Chameleon

www. chameleoncloud.org

CHAMELEON: AN INNOVATION PLATFORM FOR COMPUTER SCIENCE RESEARCH AND EDUCATION

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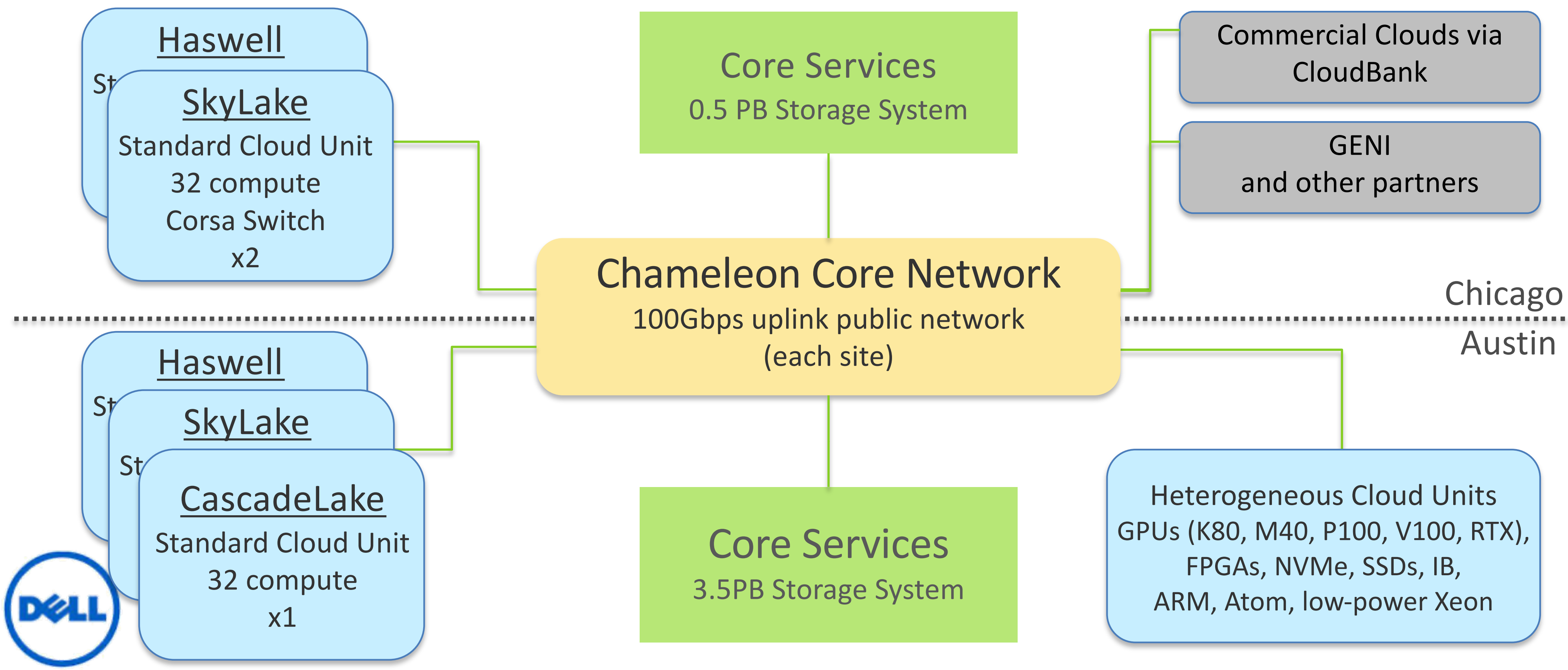
12th JLESC WORKSHOP

THE UNIVERSITY OF CHICAGO | TACC | renci | NORTHWESTERN UNIVERSITY | NSF

CHAMELEON IN A NUTSHELL

- Balance: large-scale versus diverse hardware
  - Large-scale: ~large homogenous partition (~15,000 cores), ~6 PB of storage distributed over 2 sites (UC, TACC) connected with 100G network
  - Diverse: ARMs, Atoms, FPGAs, GPUs, Corsa switches – and more to come!
- We like to change: a testbed that adapts itself to your experimental needs
  - Deep reconfigurability (bare metal) and isolation
  - power on/off, reboot, custom kernel, serial console access, etc.
- Cloud++: leveraging mainstream cloud technologies
  - Powered by OpenStack with bare metal reconfiguration (Ironic) + "special sauce"
  - Blazar contribution recognized as official OpenStack component
- We live to serve: open, production testbed for Computer Science Research
  - Started in 10/2014, available since 07/2015, recently renewed till 10/2024!
  - Currently 5,000+ users, 600+ projects, 100+ institutions, 300+ publications

CHAMELEON HARDWARE



CHAMELEON HARDWARE (EXISTING)

- "Start with large-scale homogenous partition"
  - 12 Haswell Standard Cloud Units (48 node racks), each with 42 Dell R630 compute servers with dual-socket Intel Haswell processors (24 cores) and 128GB RAM and 4 Dell FX2 storage servers with 16 2TB drives each; Force10 s6000 OpenFlow-enabled switches 10Gb to hosts, 40Gb uplinks to Chameleon core network
  - 3 SkyLake Standard Cloud Units (32 node racks); Corsa (DP2400 & DP2200) switches, 100Gb ulpinks to Chameleon core network
  - CascadeLake Standard Cloud Units (32 node rack) , 100Gb ulpinks to Chameleon core network
  - Allocations can be an entire rack, multiple racks, nodes within a single rack or across racks (e.g., storage servers across racks forming a Hadoop cluster)
- Shared infrastructure
  - 3.6 + 0.5 PB global storage, 100Gb Internet connection between sites
- "Graft on heterogeneous features"
  - Infiniband with SR-IOV support, High-mem, NVMe, SSDs, P100 GPUs (total of 22 nodes), RTX GPUs (40 nodes), FPGAs (4 nodes)
  - ARM microservers (24) and Atom microservers (8), low-power Xeons (8)

COMING SOON TO A TESTBED NEAR YOU…

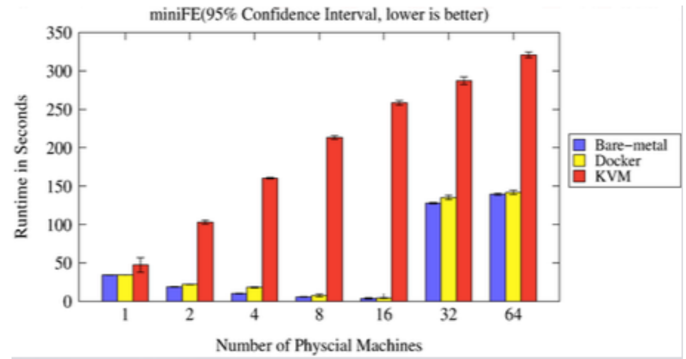
- New servers for old: upgrading Haswell to CascadeLake at TACC and UC
- More accelerators: V100s, AMD + AMD GPU, Xilinx
- Storage hierarchy options: Optane, a mix of enterprise NVMes and SSDs
- Composable hardware: IB rack with GPU/storage nodes (UC), LiQid (TACC)
- Networking: replicating FABRIC Hank design, P4 switches
- IoT devices & CHI@Edge
- Also a strategic reserve – we want to hear from you!

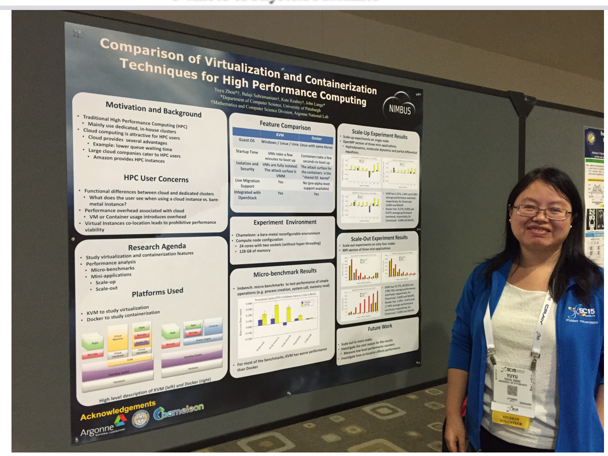
EXPERIMENTAL WORKFLOW

discover resources	allocate resources	configure and interact	monitor
- Fine-grained - Complete - Up-to-date - Versioned - Verifiable	- Allocatable resources: nodes, VLANs, IPs - Advance reservations and on-demand - Expressive interface - Isolation	- Deeply reconfigurable - Appliance catalog - Snapshotting - Orchestration - Jupyter integration - Networks: stitching and BYOC	- Hardware metrics - Fine-grained data - Aggregate - Archive

VIRTUALIZATION OR CONTAINERIZATION?

- Yuyu Zhou, University of Pittsburgh
- Research: lightweight virtualization
- Testbed requirements:
  - Bare metal reconfiguration, isolation, and serial console access
  - The ability to “save your work”
  - Support for large scale experiments
  - Up-to-date hardware





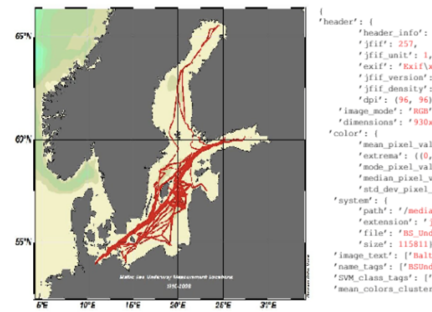
SC15 Poster: “Comparison of Virtualization and Containerization Techniques for HPC”

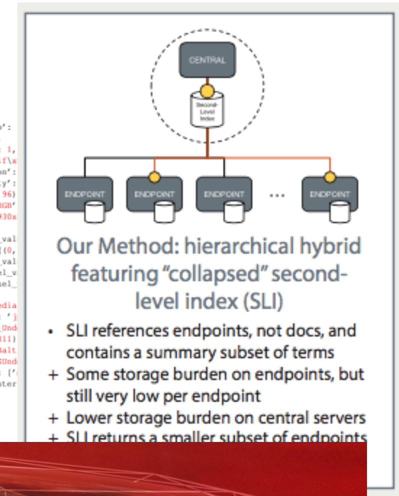
CLASSIFYING CYBERSECURITY ATTACKS

- Jessie Walker & team, University of Arkansas at Pine Bluff (UAPB)
- Research: modeling and visualizing multi-stage intrusion attacks (MAS)
- Testbed requirements:
  - Easy to use OpenStack installation
  - A selection of pre-configured images
  - Access to the same infrastructure for multiple collaborators

DATA SCIENCE RESEARCH

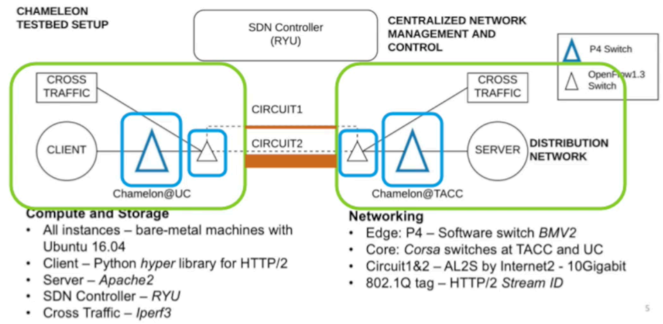
- ACM Student Research Competition semi-finalists:
  - Blue Keleher, University of Maryland
  - Emily Herron, Mercer University
- Searching and image extraction in research repositories
- Testbed requirements:
  - Access to distributed storage in various configurations
  - State of the art GPUs
  - Easy to use appliances and orchestration





ADAPTIVE BITRATE VIDEO STREAMING

- Divyashri Bhat, UMass Amherst
- Research: application header based traffic engineering using P4
- Testbed requirements:
  - Distributed testbed facility
  - BYOC – the ability to write an SDN controller specific to the experiment
  - Multiple connections between distributed sites
- https://vimeo.com/297210055



LCN'18: "Application-based QoS support with P4 and OpenFlow"

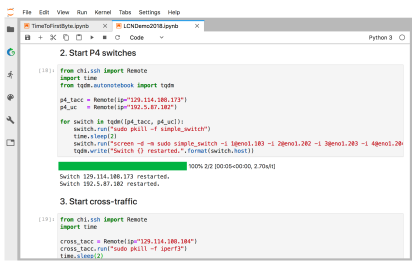
TOWARDS SHARING EXPERIMENTS

- Towards a world where experiments are as sharable as papers today
- Instruments held in common: sharing hardware
- Clouds: sharing experimental environments
  - Disk images, orchestration templates, and other artifacts
- What is missing?
  - Telling the whole story: hardware + experimental container + experiment workflow + data analysis + story – literate programming
  - The easy button: it has to be easy to package, easy to repeat, easy to find, easy to get credit for, easy to reference, etc.
  - Nits and optimizations: declarative versus imperative, transactional versus transparent

Paper: "The Silver Lining", IEEE Internet Computing 2020

PACKAGING SHARABLE EXPERIMENTS

jupyterhub **Literate Programming with Jupyter**



Experimental storytelling:
ideas/text, process/code, results

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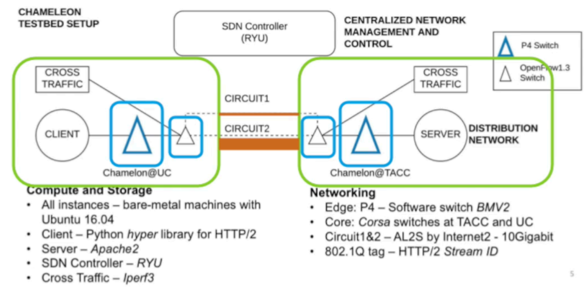
Chameleon



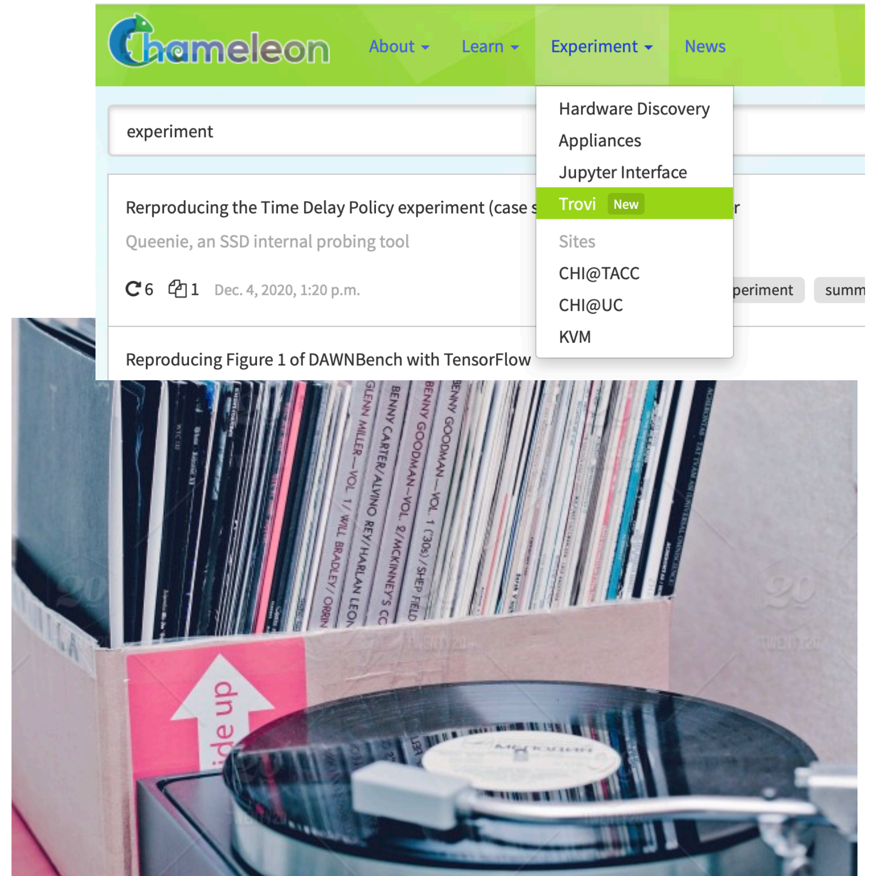
Complex Experimental containers

- Repeatability by default: Jupyter notebooks + Chameleon experimental containers
  - JupyterLab for our users: use jupyter.chameleoncloud.org with Chameleon credentials
  - Interface to the testbed in Python/bash + examples (see LCN'18: https://vimeo.com/297210055)
  - Named containers: your experimental process goes here

Paper: "A Case for Integrating Experimental Containers with Notebooks", CloudCom 2019

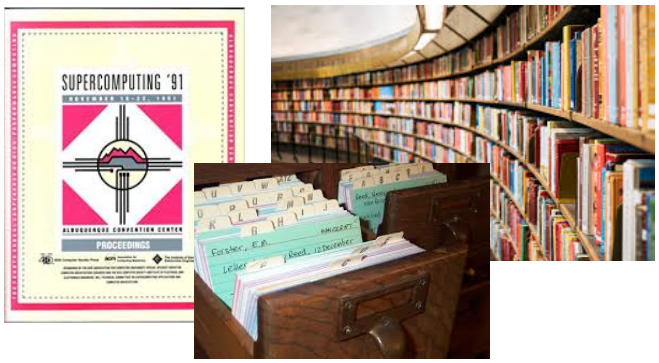
TROVI: SHARING EXPERIMENTS

- Testbed is a "player" for exiting research!
- Find existing experiments
  - Vast library including quickstarts (Python, OpenFlow, power management),and packaged of experiments from foundational papers
- Share new experiments
  - Package your experiment, create a bundle, edit sharing settings, add keywords



PUBLISHING

Familiar research sharing ecosystem



Digital research sharing ecosystem

- Digital publishing with Zenodo: make your experimental artifacts citable via Digital Object Identifiers (DOIs)
- Integration with Zenodo
  - Export: make your research citable and discoverable
  - Import: access a wealth of digital research artifacts already published
- Towards making research findable: the digital sharing platform

PHASE 3 ADVERTISEMENT

- Already here: access via federated accounts!
- New hardware: traditional servers, new GPUs and FPGAs, storage upgrades (FLASH arrays), composable hardware (LiQid), networking (P4, integration with FABRIC), IoT devices -- and strategic reserve
- New capabilities: federation, Bring Your Own Device (BYOD) & CHI@Edge, networking (allocatable switches with P4), core capability improvements
- Infrastructure: CHI-in-a-Box, integration with production infrastructures
- Research sharing: better methods of experiment packaging, publishing, and discovery, digital experiment libraries, engagement

PARTING THOUGHTS

- Science does not stand still: laying the pavement as you walk on it!
- Chameleon is a shareable research instrument – but it is also a sharing platform
- The easy button: sharing experiments as naturally as we share papers
  - Clouds help us package experimental environments as a side-effect of using them and serve as ”player” for such experiment
  - Literate programming is a convenient vehicle for “closing the gap”: packaging the whole experiment
  - Critical mass of research content: check out what you can use!
- Come, help us change: chameleoncloud.org

We're here to change – come and change with us!

www.chameleoncloud.org