SILECS

Super Infrastructure for Large-scale Experimental Computer Science

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Presented by C. Perez – Inria

INRIA, CNRS, RENATER, CEA, CPU, CDEFI, IMT, Sorbonne Université, Université Strasbourg, Université Lorraine, Université Grenoble Alpes, Université Lille 1, Université Rennes 1, Université Toulouse, ENS Lyon, INSA Lyon

http://www.silecs.net/
Experimentation
The Discipline of Computing: An Experimental Science

The reality of computer science

- Information
- Computers, networks, algorithms, programs, etc.

Studied objects (hardware, programs, data, protocols, algorithms, networks) are more and more complex

Modern infrastructures

- Processors have very nice features: caches, hyperthreading, multi-core, ...
- Operating system impacts the performance (process scheduling, socket implementation, etc.)
- The runtime environment plays a role (MPICH ≠ OPENMPI)
- Middleware have an impact (Globus/GridSolve, OpenStack)
- Various parallel architectures that can be heterogeneous, hierarchical, distributed, dynamic
Experimental Culture not Comparable with Other Sciences

Some example of studies

- 1994: 400 papers
  - Between 40% and 50% of CS ACM papers requiring experimental validation had none (15% in optical engineering) [Lukovicz et al.]
- 1998: 612 papers
  - “Too many articles have no experimental validation” [Zelkowitz and Wallace 98]
- 2007: Survey of simulators used in P2P research
  - Most papers use an unspecified or custom simulator
- 2009 update
  - Situation is improving

Computer science not at the same level than some other sciences

- Nobody redo experiments
- Lack of tool and methodologies

A good experiment should fulfill the following properties

- **Reproducibility**: must give the same result with the same input
- **Extensibility**: must target possible comparisons with other works and extensions
  (more/other processors, larger data sets, different architectures)
- **Applicability**: must define realistic parameters and must allow for an easy calibration
- **“Revisability”**: when an implementation does not perform as expected, must help to identify the reasons
Analytic Modeling

Purely analytical (mathematical) models

- Demonstration of properties (theorem)
- Models need to be tractable: over-simplification?
- Good to understand the basic of the problem
- Most of the time ones still perform a experiments (at least for comparison)

For a practical impact (especially in distributed computing): analytic study not always possible or not sufficient
Experimental Validation

A good alternative to analytical validation

- Provides a comparison between algorithms and programs
- Provides a validation of the model or helps to define the validity domain of the model

Several methodologies

- **Simulation** (SimGrid, NS, ...)
- **Emulation** (MicroGrid, Distem, ...)
- **Benchmarking** (NAS, SPEC, LINPACK, ....)
- **Real-scale** (Grid’5000, FIT, FED4Fire, Chameleon, OpenCirrus, PlanetLab, ...)

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SILECS
SILECS Motivation

• Exponential improvement of
  – Electronics (energy consumption, size, cost)
  – Capacity of networks (WAN, wireless, new technologies)

• Exponential growth of applications near users
  – Smartphones, tablets, connected devices, sensors, …
  – Prediction of 50 billions of connected devices by 2020 (CISCO)

• Large number of Cloud facilities to cope with generated data
  – Many platforms and infrastructures available around the world
  – Several offers for IaaS, PaaS, and SaaS platforms
  – Public, private, community, and hybrid clouds
  – Going toward distributed Clouds (FOG, Edge, extreme Edge)
Convergence

Computation

1950/1990 - Mainframes
1975 - Personal Computers
1999 - Salesforces SaaS Concept
2002 - Virtualised Infrastructure
2010 - Cloud democratisation
2015 - Network/Computers Convergence Software Defined XXX

ENIAC 1946
Transistor 1947
micro processor 1971

1970 - Terminals (clients/server concepts)
1967 - First virtualisation attempt
1960 - Interactive
1838 - Telegraph
1876 - Telephone
1896 - Radio

1957 - satellite
1969 - ARPANET
1985 - TCP/IP Adoption
1973 - Ethernet
1960 - Interactive

Communication

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1999 - The Grid
1995 - Commodity clusters
2002- Amazon Initial Compute/Storage services
2006 - Amazon EC2 (IaaS)
2007 - SmartPhones
2010 - Amazon Initial Compute/Storage services
2015 - Network/Computers Convergence Software Defined XXX
SILECS: based upon two existing infrastructures

- **FIT**
  - Providing Internet players access to a variety of fixed and mobile technologies and services, thus accelerating the design of advanced technologies for the Future Internet
  - 4 key technologies and a single control point: IoT-Lab (connected objects & sensors, mobility), CorteXlab (Cognitive Radio), wireless (anechoic chamber), Cloud technology including OpenStack, Network Operations Center
  - 9 sites (Paris (2), Evry, Rocquencourt, Lille, Strasbourg, Lyon, Grenoble, Sophia Antipolis)

- **Grid’5000**
  - A scientific instrument for experimental research on large future infrastructures: Clouds, datacenters, HPC Exascale, Big Data infrastructures, networks, etc.
  - 10 sites, > 8000 cores, with a large variety of network connectivity and storage access, dedicated interconnection network granted and managed by RENATER

- **Software stacks dedicated to experimentation**
  - Resource reservation, disk image deployment, monitoring tools, data collection and storage
GRID’5000

- **Testbed for research on distributed systems**
  - Born from the observation that we need a better and larger testbed
  - HPC, Grids, P2P, and now Cloud computing and BigData systems
  - A complete access to the nodes’ hardware in an exclusive mode (from one node to the whole infrastructure)
  - Dedicated network (RENATER)
  - Reconfigurable: nodes with Kadeploy and network with KaVLAN

- **Current status**
  - 10 sites, 29 clusters, 1060 nodes, 10474 cores
  - Diverse technologies/resources (Intel, AMD, Myrinet, Infiniband, two GPU clusters, energy probes)

- **Some Experiments examples**
  - In Situ analytics
  - Big Data Management
  - HPC Programming approaches
  - Network modeling and simulation
  - Energy consumption evaluation
  - Batch scheduler optimization
  - Large virtual machines deployments

https://www.grid5000.fr/
FIT

FIT-R2Lab: WiFi mesh testbed (DIANA)

FIT-CortexLab: Cognitive Radio Testbed
40 Software Defined Radio Nodes (SOCRATE)

FIT-IoT-LAB
- 2700 wireless sensor nodes spread across six different sites in France
- Nodes are either fixed or mobile and can be allocated in various topologies throughout all sites

https://www.iot-lab.info/hardware/

https://fit-equipex.fr/
Envisioned Architecture
Data Center Portfolio

Targets

- Performance, resilience, energy-efficiency, security in the context of data-center design, Big Data processing, Exascale computing, etc.

Hardware

- Servers: x86, ARM64, POWER, accelerators (GPU, FPGA)
- Networking: Ethernet (10G, 40G), HPC networks (InfiniBand, Omni-Path)
- Storage: HDD, SSD, NVMe, both in storage arrays and clusters of servers

Experimental support

- Bare-metal reconfiguration
- Large clusters
- Integrated monitoring (performance, energy, temperature, network traffic)
Wireless Portfolio

Targets

- Performance, security, safety and privacy-preservation in complex sensing environment,
- Performance understanding and enhancement in wireless networking,
- Target applications: smart cities/manufacturing, building automation, standard and interoperability, security, energy harvesting, health care.

Hardware

- Software Defined Radio (SDR), LTE-Advanced and 5G
- Wireless Sensor Network (WSN/IEEE 802.15.4), LoRa/LoRaWAN
- Wifi/WIMAX (IEEE 802.11/16)

Experimental support

- Bare-metal reconfiguration
- Large-scale deployment (both in terms of densities and network diameter)
- Different topologies with indoor/outdoor locations
- Mobility-enabled with customized trajectories
- Anechoic chamber
- Integrated monitoring (power consumption, radio signal, network traffic)
Outdoor IOT testbed

• IoT is not limited to smart objects or indoor wireless sensors (smart building, industry 4.0, ....)

• Smart cities need outdoor IoT solutions
  • outdoor smart metering
  • outdoor metering at the scale of a neighborhood (air, noise smart sensing, ....)
  • citizens and local authorities are more and more interested by outdoor metering

• Controlled outdoor testbed
  • (reproducible) polymorphic IoT: support of multiple IoT technologies (long, middle and short range IoT wireless solutions) at the same time on a large scale testbed
  • Agreement and support of local authorities
  • Deployment in Strasbourg city (500000 citizens, 384 km2) and Lyon campus
Plans for SILECS: Testbed Services

- **Provide a unified framework that (really) meets all needs**
  - Make it easier for experimenters to move for one testbed to another
  - Make it easy to create simultaneous reservations on several testbeds (for cross-testbeds experiments)
  - Make it easy to extend SILECS with additional kinds of resources

- **Factor testbed services**
  - Services that can exist at a higher level, e.g. open data service, for storage and preservation of experiments data
    - in collaboration with Open Data repositories such as OpenAIRE/Zenodo
  - Services that are required to operate such infrastructures, but add no scientific value
    - Users management, usage tracking
An experiment outline

- Discovering resources from their description
- Reconfiguring the testbed to meet experimental needs
- Monitoring experiments, extracting and analyzing data
- Controlling experiments: API
The GRAIL

**Experimental methodology:**
- experiment design & planning (workflow);
- description of scenarios, of experimental conditions;
- definition of metrics;
- laboratory journal;
- analysis and visualization of results

**Orchestration of experiments:**
- organize the execution of complex and large-scale experiments (workflow);
- run experiments unattended and efficiently;
- handles failures;
- compose experiments

**Basic services:**
- common tools required by most experiments
  - **Interact w/ testbed**
    - find, reserve and configure resources
  - **Test resources before using them**
  - **Manage the environment**
  - **Control a large number of nodes**
  - **Manage data**
  - **Change experimental conditions**
  - **Instrument the application & the environment**
  - **Monitor and collect data**

**Experimental testbed (e.g Grid’5000):**
- reconfigurable hardware and network;
- isolation;
- some instrumentation and monitoring
## European Dimension (2018): An ESFRI tentative

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European Dimension (2019)  
H2020 INFRA-DEV Design Study

• To do the design phase of SLICES, before a future implementation as ESFRI
• 11 partners (as of today)
  • FR: Sorbonne Université
  • FR: Inria
  • GR: University of Thessaly
  • CH: Mandat International alias Fondation pour la Cooperation Internationale
  • PL: PSNC
  • ES: Universidad Carlos III de Madrid
  • CY: UCLan Cyprus
  • IT: CNR
  • BE: IMEC
  • NL: University of Amsterdam
Conclusions

• New infrastructure based on two existing instruments (FIT and Grid’5000)
• Design a software stack that will allow experiments mixing both kinds of resources while keeping reproducibility level high
• Keep the aim of previous platforms (their core scientific issues addressed)
  – Scalability issues, energy management, …
  – IoT, wireless networks, future Internet for SILECS/FIT
  – HPC, big data, clouds, virtualization, deep learning … for SILECS/Grid’5000
• Address new challenges
  – IoT and Clouds
  – New generation Cloud platforms and software stacks (Edge, FOG)
  – Data streaming applications
  – Locality aware resource management
  – Big data management and analysis from sensors to the (distributed) cloud
  – Mobility
  – …