The IDV (Life Imaging) project at Université Sorbonne Paris Cité and some insights / methodologies related to data and Cloud computing.

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Section 1

Objectives of the presentation

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Give illustrative examples of programs deployed at USPC (université Sorbonne Paris Cité) related to "massive computing for the beginners".

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Issues

1. Research problem(s) in Cloud Computing;
2. Multidisciplinary research;
3. Compute and Data intensive infrastructure;
4. Educating in Cloud Computing (and in distributed systems).

Illustrations

1. Volunteer Cloud; SlapOS; Energy minimization;
2. The IDV (Imageries du vivant) project;
3. The MAGI cluster and Storage equipment with USPC;
4. The USPC doctoral school program;

The institutional context

How to manage change?

1. Objective in terms of infrastructure to match the means provided by the current infrastructure and the needs of users over period 2014-2018.
2. Objectives related to the practice:
   - An instrument should be used in accordance with procedures, international standards;
   - Such instrument is used to strengthen and develop the cultures of large-scale computing;
   - This is a major issue for those who have a strong relationship with machines in their scientific approach. . . and necessary requirement to produce quality science.
3. The goal is to change the research landscape at P13/USPC both at a methodological and thematic level; New methodologies, scientific and modeling approaches become possible;

The institutional context

USPC

1. Sorbonne Paris Cité is one of France's major university consortiums bringing together four Parisian universities and four higher education and research institutes:
   - Sorbonne Nouvelle University
   - Paris Descartes University
   - Paris Diderot University
   - Paris 13 University
   - Institute of Physics of the Globe (IPGP)
   - National Institute of Oriental Languages and Civilizations (INALCO)
   - Sciences Po (Institute of Political Science)
   - EHESP School of Public Health
2. In addition to its 120,000 students USPC hosts many teams of researchers, who are often attached to CNRS, INSERM, IRD, CEA...
3. With about 8 500 researchers and, SPC gives priority to the quality of training and research development.

The institutional context

Strength and Weakness related to infrastructure for doing experimental Sciences

1. Some institutes have a great background on scientific computing (Institut de Physique du Globe de Paris - IPGP: Earth, Planet and Environmental Sciences) ; The François Arago Centre is a project at the Astroparticule et Cosmologie (APC) laboratory and is supported by the IPGP within the Space Campus of Université Paris Denis-Diderot.
2. Cluster/Grid Computing, tenuous relationship with national supercomputing facilities;
3. Many disciplines have not yet investigated large-scale platforms;
4. The culture of experiments is spread over the researchers without a global vision, policies to federate people and pooling equipments;
5. Bring people at the "little guru" level.

The international context (US)

XSEDE, NSF Release Cloud Survey Report

XSEDE: The Extreme Science and Engineering Discovery Environment
NSF: National Science Foundation Division of Advanced Cyberinfrastructure
propose a survey identifying cloud computing use cases in research and education:

1. Data was collected from eighty projects from around the globe, representing a cross-section of cloud users from twenty-one science and engineering disciplines and the humanities, arts, and social sciences.
2. Quantitative dimensions of cloud usage (number of cores used peak/steady state, bandwidth in/out of the cloud, amount of data stored in the cloud, etc.) and qualitative experiences (the benefits and challenges of using the cloud) were explored.

See: http://hdl.handle.net/2142/45766.

The international context (US)

Key findings in XSEDE, NSF Release Cloud Survey Report

1. The top three reasons survey participants used the cloud were: (1) on-demand access to burst resources, (2) compute and data analysis support for high throughput scientific workflows, and (3) enhanced collaboration through the rapid deployment of research team web sites and the sharing of data.
2. MapReduce was the most heavily used special feature offered by the cloud service providers, followed by access to community datasets.
3. Application and programming models considered good candidates for the cloud were high throughput, embarrassingly parallel workloads; academic labs and teaching tools; domain-specific computing environments; commonly requested software; science gateways; and, real-time event-driven science.

See: http://hdl.handle.net/2142/45766.

The international context (US)

Key findings in XSEDE, NSF Release Cloud Survey Report

4. Cloud benefits identified by the survey participants were pay as you go, lower costs, compute elasticity, data elasticity, Software as a Service, Education as a Service, broader use, scientific workflows, rapid prototyping, and data analysis.
5. Cloud challenges identified included the learning curve, virtual machine performance, variability in bandwidth, memory limits, database instability, private/public cloud interoperability, security, data movement, storage, and cloud computing cost and the funding availability.

See: http://hdl.handle.net/2142/45766.

The international context (US)

Consequences of key findings

1. A more comprehensive and balanced cyberinfrastructure, i.e., a multi-level CI (Cloud Infrastructure), is needed to support the entire spectrum of NSF-funded communities.
2. Unlike traditional HPC workloads, many of the research and education app required many cores rather than fastest perf per core.
3. The challenges of using the cloud require continued investments in basic, applied, and experimental research.
4. Investments that facilitate access to production cloud resources, cloud training, and cloud user consulting are needed as well.
5. Although in their infancy, hybrid clouds hold the promise of enabling modest size private clouds used for steady-state workloads to burst to public, community, or national CI during peak workloads. The challenge will be implementing a management framework.

Section 2

Doing research in Cloud Computing

Studying Distributed Systems

SlapOS Essential Characteristics

- It is not a HPC (High Performance Computing) Cloud. . . despite our background in HPC!
- Breaking Cloud because the virtual machine is an option and because home machines can be aggregated;
- A conceptual view with 3 ingredients:
  - An ERP (Enterprise Resource Planning) for managing the catalog of applications, sales, and clients;
  - A model for the deployment;
  - Nodes.

Architecture

SlapOS is based on an architecture for which slave nodes are connected to a master node.

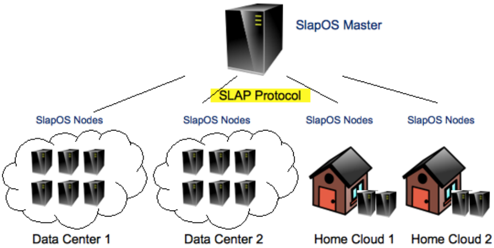


Figure : SlapOS Architecture.

SlapOS deployment model: Public Cloud (The cloud infrastructure is provisioned for open use by the general public) + Community Cloud (owned, managed, and operated by one or more of the organizations in the community since you can add volunteer nodes)

Why SlapOS?

A little story:

- NEXEDI/VFIB has the ERP technology (see the open source ERP5 project < 2000)
- PARIS 13 has an experience in Desktop Grid / Volunteer Computing (see the BonjourGrid project - 2006).
  - BonjourGrid is a meta-desktop grid platform where you can deploy, on demand, your favorite computing element among BOINC, Condor, XtremWeb;
  - BonjourGrid is, in some way, a Cloud before the Cloud!
- SlapOS is a merging of ideas from NEXEDI and PARIS 13;

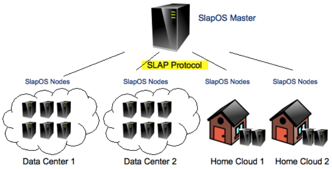


Figure : SlapOS Architecture.

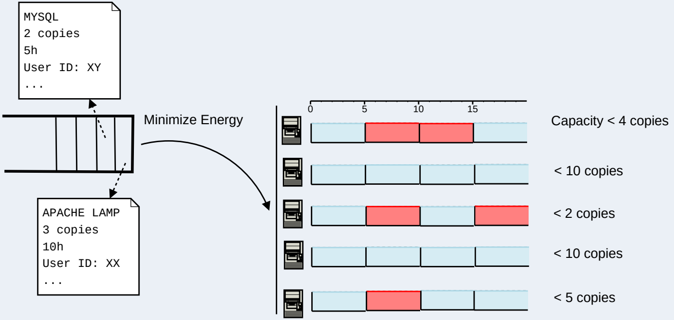
Mastering energy in the volunteer cloud

Elements of context

- *Volunteer Cloud*: home machines AND data centers serve user requests/demands;
  - Potential benefits: elasticity (with cost negotiations for Cloud access, for example); deporting the application ⇒ Electricity is also used for something else (heating apartments);
  - But we need to deal with unavailability of nodes → migrations of applications and replicates;
- Problem solved: given a set of applications required by clients during a time slot, the goal is to find a plan of deployment that is the most energy efficient;
- Techniques used for solving: Combinatorial Optimization, ILP (Integer Linear Programming), greedy heuristics;
- Experimental Validations: through simulation from observed data

Uses case

Objective: Minimize the energy consumption in a PAAS-volunteer cloud



Inputs and constraints

Paramter	Description
$t,\ T = \{0..t-1\}, dt$	Time horizon discretized in periods of equal size
$n,\ N = \{1..n\}$	Number and set of applications
k_j	Number of instances of the application j
$m,\ M = \{1..m\}$	Set of machines
q_i	Capacity of machine i
B_i^τ	Availability of i at the date τ
E_{ji}	Energy consumed by the application j on machine i in a time period
$C_{jii'}$	Energy required for migrating the application j from i to i'

Constraints

C_1: *Deploy the instances on available machines;*

C_2: *Deploy the instances of a same application on distinct machines (resilience);*

C_3: *On machine i, the number of unfolded application must not exceed q_i (power capping).*

Computational problems

Provisioning Plan Problem on Volunteer Clouds (PPPVC)

- Provider problem: Find a deployment that minimize the total energy consumption (PPPVC-MinSum).
- User problem: Find a deployment that minimize the maximal energy consumed in a volunteer resource (PPPVC-MinMax).
- Distinguish between base energy (consumed by the operating system) and overhead induced by the run of applications: $\sum_i E_{ji} = E_i^b + \sum_i E_{ji}^+$;

		a_1, a_2 a_3, a_4, a_5
a_1, a_2 a_3, a_4, a_5	a_1, a_2 a_3, a_4, a_5	
a_6, a_7		a_6, a_7
	a_6, a_7	

Section 3

Doing multidisciplinary research at a large scale and with large scale systems

Doing multidisciplinary research – 2014 and beyond at USPC

"Life Imaging: between progress and Freedoms" USPC project

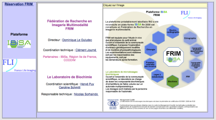
1. Animating a multidisciplinary network research bringing together colleagues and teams working on the generation / acquisition of biomedical images and their exploitation;
2. Creating an environment dedicated to the exploitation of large amounts of generated images (big data) for the development of new imaging biomarker;
3. A reflection on the problems raised by ethical and legal image exploitation in life imaging;
4. About 190 persons are involved in the project ; Some experimental platforms exist (but not a global/universal platform for managing and exploiting data: find the infrequent events, discover new facts, mine massive datasets. . .)

Examples of platforms used by IDV members

Issues

1. Paris Descartes: http://ipa.medecine.univ-paris5.fr (Imaging for small animals)
2. FRIM platform: http://www.bichat.inserm.fr/plateformes_plateaux.html (Bio-chemistry - in-vivo study of small animal phenotypes)
3. http://www.ch-sainte-anne.fr/Plateforme-imagerie/Recherche (Centre d'Imagerie de Recherche et d'Enseignement en Neurosciences (CIREN))

Illustrations



Doing multidisciplinary research

Elements of methodology: Questionnaire about scientific methods and process

- A dedicated person is in charge of the questionnaire (running and exploiting the interviews of researchers) and a committee has also been setup to define it;
- The questionnaire is organized in 3 parts:
  1. Questions about the researchers;
  2. Questions about the experimental methodologies;
  3. Questions about the data life cycle in the current practices;

Doing multidisciplinary research

Elements of methodology: Questionnaire about scientific methods and process

- Agenda:
  - Phase 0 (October 2014): creation of the questionnaire and review / supplements by members;
  - Phase 1 (November 2014): Analysis and Integration opinions of members;
  - Phase 2 (December 2014, January 2015): Enter the questionnaire by the Member;
  - Phase 3 (February 2015): analysis of responses and requests for appointments for clarification;
  - Phase 4 (March 2015): Synthesis and restitution.
- We mix online questionnaire and face-to-face interviews;
- The difficulty is with the great diversities of actors!

Section 4

Infrastructures for computing and for data management

Infrastructures for computing

Renovating the cluster infrastructure @ P13

- In 2012 we change our paradigm: a mutual cluster has been bought starting with a 200k€ investment made by Direction des Systèmes d'Information;
- A research engineer has been recruited; Two committees have been setup (technical versus political decisions); Policies to include people ; Light bylaws to access the platform;
- Best practices are now available: we reserve nodes, we deploy, we run the experiment, we collect results (Big change!);
- The Scientific Council provides with annual support as well as the Pole Math&Stic (a federation of labs); Many negotiation and proposals to write!
- Researchers are invited to request money in their projects and to invest into the cluster;

Infrastructures for computing

Renovating the cluster infrastructure @ P13

- Training is also available for researchers: "How to use the cluster" two times per year (tutorial given by the research engineer);
- The research engineer can help also in the code development;
- The wiki allows to register a new user in 2 clicks + online help;
- Open to P13 members and collaborators (without limits)
- Operating the cluster is also a big challenge (replace the Bull layer by open source ones + automate ("à la Google") the deployment when new nodes are added...)
- After 2 years of operation, we see the roadmap for developing the infrastructure!

Building the Cloud / Storage infrastructure

Evolution of the Information System @ USPC

- Creation of a repository of business data (covering research projects, researchers and structures):
  - This mapping will also help to accurately compare the capabilities of the teams within SPC and thus identify where you need to put more and where it is less necessary;
- Creating and animating a network of scientific communities and the acquisition of a dedicated tool in the daily management of projects:
  - Multiple calls for proposals launched by SPC make possible strong synergies between the research teams. The IS of SPC should facilitate these collaborations between members, institutions and with National institutions.

Building the Cloud / Storage infrastructure

Archive, storage. . .

- The first step is to provide the capabilities of secure data storage to researchers. Most researchers save their data in a traditional way, with significant risks to their privacy and their sustainability.
- In a second step, the priority is to secure the collaboration of researchers and the secure exchange of data between researchers (including outside the COMUE and international).
- Great instrument for doing High Performance Computing) would strengthen and develop the culture of experimentation at large scale ;

Building the Cloud / Storage infrastructure

Archive, storage. . .

- The goal is to change the scale and develop both infrastructure for production and for testing, and expand the capacity of these facilities on issues related to Big Data, Visualization, Cloud, Networks
- It is also very important to provide assistance for the use of these digital tools.

Section 5

Teaching large scale systems

USPC doctoral school program

Cluster / Grid / Cloud

- This program is for fresh PhD students (but it is also open to researchers) and targets good practices in order to use infrastructures (not for solving the problems of PhDs);
- Open to all PhDs involved in Sciences; Build a culture of experiments on large scale systems;
- Training course now available in the catalogue of USPC after running it for two years in Paris 13; About 32 hours; Many practical work on real systems;
- Basic stuff with the Operating System to access the infrastructure ; Math libraries ; GPU with Cuda ; Sharing resources with Grids ; MapReduce framework ; SlapOS cloud;

Section 6

Conclusion

Conclusion

Lessons learned

- Count on your institutions but you need to convince them that Sciences can also be made according to experimental methods that require large scale systems;
- Infrastructure: adopt a mutual system not only for economic reasons but also to share risks and to involve, in mind and physically, people;

Conclusion

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- Organize committees (according to your local culture but in the limit of the Mexican army size) ☺

Conclusion

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- Infrastructure: adopt a mutual system not only for economic reasons but also to share risks and to involve, in mind and physically, people;
- Organize committees (according to your local culture but in the limit of the Mexican army size) ☺
- The goal is not to have the technologies because of the technology or to bypass national centers but to deliver solutions to our family-users

USAGE MODEL PLEASE ☺

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