# Compliant Cloud+Campus Hybrid HPC Infrastructure

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# What is CUI?


- CUI stands for **C**ontrolled **U**nclassified **I**nformation
- NIST SP 800-171
  - Rev. 1 came out in 2016
  - Outlined the regulation standards for CUI data held in non-federal IT infrastructure
  - 110 requirement controls in 14 different categories
- CUI compliance required for many DOD or DARPA federal grants and by other federal agencies
- Focus is only on protecting *confidentiality* of CUI data

# CUI at ND

- Multiple recent federal grants requiring CUI compliance
  - Mostly DARPA and DOD grants
- One group with these grants is the Notre Dame Turbomachinery Laboratory (NDTL)
  - Requires HPC environment (CRC responsibility)

- Cloud or on-premise?

# Cloud Benefits

- Less regulation requirements to manage (taken care of by cloud vendor)
- More elastic and scalable than on-prem resources
- Newer, more powerful individual servers than in the average on-prem HPC environment
- Doesn't require such large capital investments typical of large on-prem HPC purchases

# Cloud Downsides

- All three major cloud vendors (AWS, Azure, GCP) all claim to support HPC
  - But no cost-effective support for true, top-tier HPC workloads
- HPC typically requires much higher utilization rates than enterprise or general IT systems
  - HPC is significantly more expensive in the cloud than other IT segments

# Cloud Downsides

- No cost-effective high-speed interconnect offerings, like InfiniBand
  - Azure is the only major vendor that offers InfiniBand, but it isn't cost-effective
  - Low latency, fast network performance is a major concern for true, top-tier HPC in the cloud
- No readily available high performance file storage like Lustre or Panasas

# Hybrid Approach

- Decision was made to implement a hybrid CUI environment for the NDTL group
- Takes advantage of the benefits of the cloud while performing true HPC in an on-campus data center
- Notre Dame already uses commercial AWS; AWS GovCloud is used for cloud CUI environment
- Collaboration with ND Office of Information Technology (OIT) and Engineering & Science Computing (ESC) groups and the CRC

# System Architecture Diagram

- http://www.crc.nd.edu/~mvanderw/crc_cui.pdf

# Client Facing

- Users/administrators use Ericom Connect software to access ND CUI GovCloud environment
  - Uses separate CUI environment-specific Active Directory (AD) domain for authentication
  - Web, desktop, or mobile application interface
  - Duo is used for 2FA
  - Provides an interface for users to log into various workstations in different projects in the GovCloud CUI environment
  - Users get a desktop for a Windows or Linux workstation through an RDP connection via Ericom

# Shared Services

- Managed by ND OIT group
- Isolated AWS VPC; peers with all project VPCs
- Designed and implemented over the course of 2 years; production since January 2018
- Offers shared infrastructure services to project VPCs and on-campus CUI environment
  - DNS, AD, Windows Update, Red Hat Satellite server, Ericom Connect server, etc.
- All inbound & outbound traffic between campus, GovCloud CUI environments and the outside world must go through Shared Services

# NDTL Project VPC

- Managed by ND ESC and OIT
- Production since January 2018
- Contains user workstations for the NDTL group
  - Used for small computational models and graphics-intensive data analysis
  - Also used to access the on-campus CUI HPC environment
- Other non-hybrid project VPCs also exist in ND AWS GovCloud environment

# CUI HPC Infrastructure

- Managed by CRC; resides in CRC data center
- Systems enclosed in two locked racks only accessible via special RFID proximity access cards, using an APC NetBotz rack monitoring appliance
- HPE DL385 Gen10 systems running AMD EPYC processors
  - 20 compute nodes + 1 interactive frontend
  - 10 Gb Ethernet, Mellanox EDR InfiniBand interconnect


APC
APC


THIS DOOR MUST REMAIN
CLOSED AT ALL TIMES

# Campus Bridge

- On-campus HPC and GovCloud CUI environments connected via multiple encrypted tunnels
  - Using a Cisco ASR network appliance
- Two tunnels: between Shared Services VPC and on-campus HPC and between NDTL project VPC and on-campus HPC
- Only path to access on-campus CUI HPC environment over the network