Next Generation Infrastructure Based on SDI, SDN, and SDX Architecture and Technologies
Joe Mambretti, International Center for Advanced Internet Research, Northwestern University

The International Center for Advanced Internet Research (iCAIR), with its multiple national and international partners, is interested in designing, developing, and conducting research experiments with next generation, highly distributed environments with advanced infrastructure based on software defined architecture, especially software defined infrastructure (SDI), Software Defined Networks (SDNs), and Software Defined Network Exchanges (SDXs). These distributed environments provide for a transition from today's infrastructure, which is designed with static hardware and with limited flexibility in rigid configurations for single services or for a small range of services (built for narrow specific purposes) to a highly distributed (virtually ubiquitous), highly programmable, dynamic, extensible, integrated and customizable platform that can support an almost unlimited number of services.

Architectural components for such next generation infrastructure include: a) higher levels of virtualization than that used in current approaches, b) open, transparent, standard APIs, c) deep programmability at all levels enabled by such virtualization d) specialized programming languages designed specifically for dynamically controlling, managing, and slicing SDI environments e) capabilities for highly dynamic provisioning at all levels- including the realtime dynamic changes in live, running programs, including operating system processes f) elimination of barriers among silos of resources, i.e., computers, network, storage, data to create contiguous environments g) capabilities for integration within wider contexts - among multiple distributed environments and systems vs today's closed, narrowly focused systems h) exceptional low latency for all transits i) exceptional high performance for all components (relative to today -- and scaleable in the future), j) exceptional high capacity for all components (relative to today -- and scaleable in the future) k) reliable, resilience, and self-healing l) capable of processes that are highly predictable and deterministic m) direct access to a wide range of selectable blendable compute options - Grids, clouds, GPUs CPUs, VM, bare metal, specialized accelerators, supercomputers, custom chips, etc. within the same distributed environment n) SDI specific orchestration systems based in part on detailed resource schematics and resource data models o) foundations of extremely high capacity (Tbps and beyond) high performance networking capable of blended streams and hybrid multi-layer services p) highly precise measurements that in real time steer performance, load balancing, optimization, and performance vs simple information archiving and q) exceptional security by default and r) high performance real time (i.e., 100 Gbps +) encryption.

This year at the SC15 supercomputing conference iCAIR and its research partners are staging and/or supporting multiple demonstrations and experiments directed at creating some of these capabilities based on Software Defined Networking (SDN), Software Defined Infrastructure (SDI) and the StarLight International/National Communication Exchange Facility's Software Defined Networking Exchange (SDX). The supported demonstrations/experiments include using a bioinformatics SDX customized for precision medicine, using programmable cloud and networking technology for network security, using programming tools for HPC clouds, international multi-domain provisioning using Automated GOLE NSI technology, prototyping an LHCONE point2point service using Data Transfer Nodes, using NSI in an SDX topology exchange, prototyping distributed resource orchestration tools, using dynamic remote I/O and dynamic process pipelining, conducting 100 Gbps disk-to-disk WAN file transfer using SDX services, integrating extended science DMZs over 100 G WANs, prototyping100 Gbps services over IP using specialized accelerators, conducting petascale science transfers at 100 Gbps using customized Data Transfer Nodes, showcasing HPC data commons and data peering at 100Gbps, showcasing 100 G real time encryption, conducting PetaTransfer experiments for large scale science using the Pacific Research Platform (PRP), conducting Open Science Data Cloud transfers of National Oceanographic and Atmospheric Administration data, using international multidomain open architecture E2E flows with 100Gpbs services, supporting specialized high performance highly distributed science networking at 100Gbps, and using SDN optimized high-performance data transfer systems for exascale science.