www. chameleoncloud.org

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

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WHY EXPERIMENT?

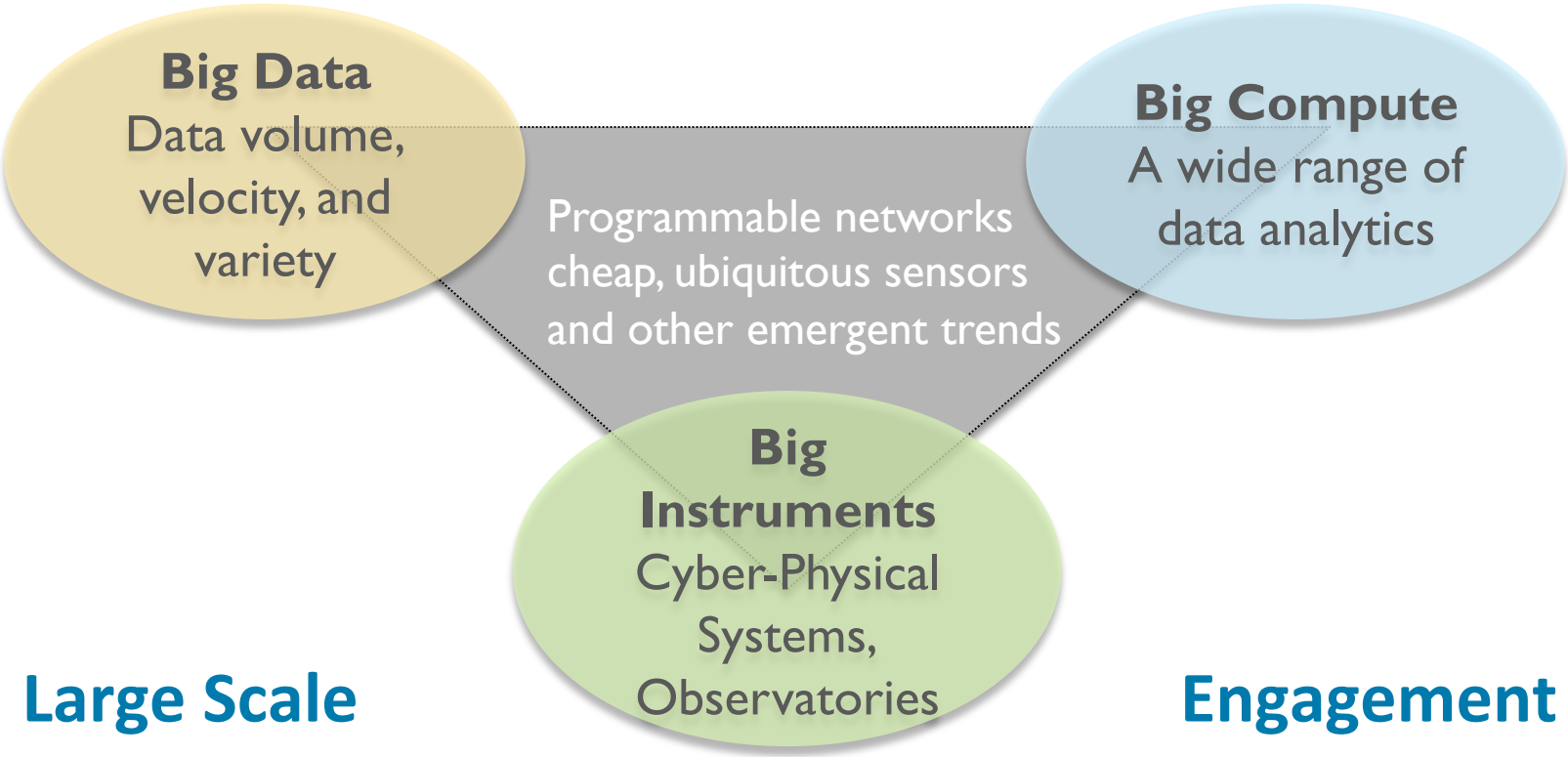
"Beware of bugs in the above code;
I have only proved it correct, not tried it"

(Donald Knuth)

"In theory there is no difference between theory and practice. In practice there is."

(Yogi Berra)

SCALING TO THE CHALLENGE



Large Scale

Engagement

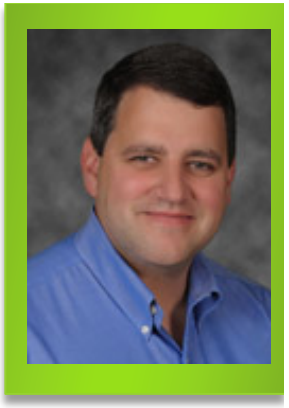
Reconfigurability

Connectedness

CHAMELEON: A POWERFUL AND FLEXIBLE EXPERIMENTAL INSTRUMENT

- Large-scale instrument
  - Targeting 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 instrument
  - Bare metal reconfiguration, operated as single instrument, graduated approach for ease-of-use
- Connected instrument
  - Workload and Trace Archive
  - Partnerships with production clouds: CERN, OSDC, Rackspace, Google, and others
  - Partnerships with users
- Complementary instrument
  - Complementing GENI, Grid'5000, and potentially other testbeds

CHAMELEON HARDWARE



To UTSA, GENI, Future Partners

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

Chicago

Austin

SCUs connect to core and fully connected to each other

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)

Switch
Standard Cloud Unit
42 compute
4 storage
x10

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

Heterogeneous Cloud Units
Alternate Processors and Networks

STANDARD CLOUD UNIT

- Each of the 12 SCUs is comprised of a single 48U rack
  - Allocations can be an entire SCU, multiple SCUs, or within a single one.
- A single 48 port Force10 s6000 OpenFlow-enabled switch connects all nodes in the rack (with an additional network for management/control plane).
  - 10Gb to hosts, 40Gb uplinks to Chameleon core network
- An SCU has 42 Dell R630 compute servers, each with dual-socket Intel Xeon (Haswell) processors and 128GB of RAM
- In addition, each SCU has 4 DellFX2 storage servers, each with a connected JBOD of 16 2TB drives.
  - Can be used as local storage within the SCU, or allocated separately (48 total available for Hadoop configurations); SCU storage nodes will not be used for permanent storage.

HETEROGENEOUS CLOUD UNITS

- One of the SCUs will also contain an Infiniband network, and (hopefully) an OmniScale network
- Additional HCUs will contain:
  - 48 Intel Atom microservers
  - ARM microservers
  - A mix of servers with:
    - High RAM
    - FPGAs (Xilinx/Convey Wolverine)
    - NVidia K40 GPUs
    - Intel Xeon Phis

CHAMELEON CORE HARDWARE

- Shared Infrastructure:
  - In addition to distributed storage nodes, Chameleon will have 3.6PB of central storage, for a *persistent* object store and shared filesystem.
  - An additional dozen management nodes will provide data movers, user portal, provisioning services, and other core functions within Chameleon.
- Core Network
  - Force10 OpenFlow-enabled switches will aggregate the 40Gb uplinks from each unit and provide multiple links to the 100Gb Internet2 layer 2 service.

CAPABILITIES AND SUPPORTED RESEARCH

Development of new models, algorithms, platforms, auto-scaling HA, etc., innovative application and educational uses

Persistent, reliable, shared clouds

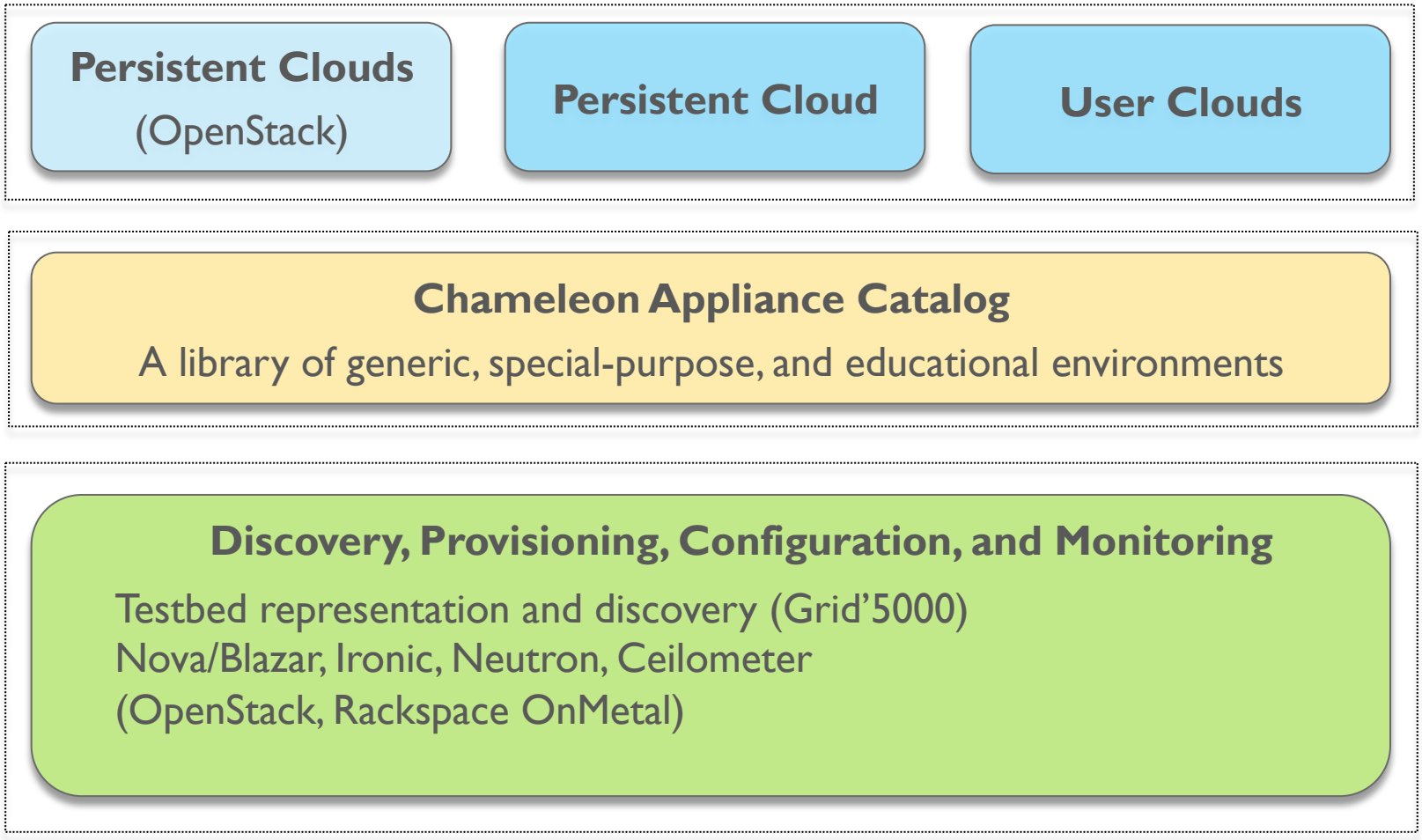
Repeatable experiments in new models, algorithms, platforms, auto-scaling, high-availability, cloud federation, etc.

Isolated partition, Chameleon Appliances

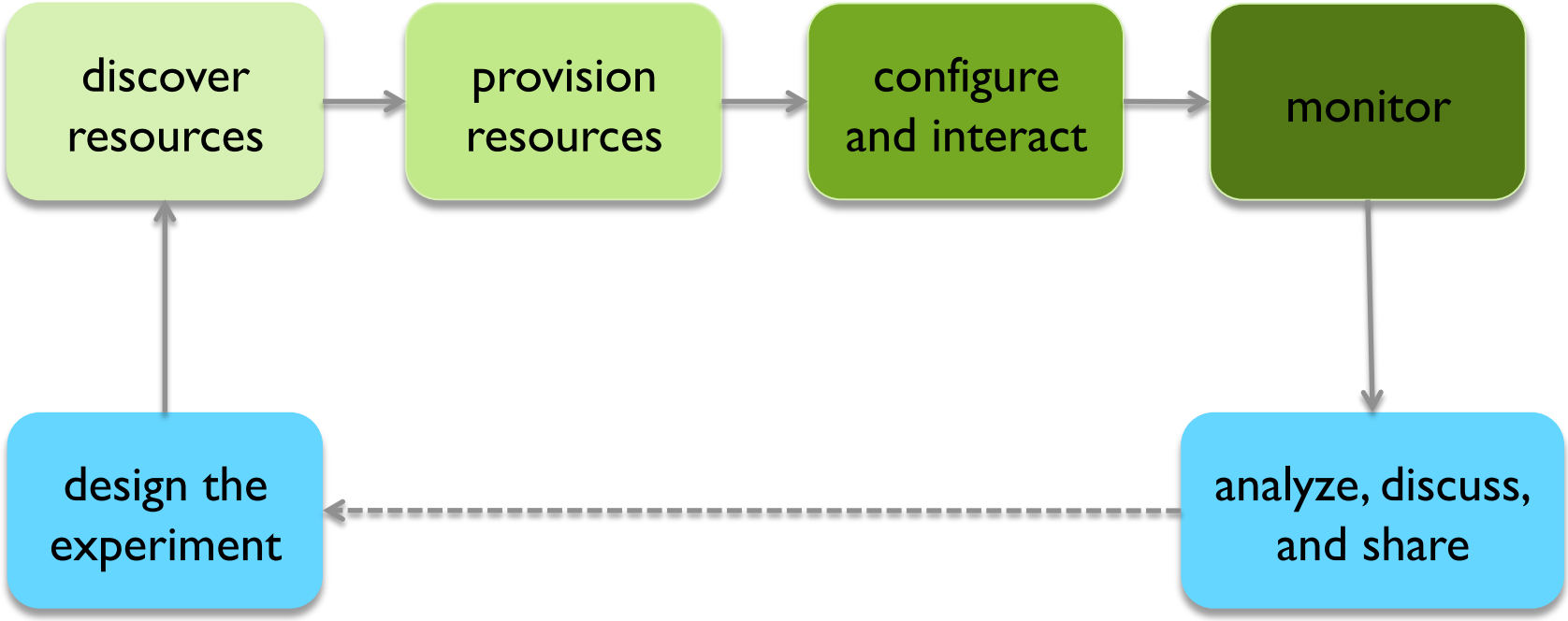
Virtualization technology (e.g., SR-IOV, accelerators), systems, networking, infrastructure-level resource management, etc.

Isolated partition, full bare metal reconfiguration

SOFTWARE: CORE CAPABILITIES



SUPPORT FOR EXPERIMENT WORKFLOW



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!

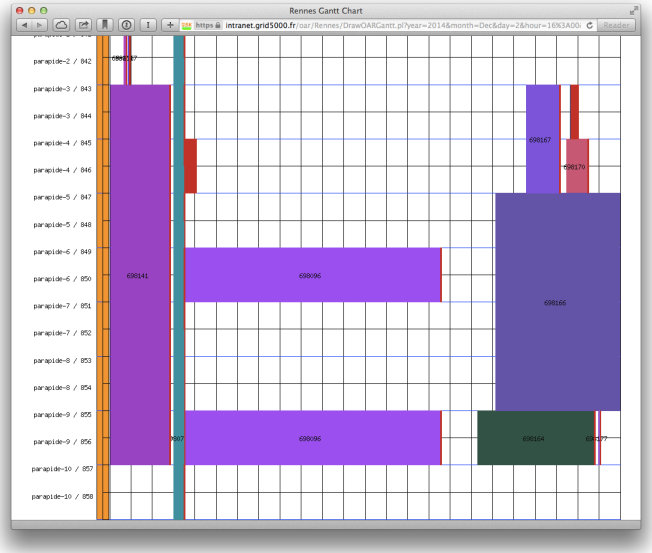
RESOURCE CATALOG

- 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


```
"processor": {
  "cache_l2": 8388608,
  "cache_l1": null,
  "model": "Intel Xeon",
  "instruction_set": "",
  "other_description": "",
  "version": "X3440",
  "vendor": "Intel",
  "cache_l1i": null,
  "cache_l1d": null,
  "clock_speed": 2530000000.0
},
"uid": "graphene-1",
"type": "node",
"architecture": {
  "platform_type": "x86_64",
  "smt_size": 4,
  "smp_size": 1
},
"main_memory": {
  "ram_size": 17179869184,
  "virtual_size": null
},
"storage_devices": [
  {
    "model": "Hitachi HDS72103",
    "size": 298023223876.953,
    "driver": "ahci",
    "interface": "SATA II",
    "rev": "JPFO",
    "device": "sda"
  }
],
```

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

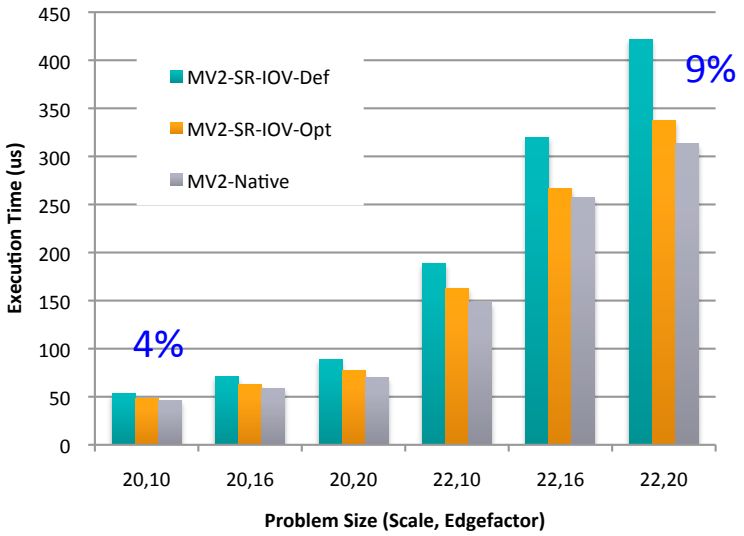
- OpenStack Ceilometer

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



Graph500

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

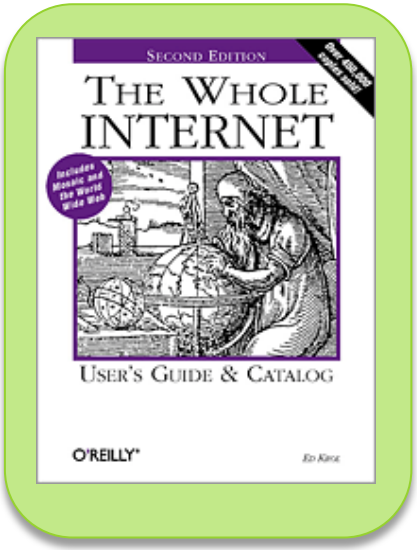
THE TESTBED IS THERE…

- Large-scale, responsive experimental testbed
  - Targeting critical research problems at scale
  - Evolve with the community input
- Reconfigurable environment
  - Support use cases from bare metal to production clouds
  - Support for repeatable and reproducible experiments
- One-stop shopping for experimental needs
  - Trace and Workload Archive, user contributions, requirement discussions
- Engage the community
  - Network of partnerships and connections with scientific production testbeds and industry
  - Partnerships with existing experimental testbeds
  - Outreach activities

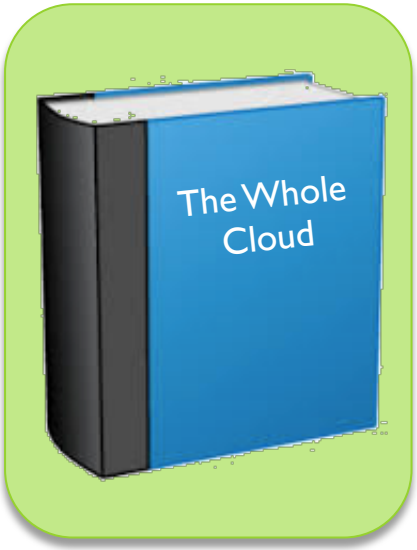
…"JUST" ADD RESEARCH

The most important element of any experimental testbed is users and the research they work on.

From the Internet…



…to cloud…



…and beyond