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Grid'5000

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► **To cite this version:**

Lucas Nussbaum. Grid'5000. Grid'5000/FIT School, Apr 2018, Sophia-Antipolis, France. hal-01944478

HAL Id: hal-01944478

<https://inria.hal.science/hal-01944478>

Submitted on 4 Dec 2018

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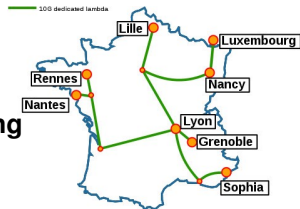
Grid'5000

Lucas Nussbaum
Grid'5000 Technical Director

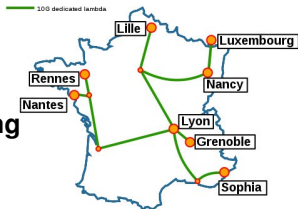
2018-04-03

The Grid'5000 testbed

- ▶ **A large-scale testbed for distributed computing**
 - ◆ 8 sites, 30 clusters, 840 nodes, 8490 cores
 - ◆ Dedicated 10-Gbps backbone network
 - ◆ 600 users and 100 publications per year



The Grid'5000 testbed



- ▶ **A large-scale testbed for distributed computing**
 - ◆ 8 sites, 30 clusters, 840 nodes, 8490 cores
 - ◆ Dedicated 10-Gbps backbone network
 - ◆ 600 users and 100 publications per year
- ▶ A meta-grid, meta-cloud, meta-cluster, meta-data-center:
 - ◆ Used by CS researchers in HPC / Clouds / Big Data / Networking
 - ◆ To experiment in a fully controllable and observable environment
 - ◆ Similar problem space as Chameleon and Cloudlab (US)
 - ◆ Design goals:
 - ★ Support high-quality, reproducible experiments
 - ★ On a large-scale, shared infrastructure

Organization and governance

- ▶ **Director** – Frédéric Desprez
 - ▶ **Bureau** (6 members: FD, LN, Christian Perez, Adrien Lebre, Laurent Lefevre, David Margery)
 - ▶ **Comité des responsables de sites**
 - ▶ **Technical Director** – Lucas Nussbaum
 - ◆ Technical team: 9 full-time engineers
 - ▶ **Architects committee** (6 membres)
 - ▶ **Conseil de groupement**
 - ◆ Inria, CNRS, RENATER, CEA, CPU, CDEFI, Mines-Telecom
 - ▶ **Conseil scientifique**
 - ◆ 10 members
- institutional and scientific steering
- technical steering
- advisory and evaluation bodies

Landscape – cloud & experimentation¹

- ▶ **Public cloud infrastructures** (AWS, Azure, Google Cloud Platform, etc.)
 - ☹ No information/guarantees on placement, multi-tenancy, real performance
- ▶ **Private clouds**: Shared observable infrastructures
 - 😊 Monitoring & measurement
 - ☹ No control over infrastructure settings
 - ↪ Ability to **understand** experiment results
- ▶ **Bare-metal as a service, fully reconfigurable infrastructure** (Grid'5000)
 - 😊 Control/alter all layers (virtualization technology, OS, networking)
 - ↪ *In vitro* Cloud

¹ Inspired from a slide by Kate Keahey

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And the same applies to all other environments (e.g. HPC)

¹ Inspired from a slide by Kate Keahey

Some results from Grid'5000 users

HPC: In Situ Analytics²

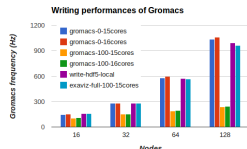


Goal: improve organization of simulation and data analysis phases

- ▶ Simulate on a cluster; move data; post-mortem analysis
 - ◆ Unsuitable for Exascale (data volume, time)
- ▶ Solution: analyze on nodes, during simulation
 - ◆ Between or during simulation phases? dedicated core? node?

Grid'5000 used for development and test, because control:

- ▶ Of the software environment (MPI stacks)
- ▶ Of CPU performance settings (Hyperthreading)
- ▶ Of networking settings (Infiniband QoS)



Then evaluation at a larger scale on the Froggy supercomputer (CIMENT center, Grenoble)

²Matthieu Dreher and Bruno Raffin. “A Flexible Framework for Asynchronous In Situ and in Transit Analytics for Scientific Simulations”. In: *CCGrid. 2014*.

Cloud: DISCOVERY project

Goal: design a distributed IaaS cloud, based on OpenStack

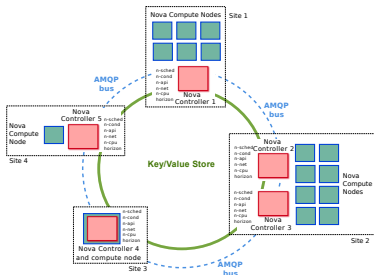
- ▶ Move services as close as possible to users
 - ◆ Legal reasons, network latency
- ▶ Leverage regional data centers
- ▶ Increase resilience (no SPOF)
- ▶ P2P and self-* approaches

Grid'5000 as a testbed already provides:

- ▶ Start and control your own OpenStack
- ▶ Possibly modified
- ▶ Running at large scale

Collaborations:

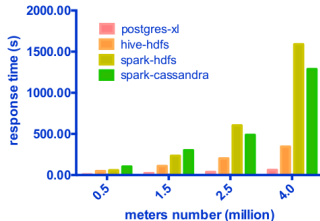
- ▶ Inria, RENATER, Orange, Mines Nantes



<http://beyondtheclouds.github.io/>

Big Data: smart power meters³

- ▶ Goal: which big data solution for Linky smart meters data?
- ▶ Collaboration with ERDF
- ▶ 4 Big Data solutions installed and compared on Grid'5000
 - ◆ Postgres-XL, Hadoop, Spark, Cassandra
 - ◆ Up to 140 nodes
 - ◆ 1.7 TB of data (\approx 5 million meters, 1 mes/h, 1 year)



³Houssem Chihoub and Christine Collet. “A scalability comparison study of smart meter data management approaches”. In: *Grid'5000 Winter School. 2016*.

Other usage areas

- ▶ Deep learning
- ▶ OS research
- ▶ Networking
- ▶ Reproducible research

An experiment's outline

- 1 Discovering resources from their description
- 2 Reconfiguring the testbed to meet experimental needs
- 3 Monitoring experiments, extracting and analyzing data
- 4 Controlling experiments: API

Discovering resources from their description

- ▶ **Describing** resources \leadsto understand results
 - ◆ Covering nodes, network equipment, topology
 - ◆ Machine-parsable format (JSON) \leadsto scripts
 - ◆ Archived (*State of testbed 6 months ago?*)
 - ◆ **Soon: better hardware description on the wiki**

- ▶ **Verifying** the description

- ◆ Avoid inaccuracies/errors \leadsto wrong results
- ◆ Could **happen frequently**: maintenance, broken hardware (e.g. RAM)
- ◆ Our solution: **g5k-checks**
 - ★ Runs at node boot (or manually by users)
 - ★ Acquires info using OHAI, ethtool, etc.
 - ★ Compares with Reference API

- ▶ **Selecting** resources

- ◆ OAR database filled from Reference API

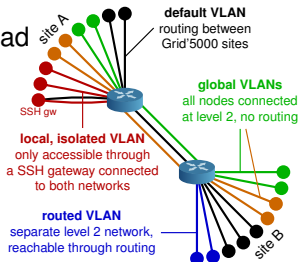
```
oarsub -p "wattmeter='YES' and gpu='YES'"
oarsub -l "cluster='a'/nodes=1+cluster='b' and
eth10g='Y'/nodes=2,walltime=2"
```

```
"processor": {
  "cache_l2": 8388608,
  "cache_l1": null,
  "model": "Intel Xeon",
  "instruction_set": "",
  "other_description": "",
  "version": "X3440",
  "vendor": "Intel",
  "cache_lli": null,
  "cache_lld": 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"
  }
],
}
```

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
- ▶ Customize **networking** environment with **KaVLAN**
 - ◆ Protect the testbed from experiments (Grid/Cloud middlewares)
 - ◆ Avoid network pollution
 - ◆ Create custom topologies
 - ◆ By reconfiguring VLANs \leadsto almost no overhead

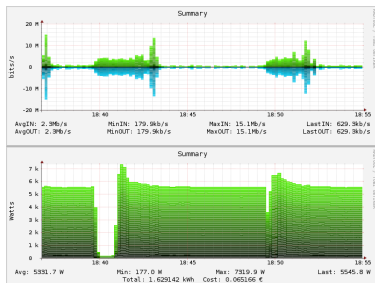
KADEPLOY



Monitoring experiments

Goal: enable users to understand what happens during their experiment

- ▶ **System-level probes** (usage of CPU, memory, disk, with Ganglia)
- ▶ **Infrastructure-level probes: Kwapi**
 - ◆ Network, power consumption
 - ◆ Captured at high frequency (≈ 1 Hz)
 - ◆ Live visualization
 - ◆ REST API
 - ◆ Long-term storage
 - ◆ **Should be fully operational again soon!**



Controlling experiments: API

- ▶ Legacy way of performing experiments: shell commands
 - ☹ time-consuming
 - ☹ error-prone
 - ☹ details tend to be forgotten over time
- ▶ Promising solution: **automation of experiments**
~ Executable description of experiments
- ▶ Support from the testbed: Grid'5000 RESTful API
(*Resource selection, reservation, deployment, monitoring*)
- ▶ Several higher-level tools to help automate experiments
Execo (Python), Ruby-cute (Ruby)
<https://www.grid5000.fr/w/Grid5000:Software>



Recent and little-known features

Data management portfolio

- ▶ Storage5k: reservation of storage space on an NFS server
- ▶ Managed Ceph clusters in Rennes and Nantes
- ▶ OSIRIM: large storage space made available in Toulouse
- ▶ Reservation of disks on nodes
 - ◆ To store large datasets between nodes reservations

Missing: long-term archival of experiment data

- ▶ Probably not a good idea to solve this on our own
- ▶ Feedback about CKAN-based servers (OpenAIRE / Zenodo), anyone?

Automated testing framework

Search:

Site	Average	cmdline	deployjob	environments	oarproperties	oarstate	refapi	sidapi	stdenv	diskreservation	refapinet	refrepopen	console	delibios	disk	kavlan	mpig
global	85.7%																
grenoble	85.1%	100%	100%	94%	100%	100%	100%	100%	100%		100%	0%	0%		50%	0%	100
illie	100.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100
luxembourg	95.6%	100%	100%	100%	100%	100%	100%	100%	50%		100%	100%	100%	100%	100%	50%	100
lyon	95.0%	100%	100%	98%	100%	100%	100%	100%	100%		100%	100%	80%	100%	80%	60%	80
nancy	89.7%	100%	100%	99%	100%	100%	100%	100%	100%	0%	100%	100%	88%	71%	77%	88%	61
nantes	97.0%	100%	100%	97%	100%	100%	50%	100%	100%		100%	100%	100%	100%	100%	100%	100
rennes	64.7%	100%	60%	57%	100%	100%	100%	100%	60%	100%	100%	100%	60%	100%	60%	80%	55
sophia	80.7%	100%	100%	92%	100%	0%	0%	100%	100%		0%	0%	75%	0%	0%	100%	87
Average	86.5%	100.0%	93.5%	91.3%	100.0%	87.5%	83.9%	100.0%	90.3%	66.7%	87.5%	75.0%	77.4%	83.3%	67.7%	77.4%	74.8%

Showing 1 to 10 of 10 entries

Graphs on Munin, documentation

Tests hidden by default: env_build_kameleon_upstream_recipes, env_deploy_and_test, env_deploy_and_test_snapshot, env_generate_snapshot_deploy, envpostinstall-new_test_deploydev, test_distem, test_enos, test_g5k-api, test_g5k-api_v3, test_g5kchecks, test_kwapi, test_wakeup

Tests ignored: env_deploy, env_generate, env_generate_deploy, env_generate_deploy_snapshot, env_generate_dev, env_generate_rebased, env_generate_snapshot, env_push, update_topology_maps

hide bugs with comments reset

Search:

Job	Configuration	Status	Last successful	Last failed	Streak	Last attempt	Next	Comment (from pad)
delibios								
test_delibios	site_cluster=nancy-grisou	Fail	2018-02-26 09:41:55	2018-03-20 09:37:55	1	2018-03-20 09:37:55	2018-03-20 09:37:55	
test_delibios	site_cluster=nancy-graphique	Fail	2018-03-07 04:55:31	2018-03-29 22:05:04	5	2018-03-29 22:05:04	2018-04-06 22:05:04	
test_delibios	site_cluster=rennes-paravance	OK	2018-03-23 20:12:20	2018-02-19 11:39:03		2018-03-23 20:12:20	2018-04-06 21:12:20	
test_delibios	site_cluster=rennes-parasilo	OK	2018-03-23 20:12:20	2018-03-23 10:07:05		2018-03-23 20:12:20	2018-04-06 21:12:20	

- ▶ Detect regressions before experimenters
- ▶ 23 tests, 1055 configurations
- ▶ Still, does not cover everything ~> please report problems!

Other random stuff

- ▶ Additional switch on the *grisou* cluster
 - ◆ 48 nodes with 4x 10G interfaces and 1x 1G interface
 - ◆ 1G interfaces are connected to an ONIE-supported switch
- ▶ VPN to connect to Grid'5000
- ▶ `sudo-g5k`
- ▶ OAR job extensions (`oarwalltime` command)
- ▶ Persistent virtual machines
- ▶ News on the website (also: Twitter @grid5000, RSS)

What to expect by mid 2018 (hopefully)

- ▶ New clusters in:
 - ◆ Nantes: 48 nodes (CPER SEDUCE)
 - ◆ Grenoble: 72 nodes + 4 nodes (HPCDA project, HPC/BigData convergence with NVMe)
 - ◆ Nancy: 64 nodes (+ 48 older nodes) (*production* queue)
 - ◆ Lille: 8 nodes with P100 GPUs (CPER DATA)
- ▶ Kwapi fully operational again
- ▶ Full rework of hardware & network pages
- ▶ Wrap-up of the work around Debian 9 images (inc. move to predictable network interface names, and new postinstalls)
- ▶ Many other behind-the-scenes changes

Grid'5000-related tutorials during the school

- ▶ Tue 4:30pm, Wed 2pm – Getting Started with Grid'5000
- ▶ Wed 2pm, 4:30pm – Benchmarking **OpenStack** with EnOS
- ▶ Thu 2pm – **Monitoring energy** consumption in Grid'5000 experiments
- ▶ Thu 2pm – **BigData** Experiments with Grid5000
- ▶ Fri 9am – Distributed systems and networking **emulation with Distem**
- ▶ Fri 9am – Open session – any Grid'5000 tutorial

Come talk to the Grid'5000 team about features you need!