Testbed for the Research Community Exploring Next-Generation Cloud Platforms

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Open Cloud Testbed: Developing a Testbed for the Research Community Exploring Next-Generation Cloud Platforms

- Funded by National Science Foundation CCRI Grand Program
  - Computer Community Research Infrastructure

- Collaboration among
  - UMass Amherst
  - Boston University
  - Northeastern University

UMASS AMHERST

BOSTON UNIVERSITY

Northeastern University

Core Team

Mike Zink, PI
Orran Krieger, Co-PI, lead @ BU
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lead @ Northeastern
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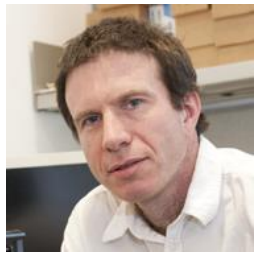

David Irwin,
Community Outreach Director, UMass
Emmanuel Cecchet,
Senior Research Scientist, UMass
Jack Brassil,
Head of Advisory Board, Princeton

MOC
MGHPCC
MASSACHUSETTS GREEN HIGH PERFORMANCE COMPUTING CENTER

CloudLab
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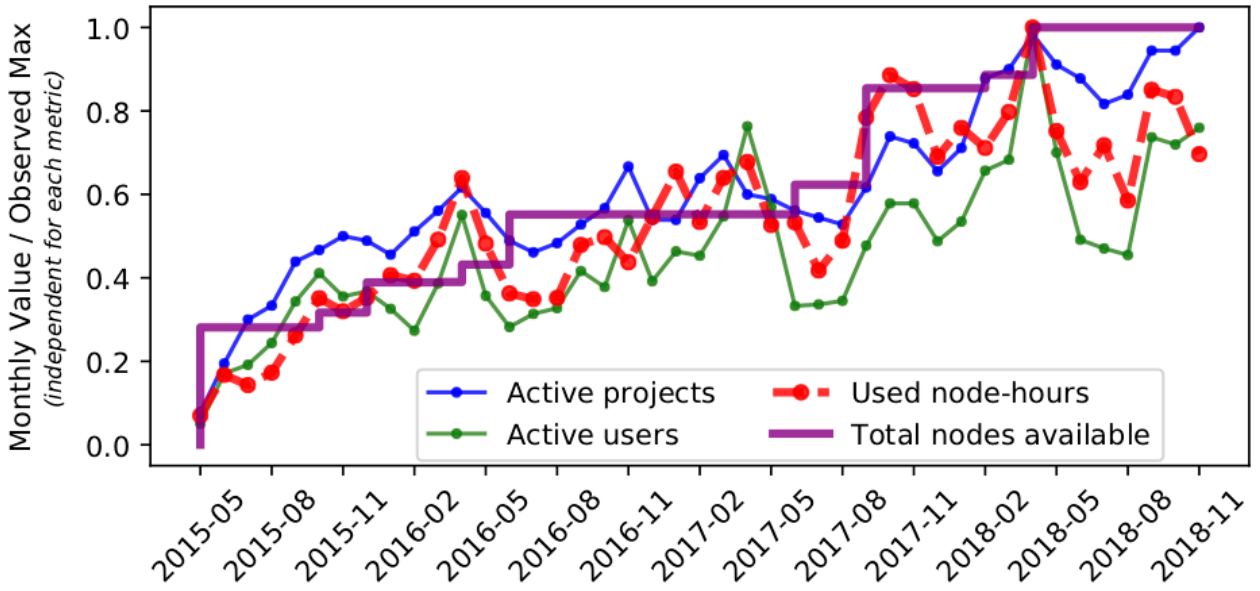
Motivation

- Cloud computing plays an important role in supporting most software we use in our daily lives
- Critical for enabling research into new cloud technologies
- Demand for cloud testbeds higher than available resources



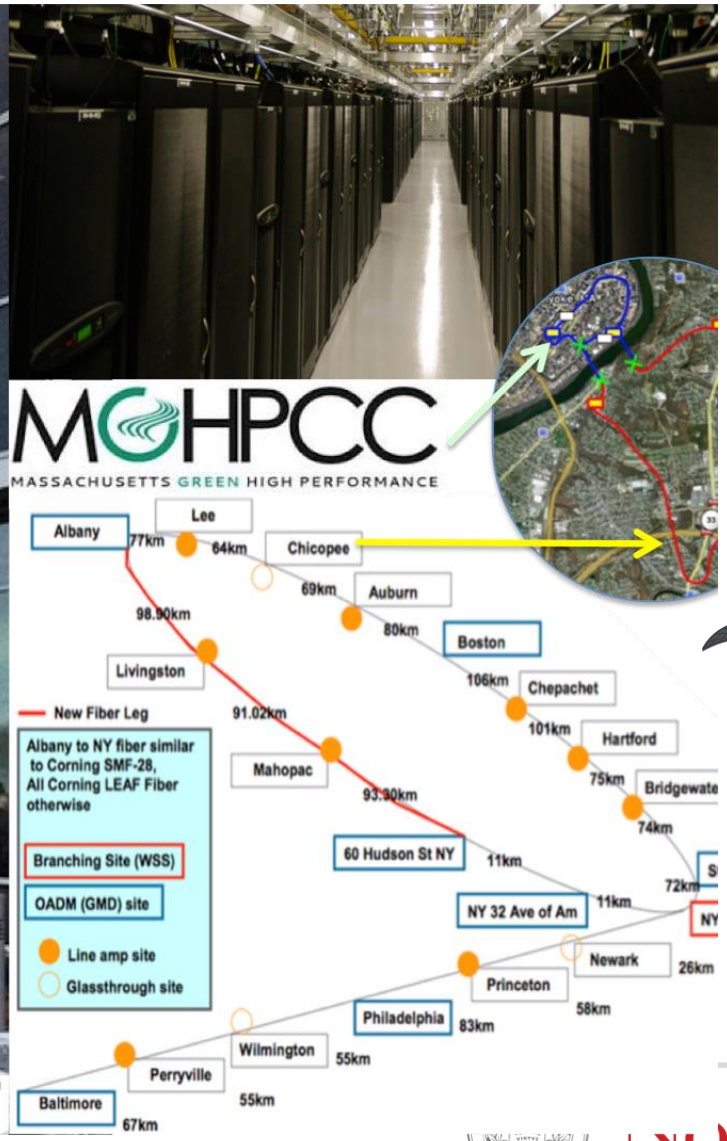
Building on Existing Infrastructure

- MGHPCC: Massachusetts Green High Performance Computing Center
- MOC: Massachusetts Open Cloud
- OpenCloudLab

- What's new:
  - FPGAs for the user community

MGHPCC: Massachusetts Green High Performance Computer Center

Mass Open Cloud



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Exploring Networks of the Future

FABRIC

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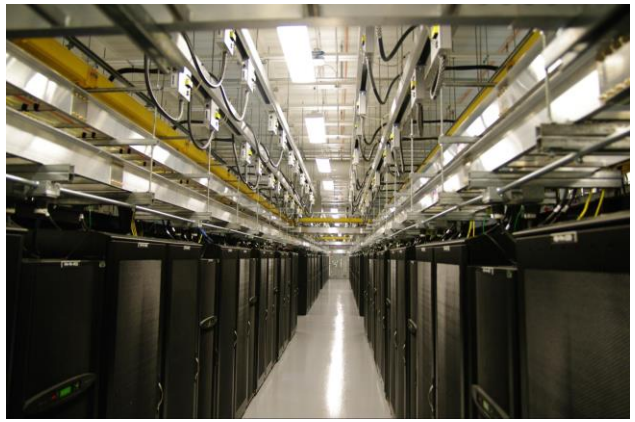
MOC: Massachusetts Open Cloud



- Funded by Commonwealth, Industry partners and universities
- Thousands users, many thousands of users of services
- New Harvard/BU research IT plan to create a production service:
  - consistent infrastructure, operations team, research facilitators, buy-in model
- Connection to NSF NESE (20+PB), NSF NE Cyberteam, Harvard Dataverse
- Sustainability through:
  - integration with research IT and support for end-users
  - industry support for cloud: interoperability lab, exposing new innovation, visibility into usage
  - extensive experience upstreaming with large industry driven open source communities
- Support smaller institutions: new MTC proposal & NE Cyberteam
- Used by regional “friends and family” CISE researchers: cybersecurity (MACS), systems, data science …

What is Massachusetts Open Cloud (MOC)?

HARVARD Dataverse

Red Hat
Two Sigma
Lenovo
Dell
Intel
Cisco
IBM
Harvard IQSS

Elastic Secure Infrastructure

1+ PB

2500 cores, ~40TB RAM

400 Power9 Cores, 40 GPUs, 5TB RAM

New North East Storage Exchange (NESE)

- 20 PB + file system & Object storage
- Massive data lake for region, co-located with MOC
- Fraction of the cost of AWS S3

20+ PB

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MOC supports

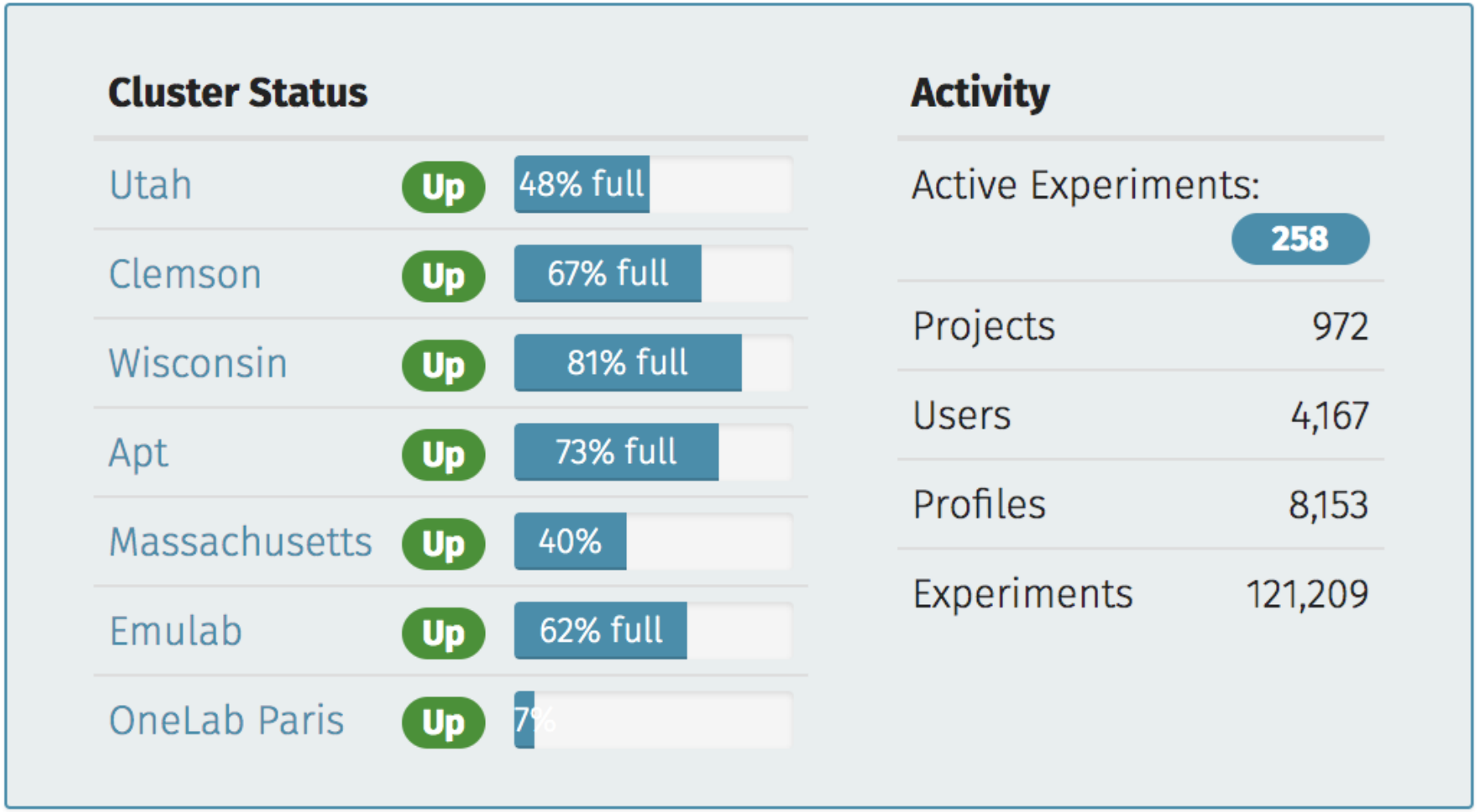
- real users
- access to real data sets
- can provide traces of real usage
- can allow services to be exposed to end-users (e.g., TTP)
- has access to production services at scale (e.g., NESE)
- infrastructure and services provided by industry partners

CloudLab

- Scientific infrastructure for cloud research
- Three clusters (Utah, Wisconsin, and Clemson), which offer 15,000 cores
  - Each cluster has a different focus: storage and networking (using hardware from Cisco, Seagate, and HP), high-memory computing (Dell), and energy-efficient computing (HP).
- Designed specifically for reproducible research
- Hard isolation to create many parallel “slices”

What is CloudLab?

CloudLab



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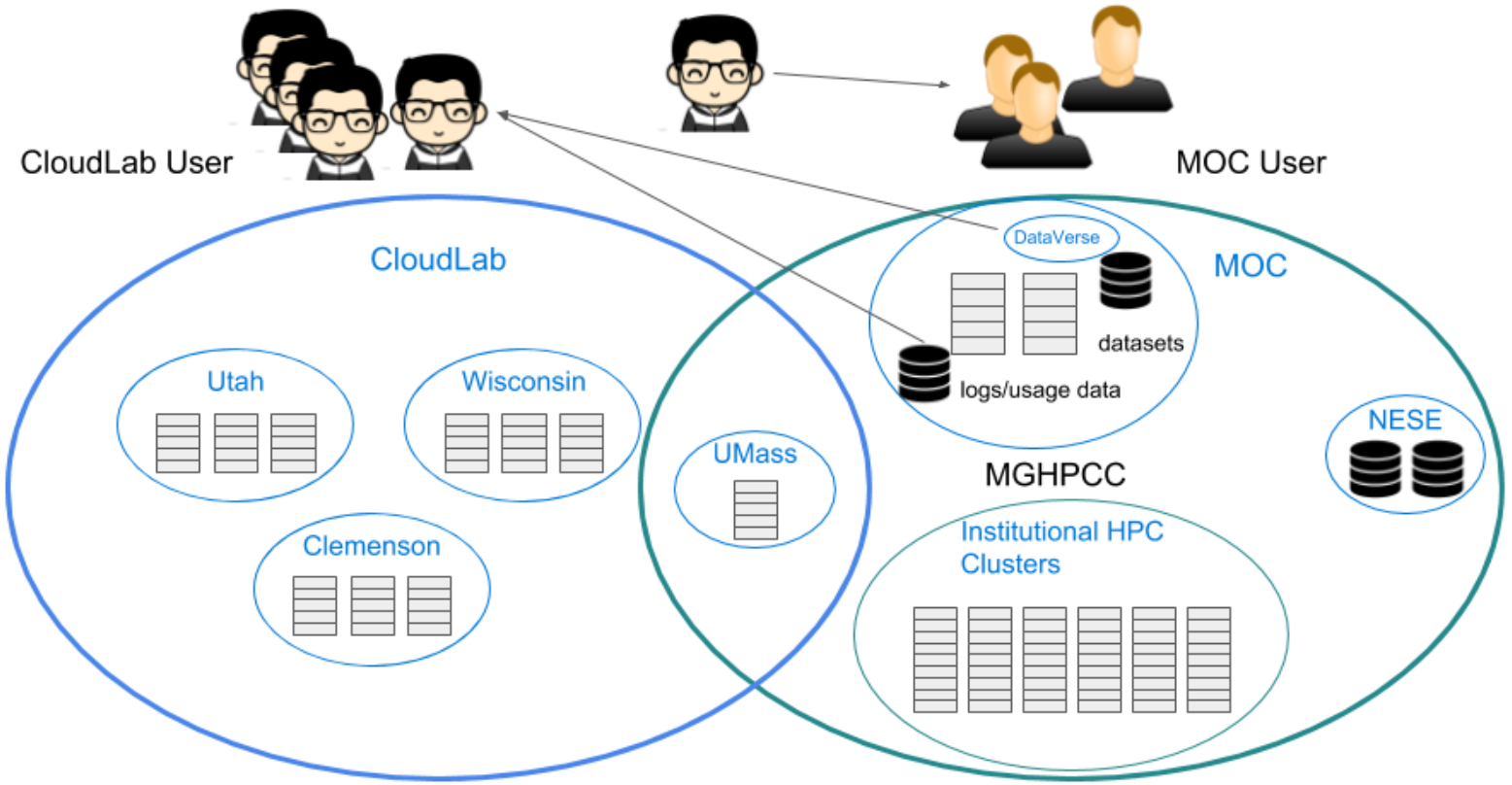
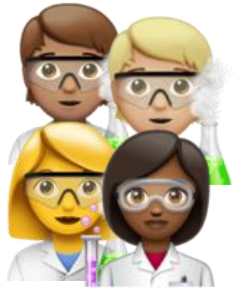
Open CloudLab Concept



Research "in" the MOC



Cloud Users

Exposing experimental services

Access to Cloud data sets

Access to Cloud metadata

Local research infrastructure

Industry engagement

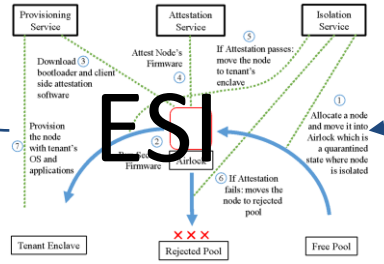
Cloud Researchers

HARVARD Dataverse

NESE

logs/usage data

MOC production cloud



NERC

intel redhat NetApp CISCO DELL Northeastern

Open Cloud Testbed: our new project

- A testbed for research and experimentation into new cloud platforms
- Combine proven software technologies with a real production cloud
- Enhanced with programmable hardware (FPGA) capabilities not present in other facilities available to researchers today

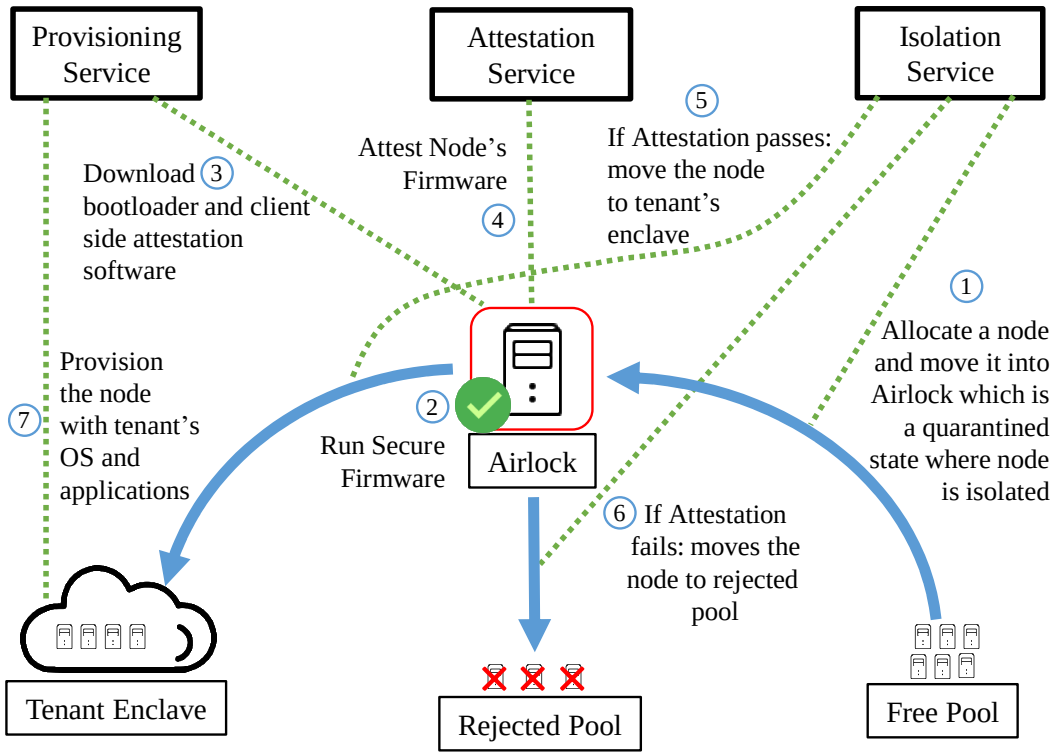
- We are just defining what we want to do

Open Cloud Testbed

- Augments MOC with CloudLab:
  - proven tool for CISE researchers with large community
  - strong model of outreach to expand on
- Dedicate NSF-funded resources to support broader CISE community
- Integrates critical new cloud capability:
  - FPGA testbed with major investment to make available to broader CISE community
- MOC/MGHPCC capabilities made available to broader CISE community:
  - traces, datasets, TTP/opt in users, NESE, Harvard Dataverse
- Hardens ESI capability to:
  - support movement of infrastructure between production MOC & OCL
  - enable exploitation of larger production HPC clusters
  - enable systems researchers access to institutional resources & facilitators
- Enable federation and replication to other OC & Cloud Lab data centers

ESI: Elastic Server Infrastructure

- Securely managed and provisioned physical servers designed for production, rather than experimentation
- Micro-services that include:
  - Isolation service
  - A stateless provisioning service
  - Attestation service (for security)



Research Opportunities

- Capacity
  1. Additional resources provided via the MOC and MGPCC CloudLab
  2. Ability to shift more resources into the testbed using ESI
  3. Ability to suspend and resume experiments using ESI
- At-scale experiments
- Cloud integration
- New hardware
  - FPGAs!

FPGAs in the Datacenter: What exists

- Microsoft Catapult
  - Difficult for users to access and program
- AWS F1 instances
  - Available to users, but interactions are restricted
- Fabric at Texas Advanced Computer Center
  - https://www.tacc.utexas.edu/systems/fabric
  - Great for exploration but small scale
  - 8 nodes with both Intel and Xilinx FPGAs
- Noctua system at Paderborn: https://pc2.uni-paderborn.de/hpc-services/available-systems/noctua/

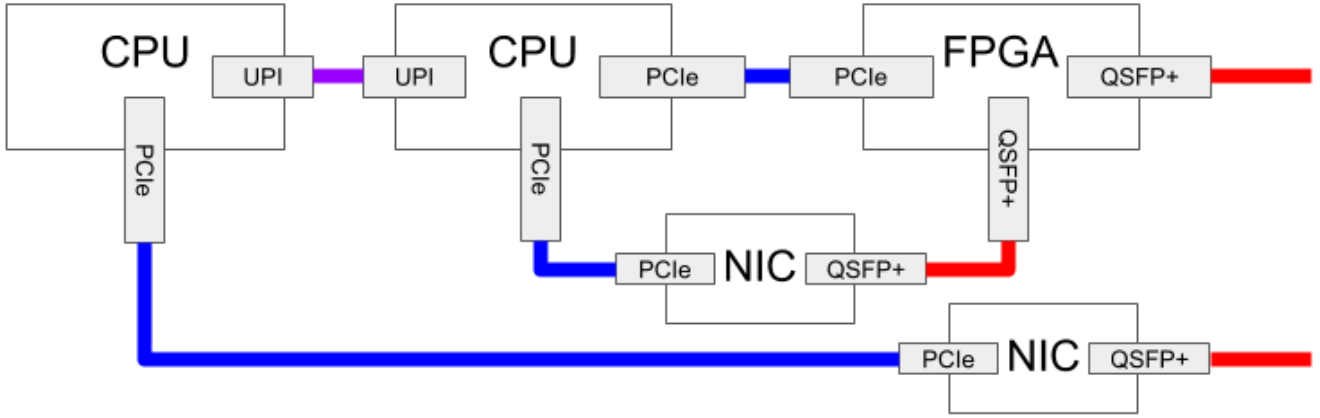
FPGAs in the datacenter: What can we add that is new?

- Large system, more flexible to program than existing systems

- “Bump in the wire” network interface
- FPGA to FPGA communications
- Multitenancy
- Support for run-time reconfiguration

- …

FPGAs



- Research enabled
  - Cloud and Operating System: BitW processing in cloud and operating systems
  - FPGA systems: Support for dynamic reconfiguration, multitenancy, elasticity and security
  - FPGA-related tools and middleware: Augmentations to High Level Synthesis tools (e.g., OpenCL, Vitis) and support for middleware that exploits FPGAs
  - Provider applications: SDN, streaming compression, encryption, and data transformations
  - Tenant applications: take advantage of the network-side position of the accelerator and/or low-latency communication

Applications

- Bioinformatics, Molecular Dynamics
- Compression -- video, genetic sequencing …
- Machine Learning
- Security and Privacy
- ….

- <Your application goes here>

Why FPGAs for HPC/Cloud?

- Replace GPUs?
- Is that the only things you want FPGAs for?

- Transceivers – cheap, flexible, high quality interconnects
- Co-location of compute and communication logic
- Flexible on-chip/ off-chip interconnects

“We are good at low latency. We will stay good at low latency.” - keynote, FPGA 2019

“Data movement is everything” - heard at FPGA 2019

Tell us what you want!

- Send us an email to be part of our survey
- Miriam: mel@coe.neu.edu
- Martin: herbordt@bu.edu

- What should we be asking about?

https://wwwhttp://www.coe.neu.edu/Research/rcl/members/MEL/index.html