www. chameleoncloud.org

CHAMELEON: CLOUD ON CLOUD

Kate Keahey

Mathematics and CS Division, Argonne National Laboratory

CASE, University of Chicago

keahey@anl.gov

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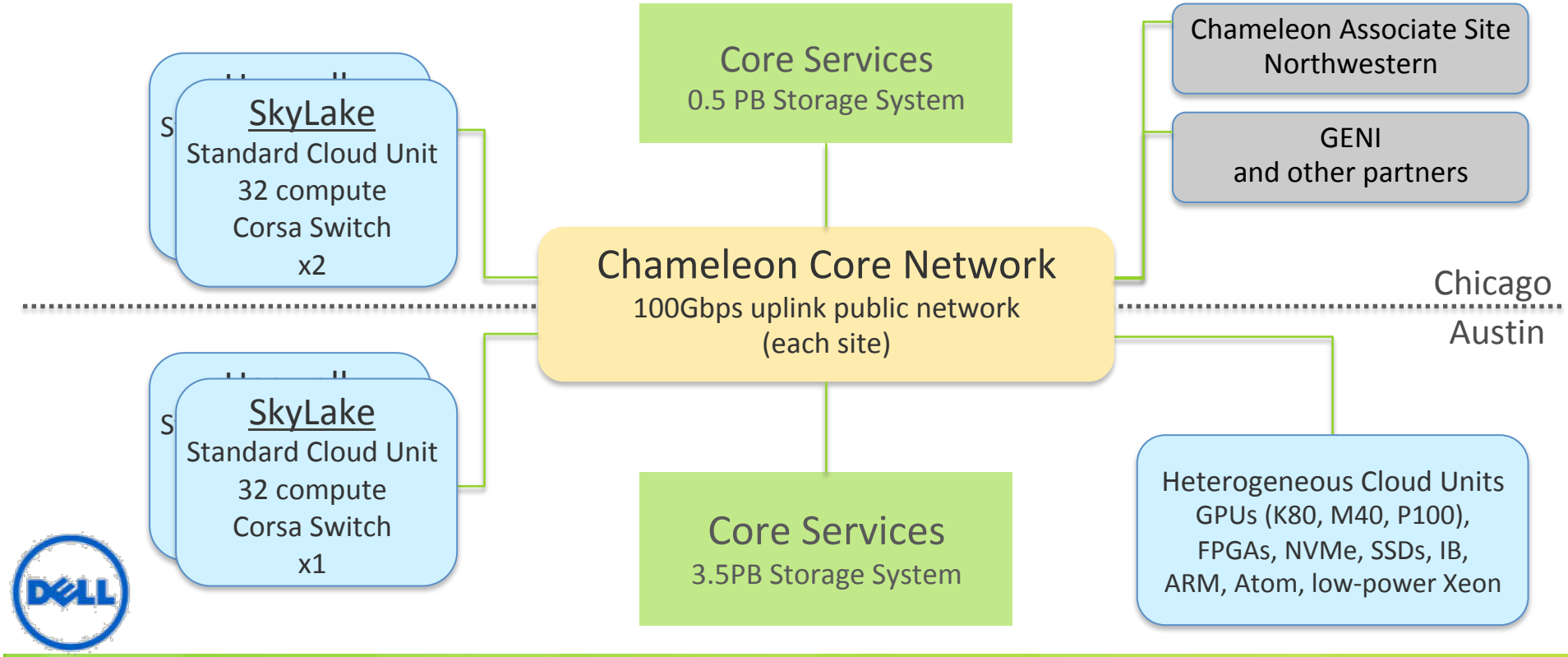
CHAMELEON IN A NUTSHELL

- We like to change: testbed that adapts itself to your experimental needs
  - Deep reconfigurability (bare metal) and isolation (CHI) – but also ease of use (KVM)
  - CHI: power on/off, reboot, custom kernel, serial console access, etc.
- We want to be all things to all people: balancing large-scale and diverse
  - Large-scale: ~large homogenous partition (~15,000 cores), 5 PB of storage distributed over 2 sites (now +1!) connected with 100G network…
  - …and diverse: ARMs, Atoms, FPGAs, GPUs, Corsa switches, etc.
- Cloud on cloud: leveraging mainstream cloud technologies
  - Powered by OpenStack with bare metal reconfiguration (Ironic) + "special sauce"
  - Chameleon team contribution recognized as official OpenStack component
- We live to serve: open, production testbed for Computer Science Research
  - Started in 10/2014, testbed available since 07/2015, renewed in 10/2017
  - Currently 3,000+ users, 500+ projects, 100+ institutions

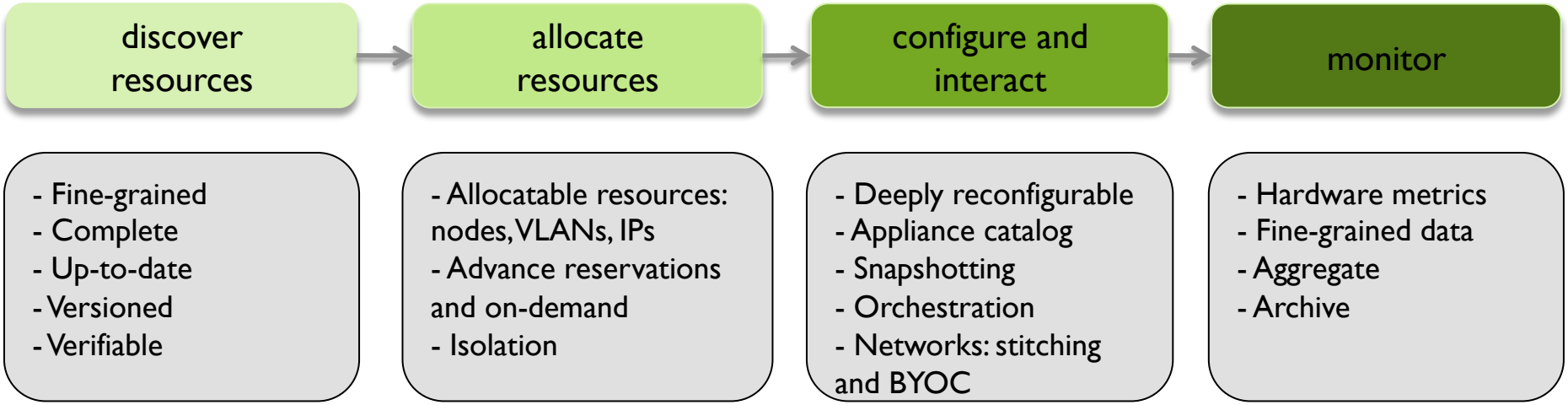
CHAMELEON HARDWARE



CHAMELEON HARDWARE (DETAILS)

- "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
  - 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, GPUs (22 nodes), FPGAs (4 nodes)
  - ARM microservers (24) and Atom microservers (8), low-power Xeons (8)
- Coming soon: more nodes (CascadeLake), and more accelerators

EXPERIMENTAL WORKFLOW



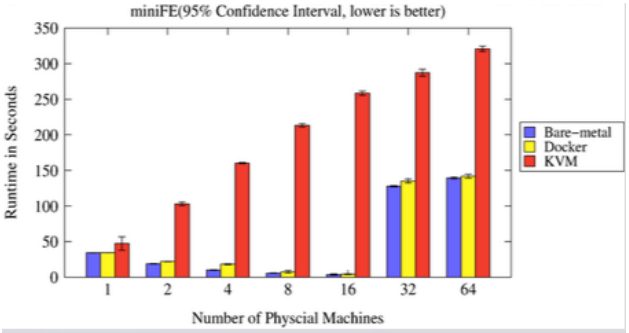
CHI = 65%*OpenStack + 10%*G5K + 25%*"special sauce"

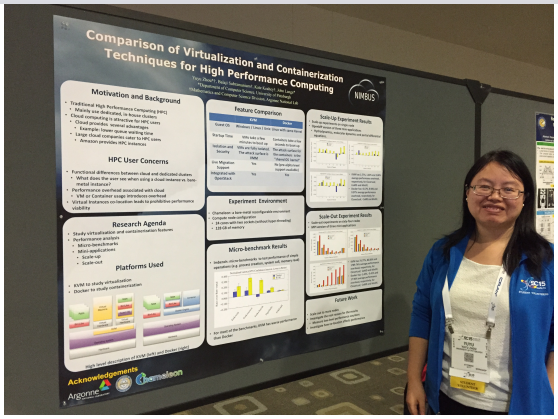
RECENT DEVELOPMENTS

- Allocatable resources
  - Multiple resource management (nodes, VLANs, IP addresses), adding/removing nodes to/from a lease, lifecycle notifications, advance reservation orchestration
- Networking
  - Multi-tenant networking,
  - Stitching dynamic VLANs from Chameleon to external partners (ExoGENI, ScienceDMZs),
  - VLANs + AL2S connection between UC and TACC for 100G experiments
  - BYOC– Bring Your Own Controller: isolated user controlled virtual OpenFlow switches
- Miscellaneous features
  - Power metrics, usability features, new appliances, etc.

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



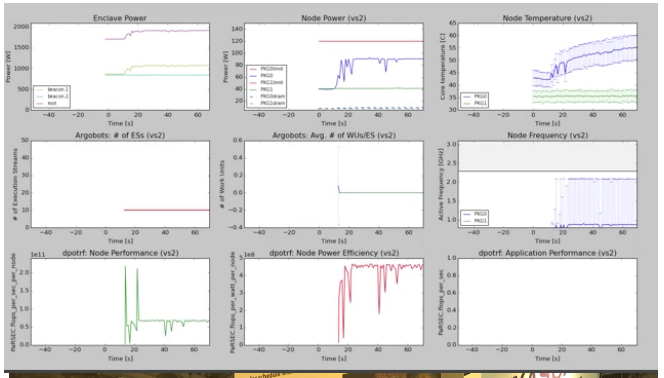


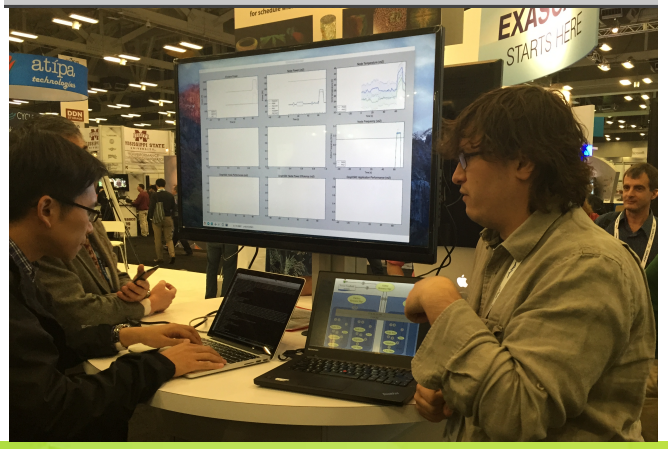
SC15 Poster:“Comparison of Virtualization and Containerization Techniques for HPC”

EXASCALE OPERATING SYSTEMS

- Swann Perarnau, ANL
- Research: exascale operating systems
- Testbed requirements:
  - Bare metal reconfiguration
  - Boot from custom kernel with different kernel parameters
  - Fast reconfiguration, many different images, kernels, parameters
  - Hardware: accurate information and control over changes, performance counters, many cores
  - Access to same infrastructure for multiple collaborators

HPPAC'16 paper: "Systemwide Power Management with Argo"



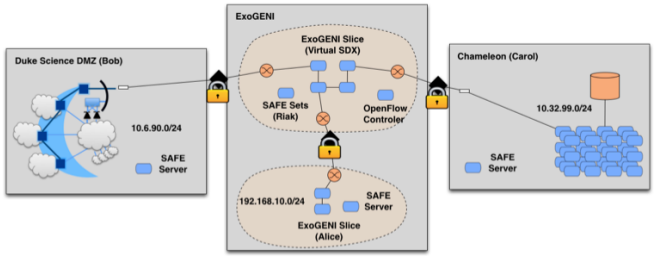


CLASSIFYING CYBERSECURITY ATTACKS

- 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

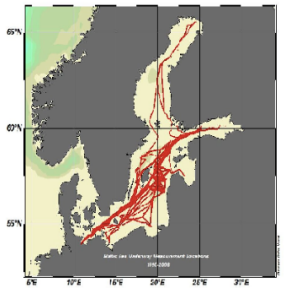
CREATING DYNAMIC SUPERFACILITIES

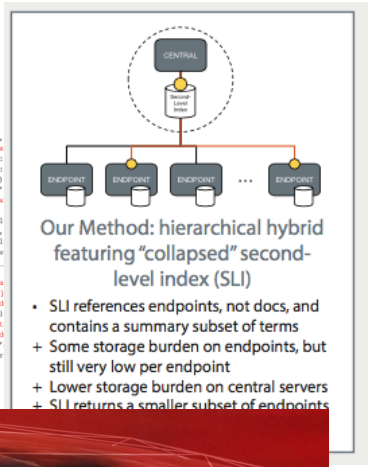
- NSF CICI SAFE, Paul Ruth, RENCI-UNC Chapel Hill
- Creating trusted facilities
  - Automating trusted facility creation
  - Virtual Software Defined Exchange (SDX)
  - Secure Authorization for Federated Environments (SAFE)
- Testbed requirements
  - Creation of dynamic VLANs and wide-area circuits
  - Support for slices and network stitching
  - Managing complex deployments



DATA SCIENCE RESEARCH

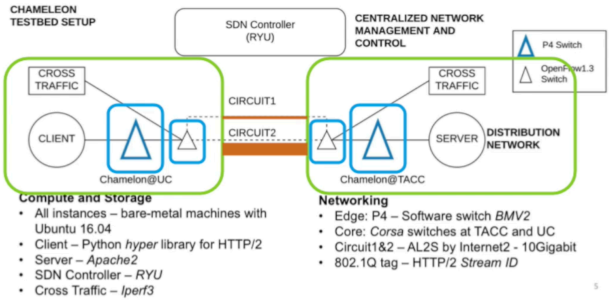
- ACM Student Research Competition semi-finalists:
  - Blue Keleher, University of Maryland
  - Emily Herron, Mercer University
- Searching and image extraction in research repositories
- Testbed requirements:
  - Access to distributed storage in various configurations
  - State of the art GPUs
  - Easy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

BEYOND THE PLATFORM: BUILDING AN ECOSYSTEM

- Helping hardware providers interact
  - Bring Your Own Hardware (BYOH)
  - CHI-in-a-Box: deploy your own Chameleon site
- Helping our user interact – with us but primarily with each other
  - Facilitating contributions of appliances, tools, and other artifacts: appliance catalog, blog as a publishing platform, and eventually notebooks
  - Integrating tools for experiment management
  - Making reproducibility easier
- Improving communication – not just with us but with our users as well

CHI-IN-A-BOX

- CHI-in-a-box: packaging a commodity-based testbed
  - First released in summer 2018, continuously improving
- CHI-in-a-box scenarios
  - Independent testbed: package assumes independent account/project management, portal, and support
  - Chameleon extension: join the Chameleon testbed (currently serving only selected users), and includes both user and operations support Part-time extension: define and implement contribution models
  - Part-time Chameleon extension: like Chameleon extension but with the option to take the testbed offline for certain time periods (support is limited)
- Adoption
  - New Chameleon Associate Site at Northwestern since fall 2018 – new networking!
  - Two organizations working on independent testbed configuration

REPRODUCIBILITY DILEMMA

Should I invest in making my experiments repeatable?

Should I invest in more new research instead?

- Reproducibility as side-effect: lowering the cost of repeatable research
  - Example: Linux “history” command
  - From a meandering scientific process to a recipe
- Reproducibility by default: documenting the process via interactive papers

REPEATABILITY MECHANISMS IN CHAMELEON

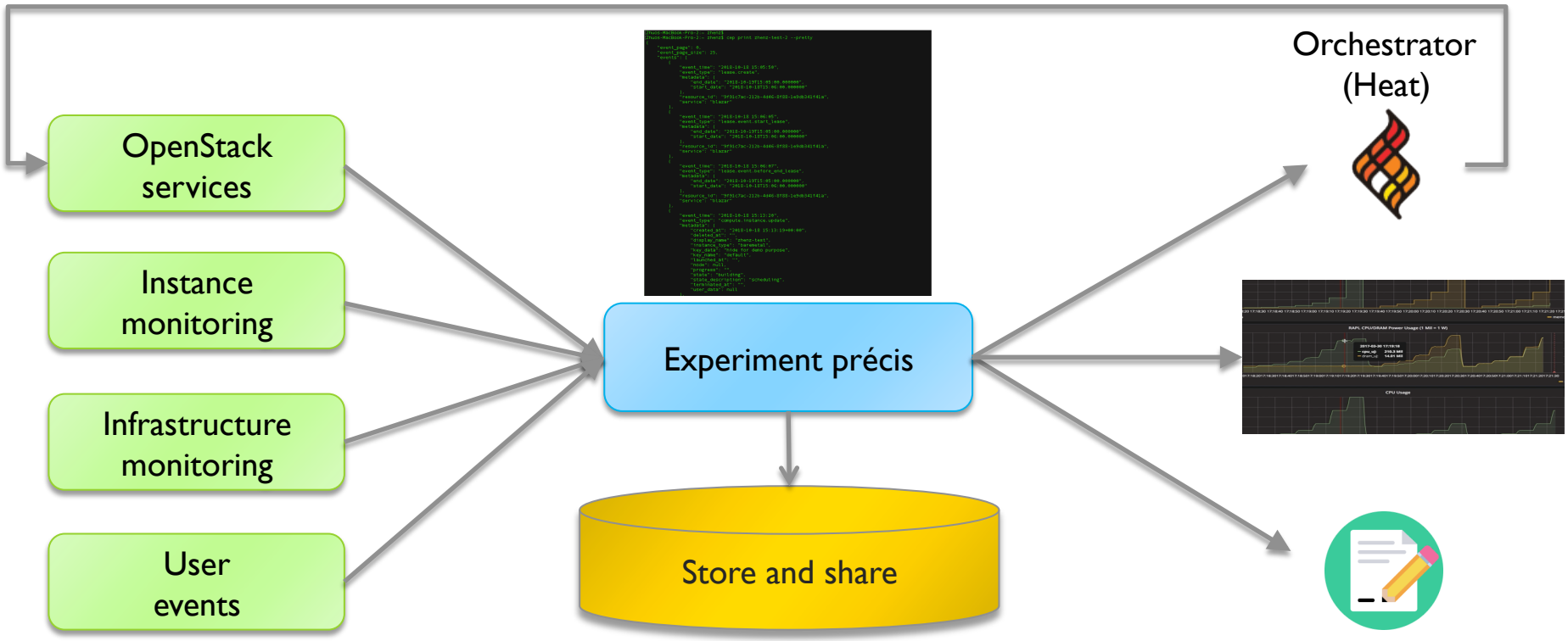
- Testbed versioning (collaboration with Grid'5000)
  - Based on representations and tools developed by G5K
  - >50 versions since public availability – and counting
  - Still working on: better firmware version management
- Appliance management
  - Configuration, versioning, publication
  - Appliance meta-data via the appliance catalog
  - Orchestration via OpenStack Heat
- Monitoring and logging
- However… the user still has to keep track of this information

KEEPING TRACK OF EXPERIMENTS

- Everything in a testbed is a recorded event… or could be
- The resources you used
- The appliance/image you deployed
- The monitoring information your experiment generated
- Plus any information you choose to share with us: e.g., “start power_exp_23” and “stop power_exp_23

- Experiment précis: information about your experiment made available in a “consumable” form

REPEATABILITY: EXPERIMENT PRÉCIS

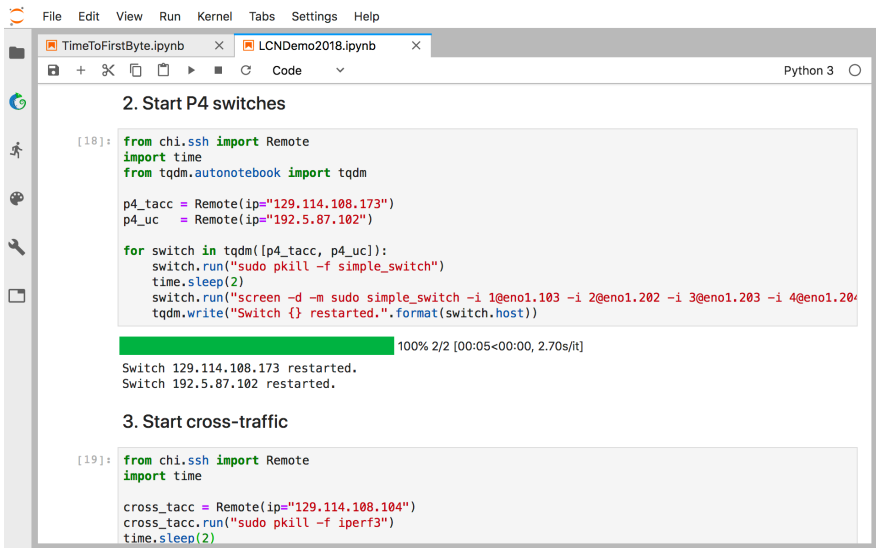


INTERACTIVE PAPERS

- What does it mean to document a process?
- Some requirements
  - Easy to work with: human readable/modifiable format
  - Integrates well with ALL aspects of experiment management
  - Bit by bit replay – allows for bit by bit modification (and introspection) as well – element of interactivity
  - Support story telling: allows you to explain your experiment design and methodology choices
  - Has a direct relationship to the actual paper that gets written
  - Can be version controlled
  - Sustainable, a popular open source choice
- Implementation options
  - Orchestrators: Heat, the dashboard, and OpenStack Flame
  - Notebooks: Jupyter, NextJournal, and others

CHAMELEON JUPYTER INTEGRATION

- Combining the ease of notebooks and the power of a shared platform
  - Storytelling with Jupyter: ideas/text, process/code, results
  - Chameleon shared experimental platform
- JupyterLab server for our users
  - Just go to jupyter.chameleoncloud.org and log in with your Chameleon credentials
- Chameleon/Jupyter integration
  - Interfaces: python and bash for all the main testbed functions
- Templates of existing experiments



Screencast of a complex experiment: https://vimeo.com/297210055

SHARING, EXPERIMENTING, LEVERAGING

- Sharing Jupyter notebooks in Chameleon
  - Sharing with your project members via Chameleon object storage
  - Publish to github for versioning and sharing in wider circle
  - Informally: send via email
  - Challenges ahead: more flexible sharing policy implementation, better integration with github to support more publishing and sharing
- Automating experiments with Jupyter
- Important educational tool: start with a simple example and keep developing

IN THE TUTORIAL TOMORROW

- Instructional examples and artifacts
  - Slides, appliances/images, orchestration templates, Jupyter notebooks
- Introduction to Chameleon
  - Chameleon/cloud basics: how to create instances, how to snapshot them, how to assign public IPs to your deployed instances, etc.
- Advanced Cloud Computing topics
  - Cloud orchestration: orchestrated deployment of multiple instances, contextualization, orchestration templates and tools, examples: Hadoop
  - Networking in the cloud: multi-tenant networking, DirectConnect and stitchports, etc.
  - Managing data in the cloud: instance storage, persistent volumes, and object store, best practices

PARTING THOUGHTS

- Chameleon is a cloud (as in: chameleoncloud.org ;-)
  - …but a special cloud with support for advanced cloud computing research
- Physical environment: Chameleon is a rapidly evolving experimental platform
  - Originally: “Adapts to the needs of your experiment”
  - Now also: “Adapts to the needs of its community and the changing research frontier”
- Towards an Ecosystem: a meeting place of users and providers sharing resources and research
  - Testbeds are more than just experimental platforms
  - Common/shared platform is a “common denominator” that can eliminate much complexity that goes into systematic experimentation, sharing, and reproducibility
- Be part of the change: tell us what capabilities we should provide to help you share and leverage the contributions of others!