



[www.chameleoncloud.org](http://www.chameleoncloud.org)

# CHAMELEON: AN INNOVATION PLATFORM FOR COMPUTER SCIENCE RESEARCH AND EDUCATION

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**February 3rd, 2021**

**MAGIC meeting**

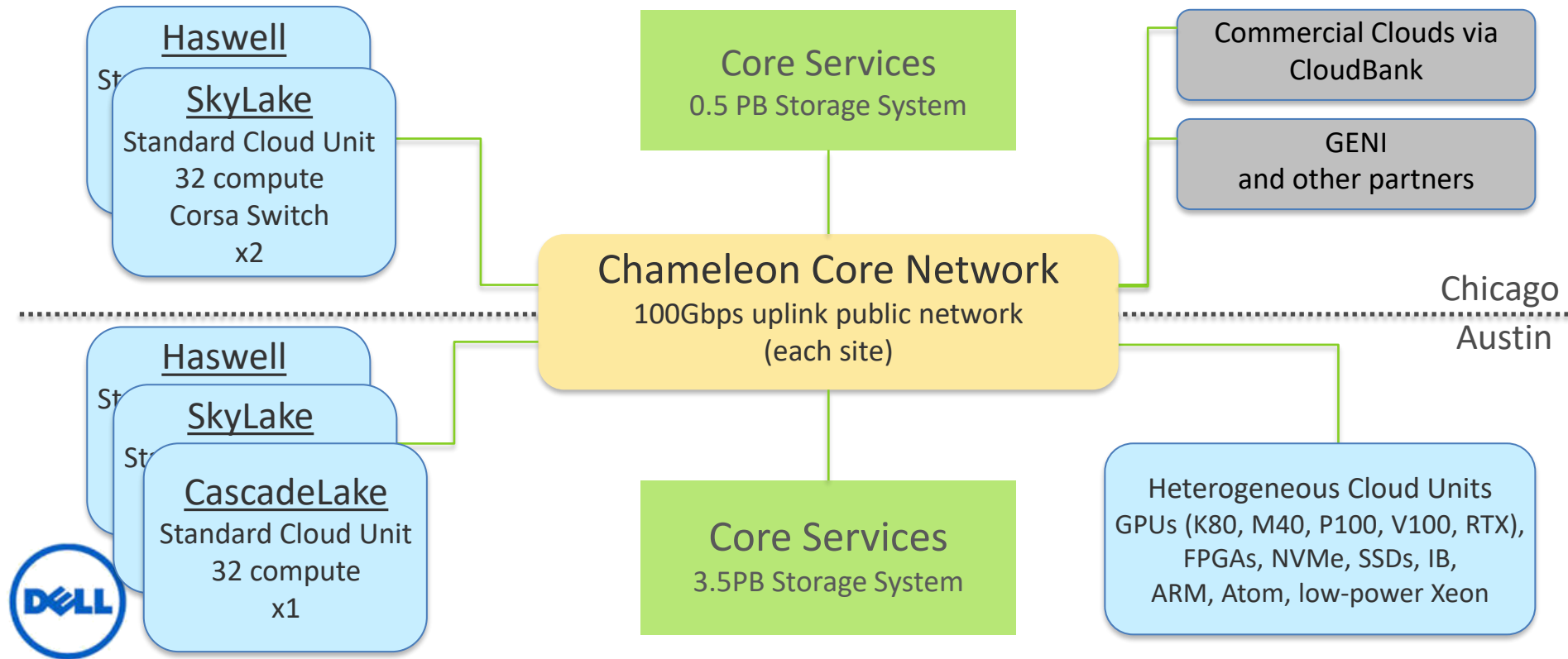


# CHAMELEON IN A NUTSHELL

- ▶ 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, Corsix 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



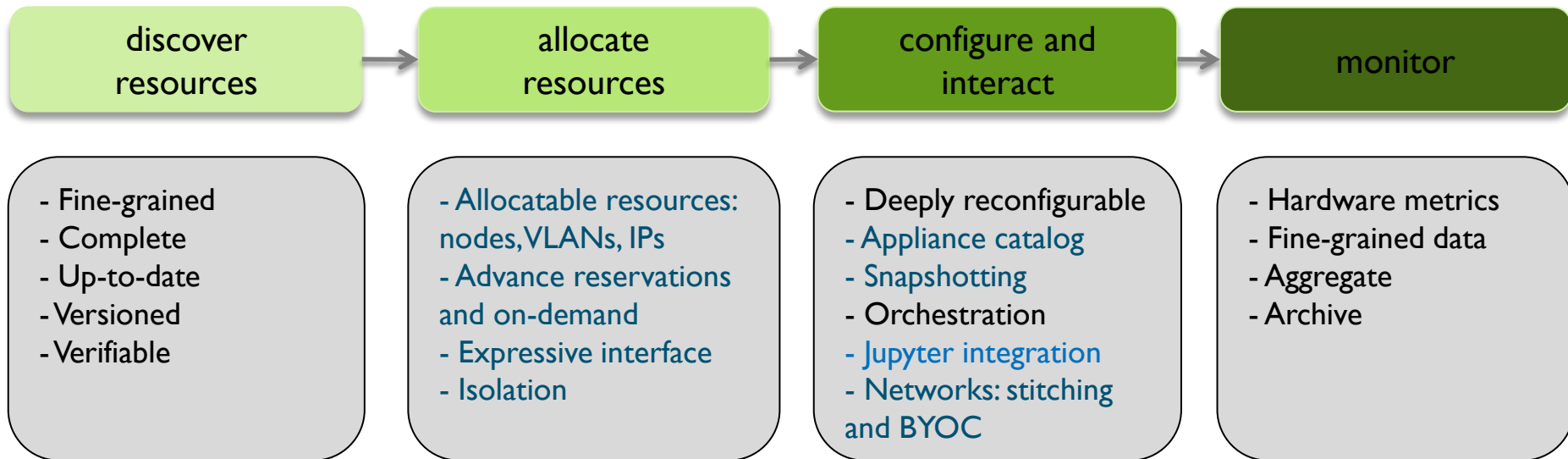
# CHAMELEON HARDWARE (EXISTING)

- ▶ “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 uplinks to Chameleon core network
  - ▶ CascadeLake Standard Cloud Units (32 node rack) , 100Gb uplinks 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...

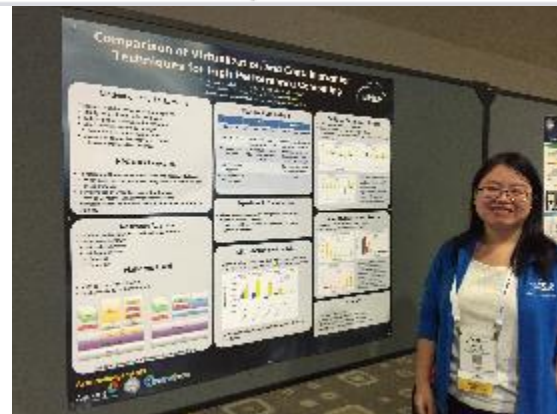
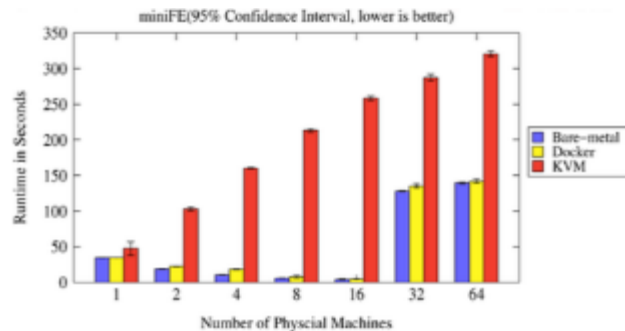
- ▶ New servers for old: upgrading Haswell to CascadeLake at TACC and UC
- ▶ More accelerators: V100s, AMD + AMD GPU, Xilinx
- ▶ Storage hierarchy options: Optane, a mix of enterprise NVMe and SSDs
- ▶ Composable hardware: IB rack with GPU/storage nodes (UC), LiQid (TACC)
- ▶ Networking: replicating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

# EXPERIMENTAL WORKFLOW



# 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

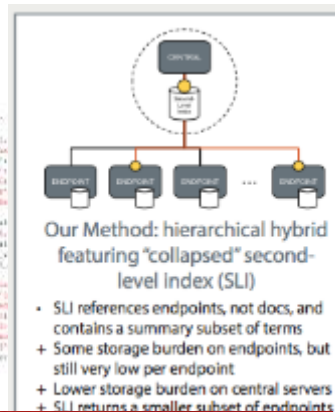
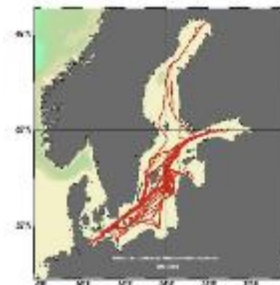
- ▶ Jessie Walker & team, University of Arkansas at Pine Bluff (UAPB)
- ▶ Research: modeling and visualizing multi-stage intrusion attacks (MAS)
- ▶ Testbed requirements:
  - ▶ Easy to use OpenStack installation
  - ▶ A selection of pre-configured images
  - ▶ Access to the same infrastructure for multiple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





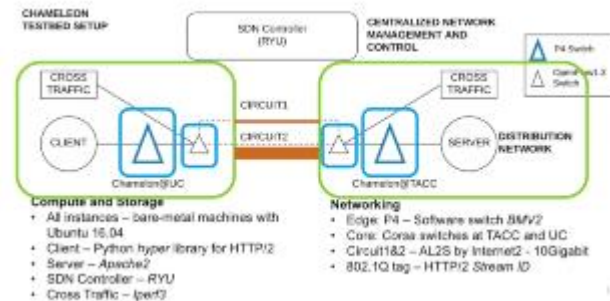
# DATA SCIENCE RESEARCH

- ▶ 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

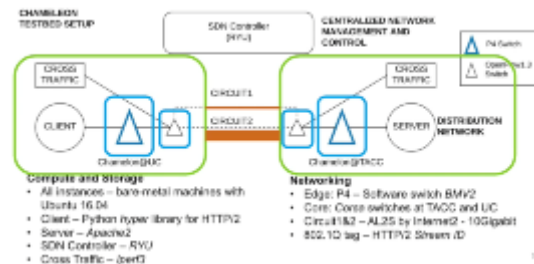
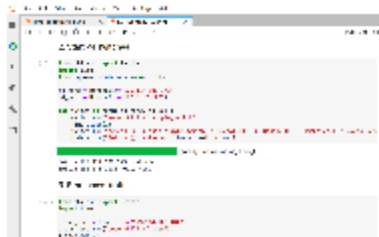
- ▶ Towards a world where experiments are as sharable as papers today
- ▶ Instruments held in common: sharing hardware
- ▶ Clouds: sharing experimental environments
  - ▶ Disk images, orchestration templates, and other artifacts
- ▶ What is missing?
  - ▶ Telling the whole story: hardware + experimental 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



Literate Programming with Jupyter



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

*Complex Experimental containers*

- ▶ Repeatability by default: Jupyter notebooks + Chameleon experimental containers
  - ▶ JupyterLab for our users: use [jupyter.chameleoncloud.org](https://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

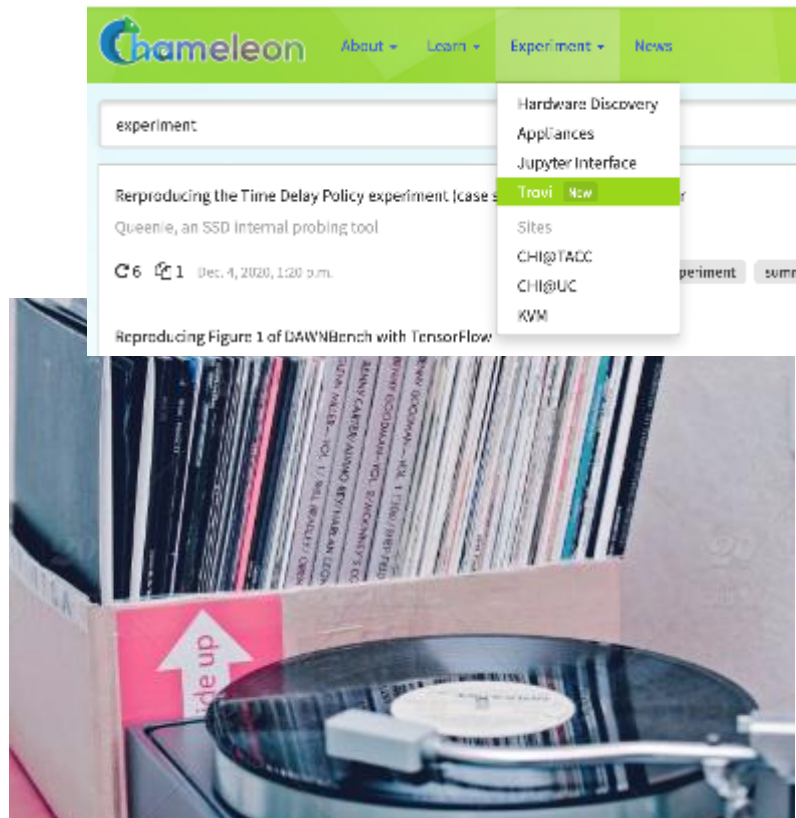
*Paper: “A Case for Integrating Experimental Containers with Notebooks”, CloudCom 2019*



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# TROVI: SHARING EXPERIMENTS

- ▶ Testbed is a “player” for existing experiments/research
- ▶ Trovi: find existing experiments
  - ▶ Library including quickstarts (Python, OpenFlow, power management), and packaged of experiments from foundational papers
- ▶ Trovi: share 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](http://chameleoncloud.org)





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

[www.chameleoncloud.org](http://www.chameleoncloud.org)

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