Thoughts After Using Grid'5000, Cloudlab and Chameleon

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Grid’5000, Chameleon, CloudLab

- **Grid’5000**
  - Established testbed (1000 machines, 500+ users/year since 2005)
  - `https://www.grid5000.fr/`
- Two recent projects (2014 $\rightsquigarrow$ 2017; NSF funding for 10 M$ each)
  - **Chameleon**
    - `https://www.chameleoncloud.org/`
  - **CloudLab**
    - `http://www.cloudlab.us`

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How do they compare: design choices? features?

(To the best of my knowledge, and as of August 2015)

Software stack used as a basis

- **Grid'5000**: mostly our own (+ OAR, Kadeploy: developed in close collaboration)
- **Chameleon**: OpenStack
- **CloudLab**: Emulab

Resources description and verification

- **Grid'5000**: reference API + g5k-checks (+ human-readable description)
- **Chameleon**: same as Grid'5000
- **CloudLab**:
  - machine-readable description using RSpec 'advertisement' format (less detailed than Grid'5000's, though) + human-readable description in the docs
  - verification: nothing similar to g5k-checks, but LinkTest[1] can validate network configuration

[1] D.S. Anderson et al. "Automatic Online Validation of Network Configuration in the Emulab Network Testbed". In: *ICAC'06*.

Grid'5000 Reference API and g5k-checks[2]

- Describing resources $\rightsquigarrow$ understand results
  - Covering nodes, network equipment, topology
  - Machine-parsable format (JSON) $\rightsquigarrow$ scripts
  - Archived (*State of testbed 6 months ago?*)
- Verifying the description
  - Avoid inaccuracies/errors $\rightsquigarrow$ false assumptions, wong experimental results, retracted publications
  - Could happen frequently: maintenance, broken hardware (e.g. RAM)
  - Our solution: g5k-checks
    - Runs at node boot (or manually by users)
    - Retrieves current description of node
    - Acquires info using OHAI, ethtool, etc.
    - Compares with Reference API

```
"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"
  }
],
```

[2] David Margery et al. "Resources Description, Selection, Reservation and Verification on a Large-scale Testbed". In: *TRIDENTCOM*. 2014.

Resources reservation

- **Grid'5000**: batch scheduler (OAR) with advance reservation
  - Selection of resources using properties generated from the Reference API
- **Chameleon**: leases using OpenStack Blazar
- **CloudLab**: experiments start immediately, default duration of a few hours, can be extended on demand (no advance reservations)

Resources reconfiguration (software level)

All three testbeds have a disk imaging solution:

- **Grid'5000**: Kadeploy
- **Chameleon**: OpenStack Ironic
- **CloudLab**: Emulab's Frisbee

Network reconfiguration and SDN

- **Grid'5000**: KaVLAN (VLAN reconfiguration on switches, to isolate experiments)
  - + Distem[3] for network emulation
- **Chameleon**: planned, using OpenFlow
- **CloudLab**:
  - Emulab's network emulation features
  - OpenFlow access on switches[4]
  - Interconnection to Internet2's AL2S

[3] `http://distem.gforge.inria.fr`

[4] `http://cloudlab-announce.blogspot.com/2015/06/using-openflow-in-cloudlab.html`

Experiment monitoring

- **Grid'5000**: Kwapi (power + network) – talk tomorrow
- **Chameleon**: planned, using OpenStack Ceilometer
- **CloudLab**: planned[5] (talk tomorrow?)

[5] `http://docs.cloudlab.us/planned.html`

Long term storage between experiments

- **Grid'5000**: storage5k (file-based and block-based)
- **Chameleon**: object store (OpenStack Swift) available soon
- **CloudLab**: yes[6], with snapshots (using ZFS) to version data (the snapshots features are not documented yet)

[6] `http://cloudlab-announce.blogspot.fr/2015/04/persistant-dataset.html`

Federation

- **Grid'5000**: no
  - In the past, (network) connection to DAS, and to a Japanese testbed
  - But no real users / use cases
- **Chameleon**: ? (talk tomorrow)
- **CloudLab**: Federated with GENI
  CloudLab can be used with a GENI account, and vice-versa

Software stacks deployments (OpenStack, Ceph)

- **Grid'5000**: both OpenStack and Ceph available (but see below)
- **Chameleon**: ?
- **CloudLab**: OpenStack available

None of the current solutions work very well. We want:

- Software stacks useful to experimenters
  - Recent versions (to stay relevant)
  - Easily customizable $\leadsto$ replace components
- Software stacks maintainable in the long run
  - Despite 6-month release cycles, with a lot of disruptive changes

Topics covered:

- Software stack
- Resources description and verification
- Resources reservation
- Resources reconfiguration
- Network reconfiguration and SDN
- Experiment monitoring
- Long term storage
- Federation
- Software stacks deployments

Thanks! Questions?

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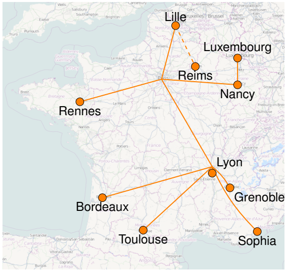
Backup slides

The Grid'5000 testbed



- **World-leading testbed for HPC & Cloud**
  - 10 sites, 1200 nodes, 7900 cores
  - Dedicated 10-Gbps backbone network
  - 550 users and 100 publications per year
- Not a typical grid / cluster / Cloud:
  - Used by CS researchers for HPC / Clouds / Big Data research
    $\rightsquigarrow$ No users from computational sciences
  - **Design goals:**
    - ★ **Large-scale, shared infrastructure**
    - ★ **Support high-quality, reproducible research on distributed computing**

Resources selection and reservation

- Roots of Grid'5000 in the HPC community
  $\rightsquigarrow$ Obvious idea to use a HPC Resource Manager
- OAR (developed in the context of Grid'5000)
  `http://oar.imag.fr/`
- Supports resources properties ($\approx$ tags)
  - Can be used to select resources (multi-criteria search)
  - Generated from Reference API
- Supports advance reservation of resources
  - In addition to typical HPC resource managers's *batch* mode
  - Request resources at a specific time
  - On Grid'5000: used for special policy:
    Large experiments during nights and week-ends
    Experiments preparation during day

Using properties to reserve specific resources

Reserving two nodes for two hours. Nodes must have a GPU and power monitoring:

```
oarsub -p "wattmeter='YES' and gpu='YES'" -l nodes=2,walltime=2 -I
```

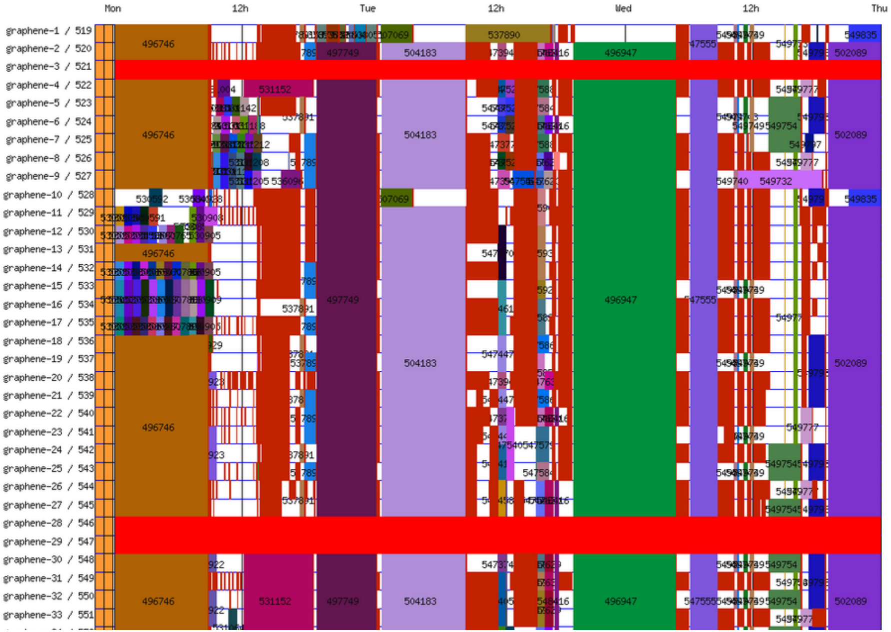
Reserving one node on cluster a, and two nodes with a 10 Gbps network adapter on cluster b:

```
oarsub -l "{cluster='a'}/nodes=1+{cluster='b' and eth10g='Y'}/nodes=2,walltime=2"
```

Advance reservation of 10 nodes on the same switch with support for Intel VT (virtualization):

```
oarsub -l "{virtual='ivt'}/switch=1/nodes=10,walltime=2" -r '2014-11-08 09:00:00'
```

Visualization of usage

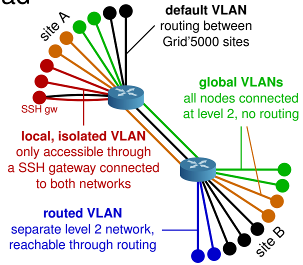


Reconfiguring the testbed

- Typical needs:
  - How can I install $SOFTWARE on my nodes?
  - How can I add $PATCH to the kernel running on my nodes?
  - Can I run a custom MPI to test my fault tolerance work?
  - How can I experiment with that Cloud/Grid middleware?
  - Can I get a stable (over time) software environment for my experiment?

Reconfiguring the testbed

- Operating System reconfiguration with Kadeploy:
  - Provides a *Hardware-as-a-Service* Cloud infrastructure
  - Enable users to deploy their own software stack & get *root* access
  - **Scalable, efficient, reliable and flexible**:
    200 nodes deployed in ~5 minutes (120s with Kexec)
- Customize networking environment with KaVLAN
  - Deploy intrusive middlewares (Grid, Cloud)
  - Protect the testbed from experiments
  - Avoid network pollution
  - By reconfiguring VLANS $\leadsto$ almost no overhead
  - Recent work: support several interfaces


site A
default VLAN
routing between Grid'5000 sites
global VLANs
all nodes connected at level 2, no routing
SSH gw
local, isolated VLAN
only accessible through a SSH gateway connected to both networks
routed VLAN
separate level 2 network, reachable through routing
site B

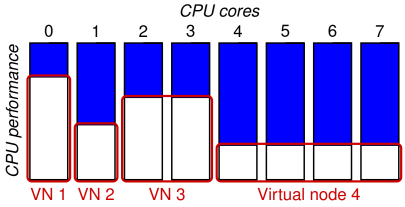
Creating and sharing Kadeploy images

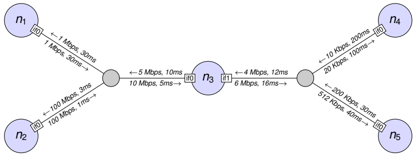
- Avoid manual customization:
  - Easy to forget some changes
  - Difficult to describe
  - The full image must be provided
  - Cannot really reserve as a basis for future experiments (similar to binary vs source code)
- Kameleon: Reproducible generation of software appliances
  - Using *recipes* (high-level description)
  - Persistent cache to allow re-generation without external resources (Linux distribution mirror) $\leadsto$ self-contained archive
  - Supports Kadeploy images, LXC, Docker, VirtualBox, qemu, etc.

http://kameleon.imag.fr/

Changing experimental conditions

- Reconfigure experimental conditions with Distem
  - Introduce heterogeneity in an homogeneous cluster
  - Emulate complex network topologies

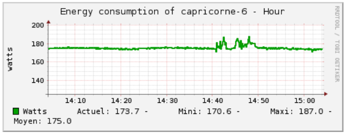




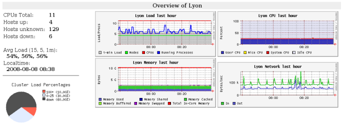
http://distem.gforge.inria.fr/

Monitoring experiments

Goal: enable users to understand what happens during their experiment



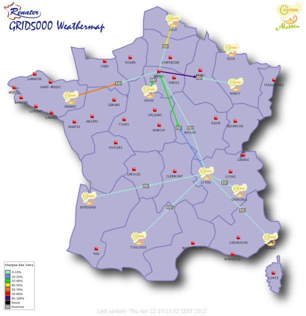
Power consumption


Overview of Lyon

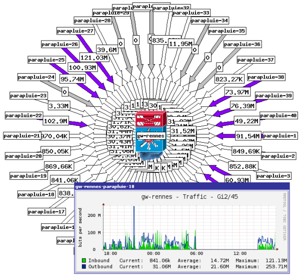
CPUs Total: 11
Hosts up: 4
Hosts unknown: 129
Hosts down: 6

Avg Load (15, 5, 1m):
54%, 56%, 56%
Localtime:
2008-08-08 08:38

CPU – memory – disk



Network backbone

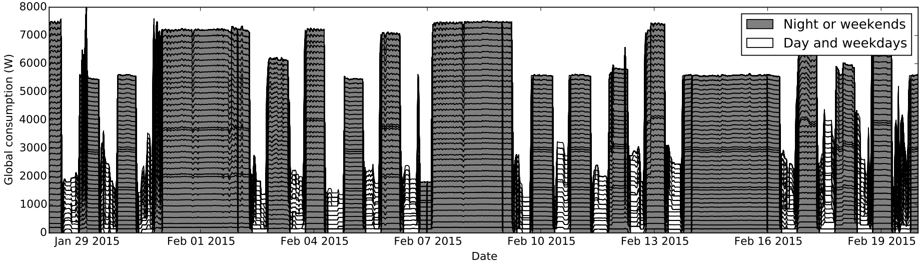


gw-rennes
gw-rennes-parapluie-18
gw-rennes - Traffic - Gi2/45
bits per second
Inbound Current: 841.06k Average: 14.72M Maximum: 121.13M
Outbound Current: 31.06M Average: 21.60M Maximum: 253.71M

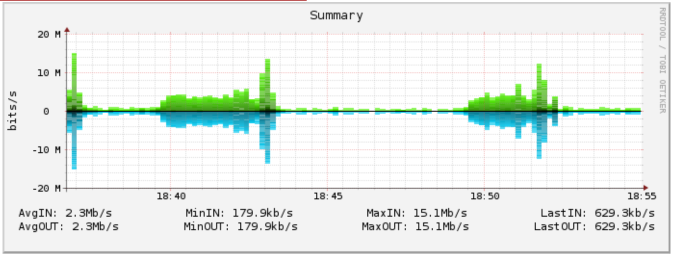
Internal networks

Kwapi: a new framework to monitor experiments

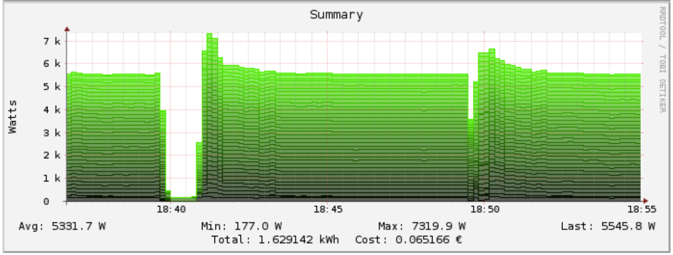
- Initially designed as a power consumption measurement framework for OpenStack – then adapted to Grid'5000's needs and extended
- For energy consumption and network traffic
- Measurements taken at the infrastructure level
  (SNMP on network equipment, power distribution units, etc.)
- High frequency (aiming at 1 measurement per second)
- Data visualized using web interface
- Data exported as RRD, HDF5 and Grid'5000 REST API



Kwapi: example output



```
AvgIN: 2.3Mb/s        MinIN: 179.9kb/s      MaxIN: 15.1Mb/s      LastIN: 629.3kb/s
AvgOUT: 2.3Mb/s       MinOUT: 179.9kb/s     MaxOUT: 15.1Mb/s     LastOUT: 629.3kb/s
```



```
Avg: 5331.7 W          Min: 177.0 W           Max: 7319.9 W          Last: 5545.8 W
                  Total: 1.629142 kWh   Cost: 0.065166 €
```

- 18:39:28 – machines are turned off
- 18:40:28 – machines are turned on again and generate network traffic as they boot via PXE
- 18:49:28 – machines reservation is terminated, causing a reboot to the default system

Conclusions

- We are moving
  - From small testbeds, on a per-team/per-lab basis
  - To large-scale shared infrastructures built with reproducibility in mind
- A bright and exciting future
- Paving the way to Open Science of HPC and Cloud!
- (Also: you can get accounts on all of them through Open Access / Preview / Early users programs)

One could determine the age of a science by looking at the state of its measurement tools.

Gaston Bachelard – *La formation de l'esprit scientifique*, 1938

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