the University of Utah. This platform combines Raspberry Pi devices, a Rockwell PLC, and a Windows MiniPC to emulate realistic industrial control system workflows.

Potential IoT demonstrations may reproduce and scale previous SPHERE IoT research experiments while visualizing live system behavior and analytics. Data generated by these enclaves will be transmitted over SCInet and/or FABRIC-connected paths to compute resources located at the SC26 booth.

At the booth, machine learning workloads and interactive visualizations (e.g., Jupyter-based dashboards and graphs) will process and display the incoming data stream in real time.

BYOD/BYOT and Portable SPHERE Facility

A key component of the demonstration is showcasing SPHERE's lightweight, portable infrastructure model. The exhibit may include a compact SPHERE facility deployed directly at SC26 using small-form-factor hardware, dev boxes, laptops, or embedded clusters.

This portable facility would dynamically join the broader SPHERE infrastructure and participate in the live experiments. Demonstrations would include:

- Deploying a lightweight SPHERE facility on local hardware or a virtual machine
- Allocating VMs on the temporary facility as part of a distributed experiment
- Connecting external devices into SPHERE through the local facility
- Allowing remote SPHERE users to access and utilize those attached devices

The architecture may additionally demonstrate deployment of SPHERE facilities on commercial cloud or virtualized infrastructure.

Multi-Facility and FABRIC Integration

The SC26 demonstration will emphasize SPHERE's support for multi-facility experimentation across geographically distributed infrastructure. Remote SPHERE enclaves will communicate with SCInet-connected resources and portable booth infrastructure through FABRIC, leveraging existing connectivity through Los Nettos. This would demonstrate interoperability between SPHERE and national-scale programmable research infrastructure, aligning with NSF interest in cross-platform experimentation and advanced cyberinfrastructure integration.

Networking Requirements

Our demonstrations do not require large bandwidth. CPS resources are at University of Utah. IoT resources are at Northeastern. SPHERE's main infrastructure is at USC Information Sciences Institute. Only the Los Angeles location is connected to FABRIC at the moment. We can do separate experiments of CPS and IoT without FABRIC, and an experiment with SPHERE, FABRIC and another FABRIC-connected infrastructure, such as a booth at SC26 or Cloudlab or Chameleon.