Mystic
Programmable Systems Research Testbed to Explore a Stack-Wide Adaptive System fabric

Ioan Raicu
Illinois Institute of Technology
Argonne National Laboratory

Trends in HPDC Workshop 2019
March 14th, 2019
WHO AM I?

• History
  • 1997-2002: BS/MS in CS at Wayne State University; MS thesis in IPv6 Network Protocols under Sherali Zeadally
  • 2003-2009: PhD in CS at University of Chicago in Many-Task Computing under Ian Foster
  • 2009-2010: Postdoc at Northwestern Univ. with Alok Choudhary
  • 2016-2017: Sabbatical at Northwestern Univ. with Peter Dinda

• Current Affiliations
  • Associate Professor in CS at Illinois Institute of Technology
    • Director of Data-Intensive Distributed Systems Laboratory
  • Guest Research Faculty in MCS at Argonne National Laboratory
  • Advisory Board Member at Ocient LLC & FusionBlock
Research Focus

Emphasize designing, implementing, and evaluating systems, protocols, and middleware with the goal of supporting data-intensive applications on extreme scale distributed systems, from many-core systems, clusters, grids, clouds, and supercomputers.
WHAT IS MYSTIC?

• $1M NSF-funded institution infrastructure grant at Illinois Institute of Technology
• A testbed for experimenting with system re-configurability across the entire computing stack
• Allow low-level experimentation and reconfiguration at multiple levels
  • Processor: network-on-chip (NoC), hybrid architectures
  • Memory: Deep memory hierarchy
  • Storage: NVMe, NVDIMM
  • Network: software defined networking, programmable NICs

• More information
  • [http://mystic.cs.iit.edu](http://mystic.cs.iit.edu)
WHAT RESEARCH DOES MYSTIC ENABLE?

• Nautilus Aerokernel Light-weight Operating System
• Xtask: eXTreme fine-grAined concurrent taSK invocation runtime
• Universal Memory through byte-addressable non-volatile memory
• XSearch: Distributed Indexing and Search in Large-Scale Storage Systems
• OS abstractions on programmable NoCs to adapt to application workloads
• Multipath routing protocols in multi-dimensional Torus networks
• Integrated data access system to support PFS/DFS
MYSTIC LEADERSHIP

• Ioan Raicu
  • Principle Investigator: explore practical aspects to realizing universal memory with byte-addressable non-volatile memory where applications compute directly on persistent memory

• Kyle Hale
  • Co-Principle Investigator: build new OS abstractions on top of programmable NoCs to adapt the on-chip network to applications’ communication topologies and to enforce performance isolation and QoS between specialized OSes that space-share the chip

• Xian-He Sun
  • Co-Principle Investigator: develop an integrated data access system, Dynamic PortHadoop to support both parallel file systems for data-coherent and MapReduce/Spark systems
MYSTIC COLLABORATORS & ADMINS

• Ophir Trigalo
  • Collaborator: provide resources and expertise needed to bring the MYSTIC testbed online, and to maintain it over the course of the testbed lifetime

• Nikos Hardavellas
  • Collaborator: provide expertise in specialized operating systems (OS) and field programable gate arrays (FPGA)

• Sanjiv Kapoor
  • Collaborator: provide expertise in improving network performance through new dynamic routing algorithms, leveraging rich multi-path topologies of multi-dimensional networks

• Alexandru Iulian Orhean
  • Lead System Administrator: provides day-to-day operational support, maintenance, and technical support

• Alexander Ballmer
  • System Administrator: provides day-to-day operational support, maintenance, and technical support
MYSTIC HARDWARE OVERVIEW

• Physically at IIT in Chicago

• 55-nodes

• 3 racks

• 45kW of power

• OpenStack bare-metal provisioning
MYSTIC HARDWARE OVERVIEW

• **Computing capabilities (240TF/s)**
  • 1396 general purpose cores (Intel Xeon SP/Phi x86, AMD Epyc x86, Cavium ARM, IBM Power)
  • 100K+ accelerator cores (Intel Arria FPGA, Intel Xeon Phi, NVIDIA Kepler/Volta)

• **Memory**
  • 4.7TB DDR4

• **Storage**
  • 375TB HDD SAS
  • 90TB SSD SAS
  • 40TB SSD NVMe (Intel Optane 900P, Samsung EVO 970)

• **Network**
  • External: 10Gb/s
  • Internal: Mellanox 100GbE Fat-tree
SPECIAL HARDWARE
SPECIAL HARDWARE
SPECIAL HARDWARE

[Images of specialized hardware components, including SSDapters and server racks.]
SPECIAL HARDWARE
PLANS FOR FUTURE HARDWARE
• All major architectures
  • x86, ARM, Power9, GPUs, FPGAs
• 1-socket to 8-socket systems
• 8-cores to 192-cores shared memory systems
• Storage nodes with 64-lanes of PCIE bandwidth across 32 NVMe drives
INTERESTED IN GETTING ACCESS TO MYSTIC?

• We encourage the community to use Mystic
• Planning to be online in May 2019
  • More information will be announced at: http://mystic.cs.iit.edu
• Planning on running a workshop at IIT in June 2019
• Write me at iraicu@cs.iit.edu if you are interested
RELATED ACTIVITIES

• NSF REU Site
  • BigDataX: From theory to practice in Big Data computing at eXtreme scales

• Competitions
  • Student Cluster Competition at IEEE/ACM Supercomputing
• National Science Foundation, CISE Research Infrastructure (CRI)

• NVIDIA

• Chameleon
• Contact:
  • iraicu@cs.iit.edu
• More information:
  • http://www.cs.iit.edu/~iraicu/
  • http://datasys.cs.iit.edu
  • http://mystic.cs.iit.edu