CHAMELEON: A LARGE-SCALE, RECONFIGURABLE EXPERIMENTAL ENVIRONMENT FOR CLOUD RESEARCH

Principal Investigator: Kate Keahey

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WHY EXPERIMENT?

“Beware of bugs in the above code; I have only proved it correct, not tried it”
(Donald Knuth)

“In theory there is no difference between theory and practice. In practice there is.”
(Yogi Berra)
SCALING TO THE CHALLENGE

Big Data
Data volume, velocity, and variety

Big Compute
A wide range of data analytics

Programmable networks
cheap, ubiquitous sensors
and other emergent trends

Big Instruments
Cyber-Physical Systems, Observatories

Large Scale
Reconfigurability

Engagement
Connectedness
CHAMELEON: A FLEXIBLE AND POWERFUL EXPERIMENTAL INSTRUMENT

- **Large-scale:** “Big Data, Big Compute, Big Instrument research”
  - ~650 nodes (~14,500 cores), 5 PB disk over two sites, 2 sites connected with 100G network
- **Reconfigurable:** “As close as possible to having it in your lab”
  - Bare metal reconfiguration, single instrument, Chameleon appliances
  - Support for repeatable and reproducible experiments
- **Connected:** “One stop shopping for experimental needs”
  - Workload and Trace Archive
  - Partnerships with production clouds: CERN, OSDC, Rackspace, Google, and others
  - Partnerships with users
- **Complementary:** “Can’t do everything ourselves”
  - Complementing GENI, Grid’5000, and other experimental testbeds
CHAMELEON HARDWARE

Switch
Standard Cloud Unit
42 compute
4 storage
x2

Core Services
Front End and Data Mover Nodes

Chameleon Core Network
100Gbps uplink public network
(each site)

Core Services
3.6 PB Central File Systems, Front End and Data Movers

Heterogeneous Cloud Units
Alternate Processors and Networks

Switch
Standard Cloud Unit
42 compute
4 storage
x10

SCUs connect to core and fully connected to each other

To UTSA, GENI, Future Partners

504 x86 Compute Servers
48 Dist. Storage Servers
102 Heterogeneous Servers
16 Mgt and Storage Nodes

Chicago
Austin

www.chameleoncloud.org
## CAPABILITIES AND SUPPORTED RESEARCH

| Development of new models, algorithms, platforms, auto-scaling HA, etc., innovative application and educational uses |
| Persistent, reliable, shared clouds |
| Repeatable experiments in new models, algorithms, platforms, auto-scaling, high-availability, cloud federation, etc. |
| Isolated partition, Chameleon Appliances |
| Virtualization technology (e.g., SR-IOV, accelerators), systems, networking, infrastructure-level resource management, etc. |
| Isolated partition, full bare metal reconfiguration |
SOFTWARE: CORE CAPABILITIES

Chameleon Appliance Catalog
A library of generic, special-purpose, and educational environments

Discovery, Provisioning, Configuration, and Monitoring
Testbed representation and discovery (Grid’5000)
Nova/Blazar, Ironic, Neutron, Ceilometer
(OpenStack, Rackspace OnMetal)
SUPPORT FOR EXPERIMENT WORKFLOW

discover resources → provision resources → configure and interact → monitor

design the experiment

analyze, discuss, and share
SELECTING AND VERIFYING RESOURCES

- Complete and current representation of actual testbed resources
- Fine-grained representation
- Machine parsable, enables match making
- Versioned
  - “What was the drive on the nodes I used 6 months ago?”
  - Hardware upgrades, maintenance, extensions
- Dynamically Verifiable
  - Does reality correspond to description? (e.g., failures)
  - Can’t afford false assumptions!
RESOURCES CATALOG

- Grid’5000 Registry
- Largely automated resource discovery and fine-grained description
- Browseable: REST, CLI, and web interfaces
- Match making
- Automated description export for the Resource Manager

G5K-checks

- Run at node boot and acquire information on node using ohai, ethtool, etc.
- Compare with resource catalog description
PROVISIONING RESOURCES

- Resource leases
- Allocating a range of resources
  - Different node types, switches, etc.
- Multiple environments in one lease
- Advance reservations (AR)
  - Sharing resources across time
- Eventually: match making, Gantt chart displays

- OpenStack Nova/Blazar
- Extensions to support working with more resources, match making, and displays
CONFIGURE AND INTERACT

- Map multiple appliances to a lease
- Allow deep reconfiguration (incl. BIOS)
- Snapshotting
- Efficient appliance deployment
- Handle complex appliances
  - Virtual clusters, cloud installations, etc.
- Interact: reboot, power on/off, access to console
- Shape experimental conditions

- OpenStack Ironic, Glance, and meta-data servers
MONITORING

- Enables users to understand what happens during the experiment
- Types of monitoring
  - User resource monitoring
  - Infrastructure monitoring (e.g., PDUs)
  - Custom user metrics
- High-resolution metrics
- Easily export data for specific experiments

OpenStack Ceilometer
NETWORKING CAPABILITIES

- Expose SDN, OpenFlow, etc. to users
  - Isolation
  - Hybrid network capabilities
  - Programmable topologies
  - Integration with other resources within and external to the testbed

- Pushing 100G network to the limit
  - Using 100G + SDN optimally is a challenge
  - Chameleon appliances and services allow experimenters a highly granulated view into -- and control over -- traffic flows

- Integration with GENI
  - Data plane integration
  - Control plane integration
  - Common policy context
HIGH PERFORMANCE NETWORKS

- Support virtualization for Big Compute and Big Data
- Chameleon Appliances:
  - HPC MPI with IB & SR-IOV
  - Hadoop with SR-IOV
  - Integration with OpenStack, etc.
- Further support for Big Data and Big Compute

Application-Level Performance (8 VM * 8 Core/VM)
EDUCATION

► New courses with new content
  ► Electronic textbooks, multi-media content, and Chameleon Appliances
  ► Graduate courses for Fall 2015: CS6463 (Cloud and Big Data), CS6643 (Parallel Processing), ECE5243 (Data Analytics in Cloud), CS 6393 (Advanced Topics in Computer Security), and others

► Broaden a Cloud Education Community by Reaching out to the MSI network and other institutes
► General education: MOOCs and other content
► Chameleon-specific training and training materials
INDUSTRY OUTREACH

- Fostering relationship between academia and industry
  - Industry Board: explore synergy between industry and academia
  - Facilitating industry-sponsored research projects
  - Interoperability with industry standards
  - Commercialization
- Workload and Track Archive
OUTREACH AND ENGAGEMENT

▶ Advisory Bodies
  ▶ Research Steering Committee: advise on capabilities and priorities needed to investigate upcoming research challenges
  ▶ Industry Advisory Board: explore synergy between industry and academia
▶ Early User Program
  ▶ Committed users, driving and testing new capabilities, enhanced level of support
▶ Chameleon Workshop
  ▶ Annual workshop to inform, share experimental techniques solutions and platforms, discuss upcoming requirements, and showcase research
PROJECT SCHEDULE

- **Fall 2014**: FutureGrid@Chameleon is ready!
- **Spring 2015**: Initial bare metal reconfiguration capabilities available on FutureGrid UC&TACC resources for Early Users
- **Summer 2015**: New hardware: large-scale homogenous partitions available to Early Users
- **Fall 2015**: Large-scale homogenous partitions and bare metal reconfiguration generally available
- **2015/2016**: Refinements to experiment management capabilities, higher level capabilities
- **Fall 2016**: Heterogeneous hardware available
FUTUREGRID@CHAMELEON

- Chameleon Portal
  - FG users can import their projects and accounts
  - FG user data (accounts, images, volumes, etc.) will be reactivated with account
  - Available generally by end of year
- Hotel (UC) and Alamo (TACC) configured FG-style
  - OpenStack Juno with KVM images
  - Available via a single interface as OpenStack regions (replicated Keystone)
  - The same set of images available for both
THE TESTBED IS THERE – JUST ADD RESEARCH!

- Large-scale, responsive experimental testbed
  - Targeting critical research problems at scale
- Reconfigurable environment
  - Support use cases from bare metal to production clouds
- One-stop shopping for experimental needs
  - Trace and Workload Archive
- Engage the community
  - The most important element of any experimental testbed is users and the research they work on
  - Chameleon appliances, contributing experience and tools
  - Community feedback for evolution