SILECS

Super Infrastructure for
Large-scale Experimental Computer Science

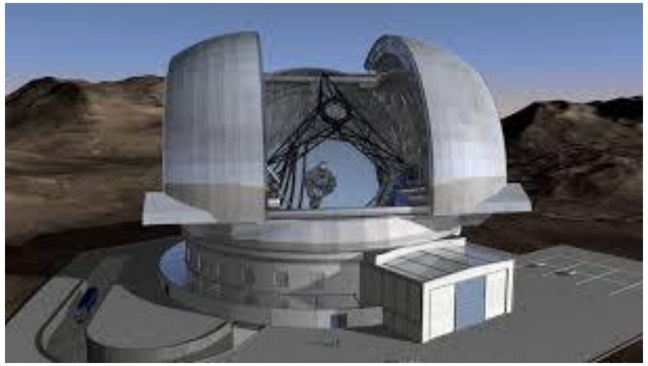
F. Desprez – Inria

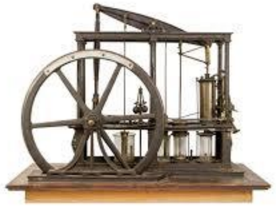
Presented by C. Perez – Inria

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

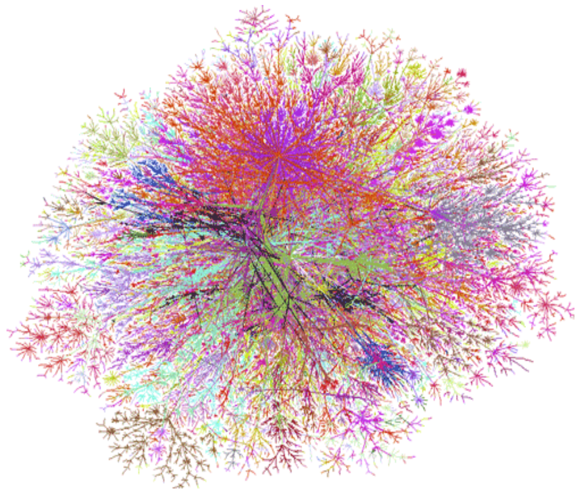
The reality of computer science

- 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

Paul Lukowicz et al. **Experimental Evaluation in Computer Science: A Quantitative Study**. In: *J.l of Systems and Software* 28:9-18, 1994
M.V. Zelkowitz and D.R. Wallace. **Experimental models for validating technology**. Computer, 31(5):23-31, May 1998
Marvin V. Zelkowitz. **An update to experimental models for validating computer technology.** In: *J. Syst. Softw.* 82.3:373–376, Mar. 2009
S. Naicken et al. **The state of peer-to-peer simulators and simulations**. In: *SIGCOMM Comput. Commun. Rev.* 37.2:95–98, Mar. 2007

Good Experiments

A **good experiment** should fulfill the following properties

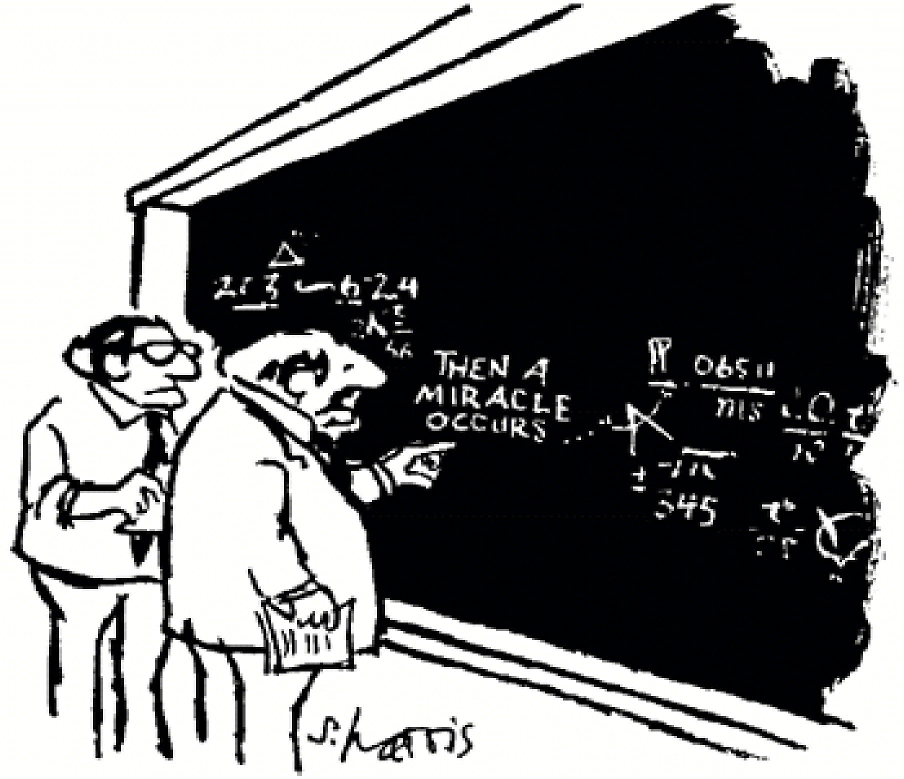
- **Reproducibility**: *must* give the same result with the same input
- **Extensibility:** *must* target possible comparisons with other works and extensions (more/other processors, larger data sets, different architectures)
- **Applicability:** *must* define realistic parameters and *must* allow for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

Association for Computing Machinery

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)



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

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

Experimental Validation

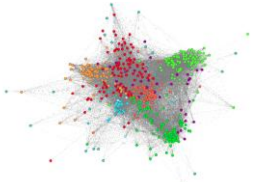
A good alternative to analytical validation

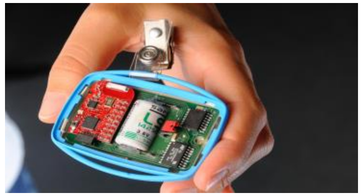
- Provides a comparison between algorithms and programs
- Provides a validation of the model or helps to define the validity domain of the model

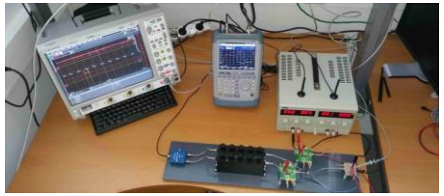
Several methodologies

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

SILECS Motivation

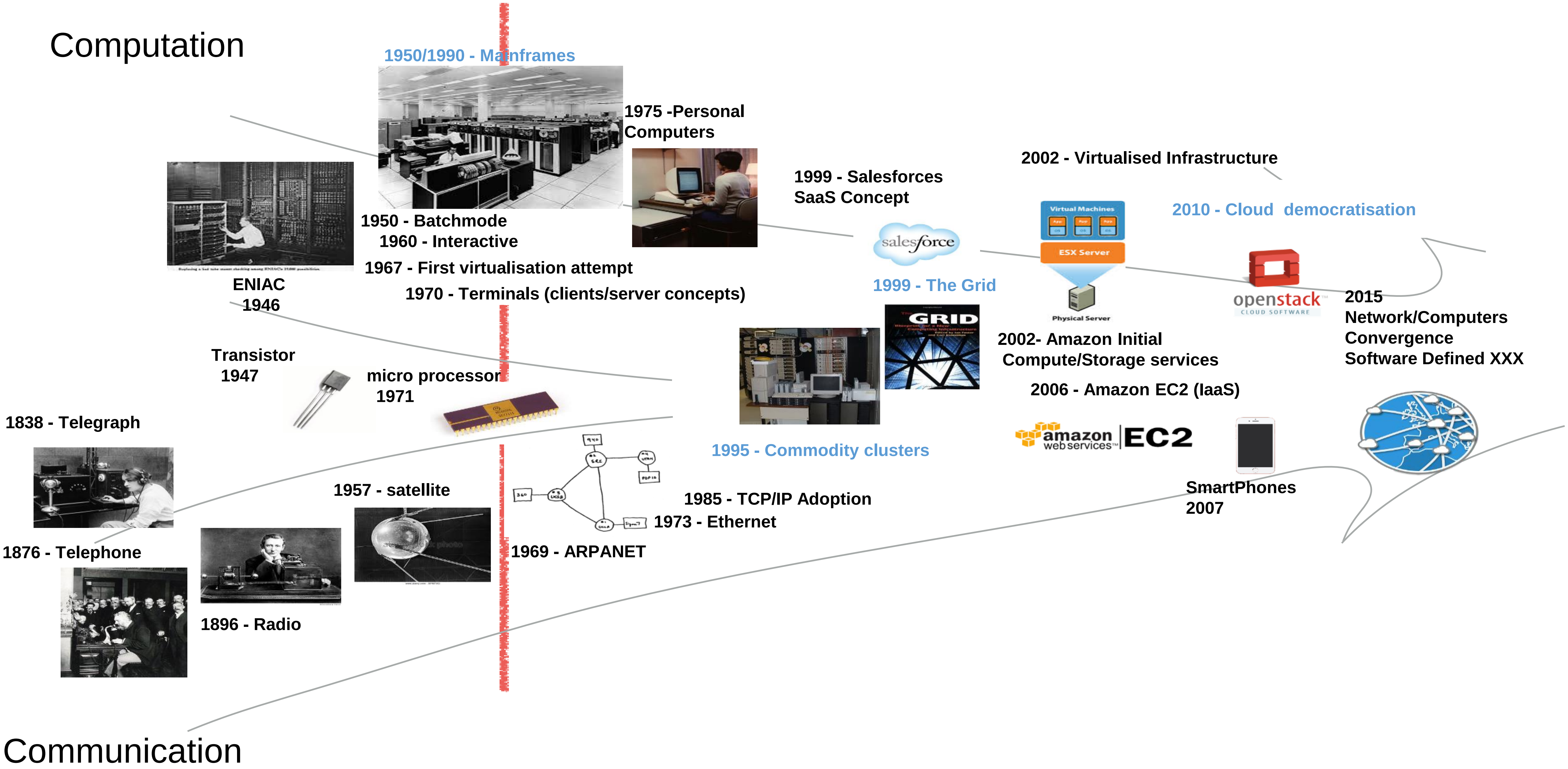






- Exponential improvement of
  - Electronics (energy consumption, size, cost)
  - Capacity of networks (WAN, wireless, new technologies)
- Exponential growth of applications near users
  - Smartphones, tablets, connected devices, sensors, …
  - Prediction of 50 billions of connected devices by 2020 (CISCO)
- 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

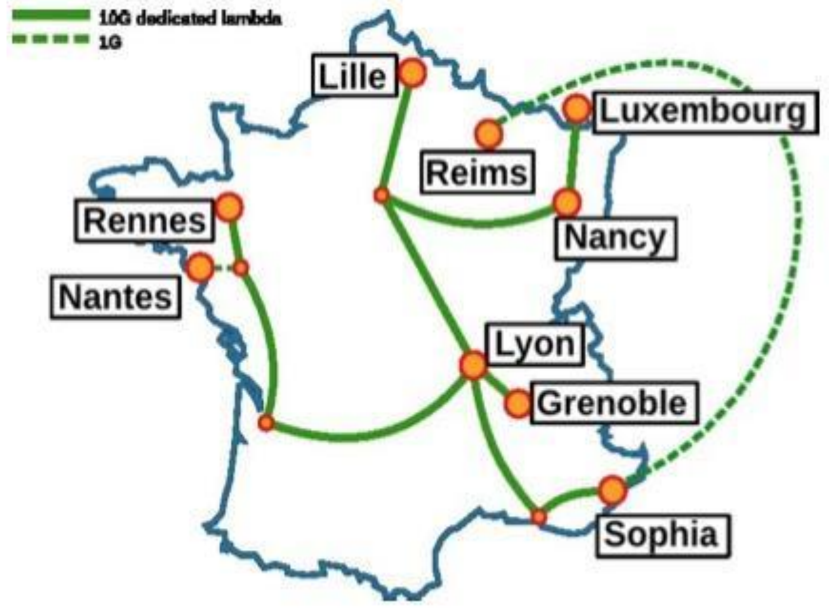


SILECS: based upon two existing infrastructures

- **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

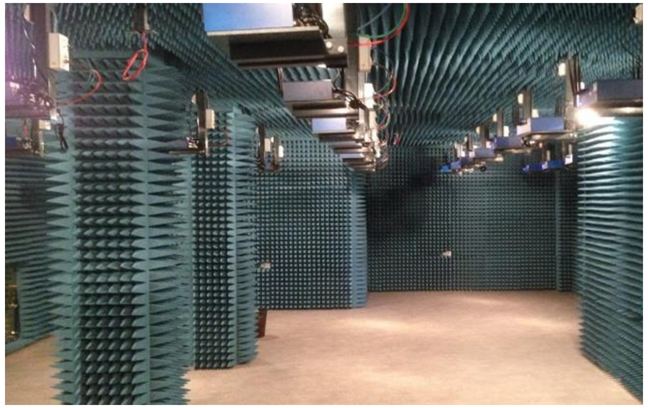
GRID'5000

- **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



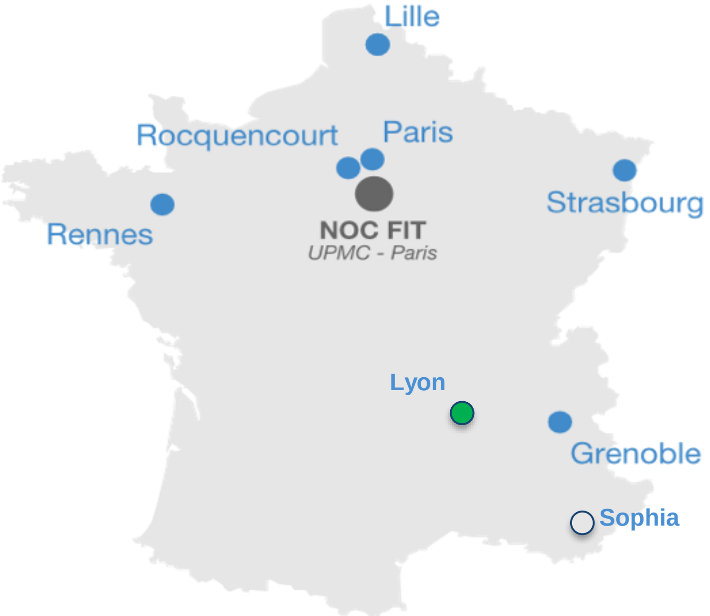
https://www.grid5000.fr/

FIT



FIT-R2Lab: WiFi mesh testbed (DIANA)

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



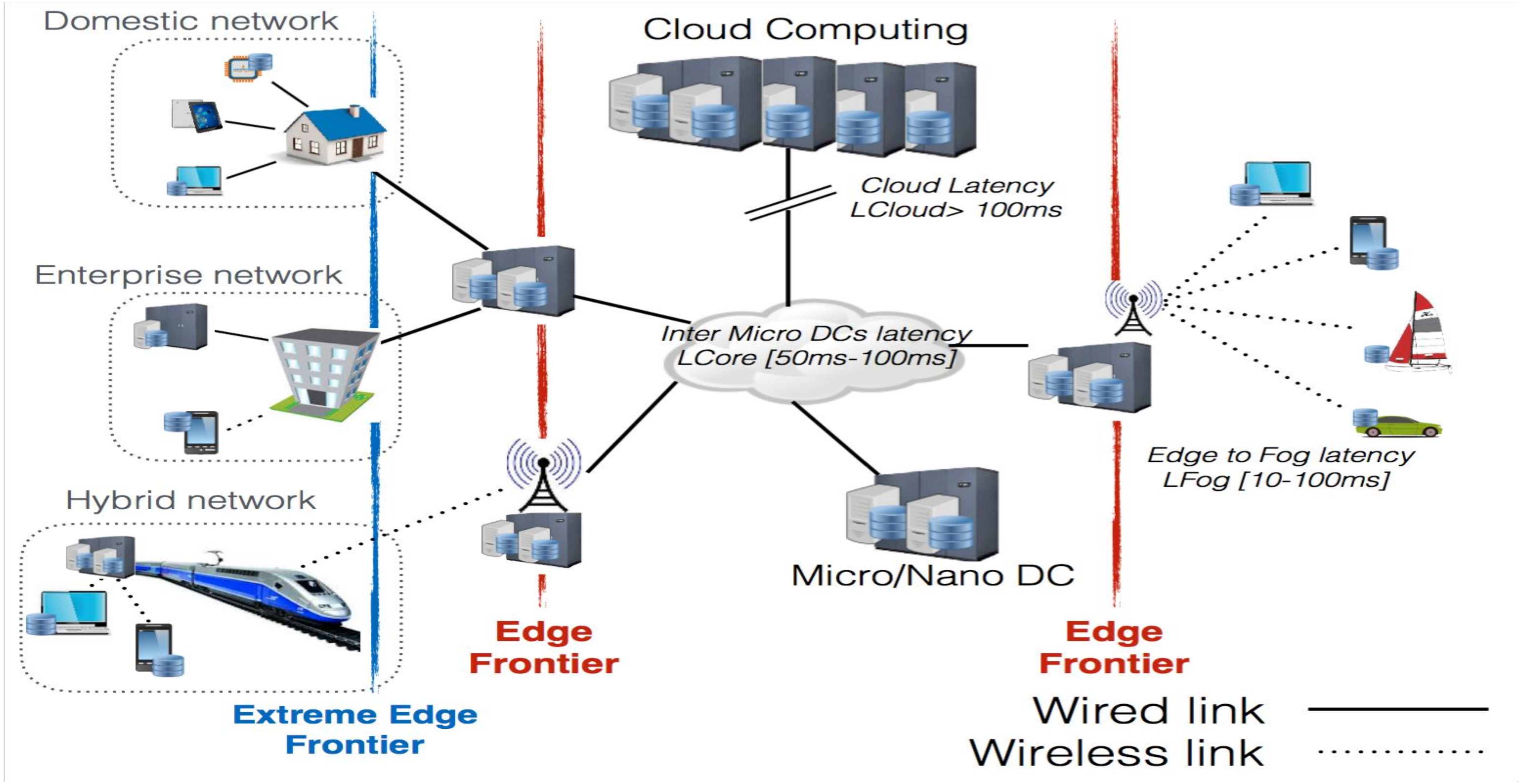
https://www.iot-lab.info/hardware/

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://fit-equipex.fr/

Envisioned Architecture



Credits: Bastien Confais

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

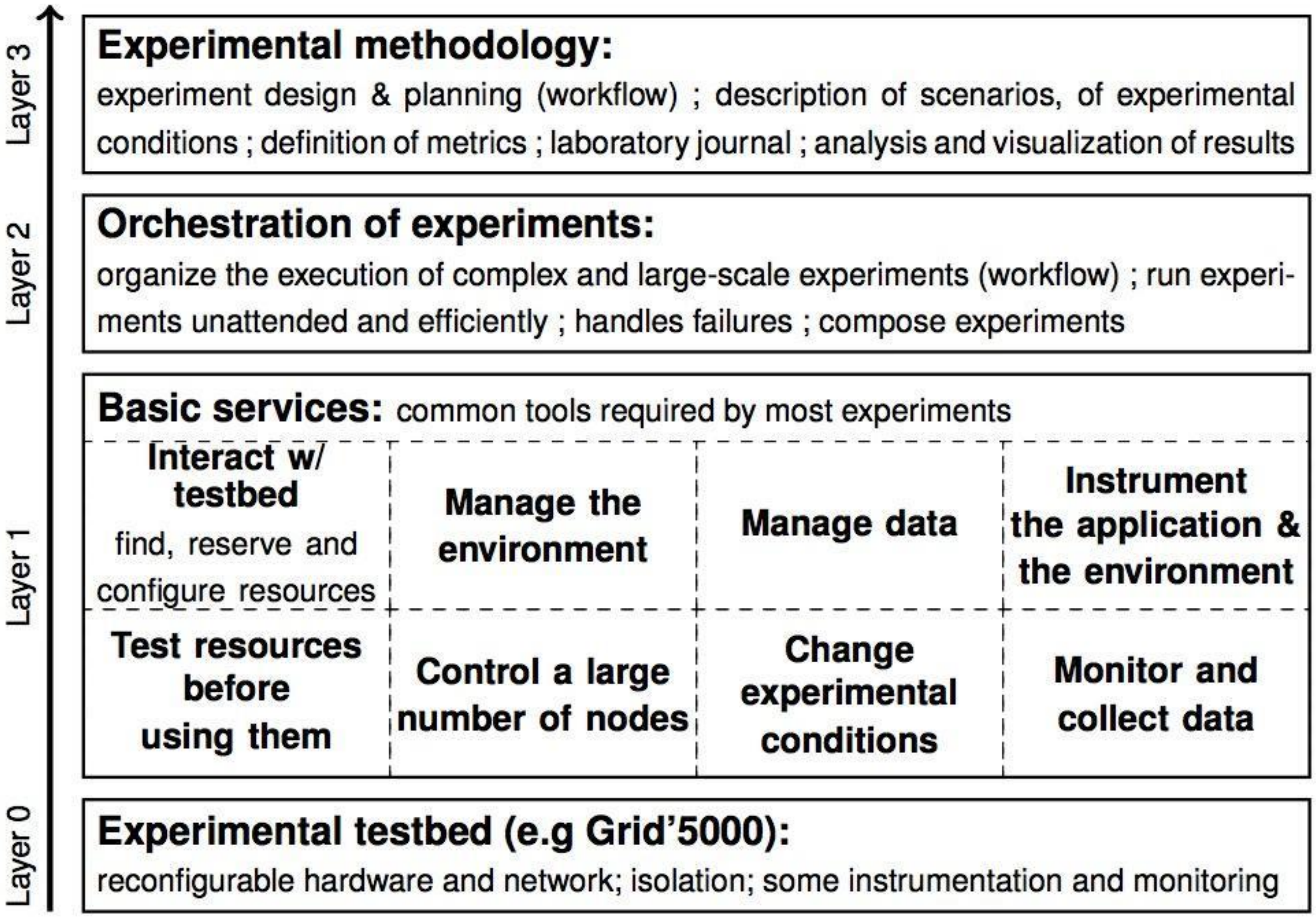
Plans for SILECS: Testbed Services

- **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


Layer 3
Experimental methodology:
experiment design & planning (workflow) ; description of scenarios, of experimental conditions ; definition of metrics ; laboratory journal ; analysis and visualization of results
Layer 2
Orchestration of experiments:
organize the execution of complex and large-scale experiments (workflow) ; run experiments unattended and efficiently ; handles failures ; compose experiments
Layer 1
Basic services: common tools required by most experiments
Interact w/ testbed
find, reserve and configure resources
Manage the environment
Manage data
Instrument the application & the environment
Test resources before using them
Control a large number of nodes
Change experimental conditions
Monitor and collect data
Layer 0
Experimental testbed (e.g Grid'5000):
reconfigurable hardware and network; isolation; some instrumentation and monitoring

European Dimension (2018): An ESFRI tentative

Countries	FR	GR	CH	ES	CY	IT	DE	NL	LU	BE
Gov.										
Research	Inria CNRS Sorbonne Université Université de Strasbourg IMT	University of Thessaly CERTH Centre for Research & Technology Hellas	Mandat International ETH Zürich EPFL École Polytechnique Fédérale de Lausanne	IMDEA networks Universidad Carlos III de Madrid Universidad de Granada Universidad Zaragoza Universidad de Alcalá UPC Universidad del País Vasco Euskal Herriko Unibertsitatea	uclan Cyprus	Università degli Studi di Milano Alma Mater Studiorum Università di Bologna CRS4	JG|U Johannes Gutenberg Universität Mainz Fraunhofer	VU University Amsterdam	uni.lu Université du Luxembourg	Universiteit Gent
Industry	Ericsson	Hewlett Packard Enterprise		Telefónica	OHL Concesiones	vodafone	Teldat bintec-elmeg		TTi	AMETIC
NRENs	RENATER Connecteur de savoirs					GÉANT				

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
  - …