

Position Paper On Federated International Future Internet Experimental Research Testbeds

Joe Mambretti, International Center for Advanced Internet Research (iCAIR), Northwestern University

With its national and international research partners, the International Center for Advanced Internet Research (iCAIR) at Northwestern University designs, develops, implements, and operates large scale, including world-wide, computer science testbeds. Generally, with its research partners, iCAIR operates between 25 and 30 national, international, and local testbeds. The majority have been designed and implemented as network research testbeds. However, several are distributed compute fabrics including the NSFCloud Chameleon, several computational science clouds, and computational science Grid facilities. iCAIR policies, procedures and technologies strongly support international collaboration and testbed federation.

Key research topics include: a) network virtualization, including network function virtualization, b) programmable networking, especially through Software Defined Networking (SDN) and P4, including SD-WAN techniques and SD integration with bit-rate coherent optics using tunable, flexible grid reconfiguration c) Network Defined Exchanges (SDXs), d) interdomain networking, e) dynamic network resource discovery and provisioning, f) close integration of high performance networks and storage systems, g) in-network computing, h) signaling and open APIs i) high performance transport protocols, j) high performance, large scale transport networks (including 100 Gbps E2E, 400 Gbps, Tbps, multi-Tbps), k) highly virtualized cloud tenant networks, l) using P4-based telemetry techniques to obtain high-fidelity visibility and analytics, m) network resource orchestrators, n) using AI/ML/DP techniques to enhance network operations, o) wavelength (lightpath) switching, p) tools for managing experimental workflows, and q) tools for recording, analyzing, diagnosing, and reproducing experiments.

Many iCAIR supported international testbeds have been implemented to support global data intensive science projects, including prototypes for specific existing and future science communities, such as the Large Hadron Collider, the Large Synoptic Survey Telescope, and the Square Kilometer Array. These projects have focused on the need to transport extremely high capacity individual data streams over multi-domain global WANs. Related projects are DTN-SDX integration, specialized transport services such as Big Data Express, which has been implemented on an international testbed.

Recently, iCAIR assisted in organizing a research consortium established to explore topics in quantum communications and quantum networking. Currently, this initiative is defining research topics and planning a quantum networking testbed, which will have multiple international partners.

With its international research partners, iCAIR assisted in organizing the Global Research Platform workshop at the University of California San Diego. This initiative was established to create a global distributed environment for scientific research, including support for international computer science and networking experimental research testbeds.

International network testbed partners include the Korea Institute of Science and Technology Information (KISTI), KREONET2, CERN, NetherLight/SURFnet (Netherlands), RNP (Brazil), CANARIE/Compute Canada, NORDUnet (Scandinavia), University of Tokyo, SINET, NII, NTT, the National Center for Supercomputing Applications, Singapore Supercomputing Center, SingAREN, National University of Singapore, TWAREN, University of Amsterdam, CESNET (Czech Republic), GEANT, Taiwan Supercomputing Center, Poznan Supercomputing Center (PSNC, Poland), University of Warsaw, University of Twente, University of Sydney, AARnet (Australia), Asia Pacific Advanced Network, TUDelft, European Space Center, multiple international science consortiums (e.g., LSST, LHC), National Center for Supercomputing Research (NCSA), Fermi National Accelerator Laboratory (FNAL), Argonne National Laboratory (ANL), the NASA Goddard Space Flight Center, Naval Research Lab, California Institute of Technology, University of Southern California, University of California San Diego, University of Chicago, University of Illinois at Chicago, Texas Advanced Computing Center, National Energy Research Scientific Computing Center, University of Massachusetts Lowell, University of Texas, El Paso University of Massachusetts Boston, Oak Ridge National Laboratory, Florida International University, Consortium for the StarLight International/National Communications Exchange Facility, Metropolitan Research and Education Network (MREN), Energy Science Network, CENIC, PacificWave, Pacific Northwest GigaPoP, Mid-Atlantic Crossroads, SCinet/the SC ACM IEEE International High Performance Computing, Networking, Storage and Analytics Conferences, Ciena, Cisco, Arista, Dell, Juniper, XILINX, and Inventech.

International P4 Experimental Networks (i-P4EN)

