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R'n'R building of an experimentation platform for the Edge

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R'n'R building of an experimentation platform for the Edge

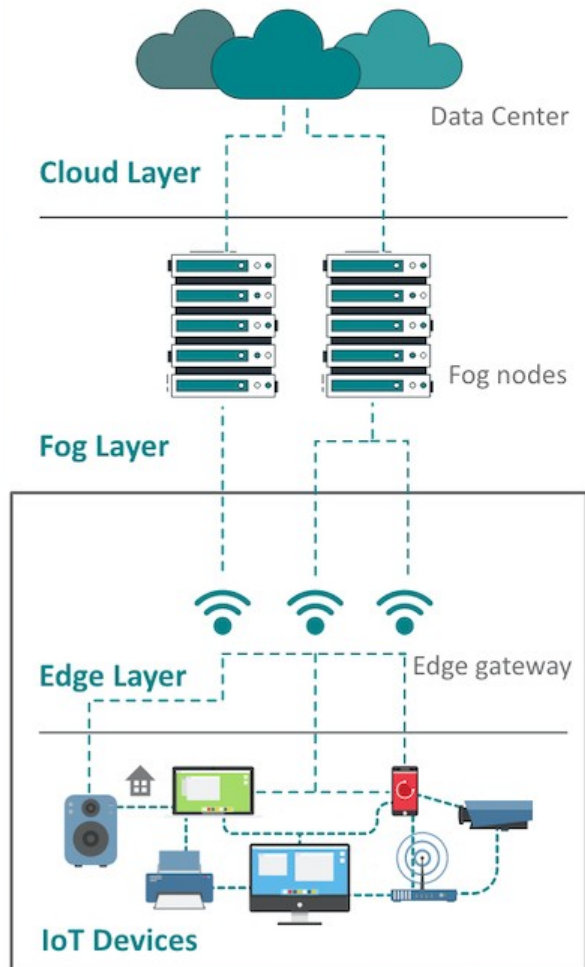
Journée Datamove 2024

Pierre Neyron - Ingénieur de Recherche LIG/CNRS

6 juin 2024



Edge computing devices?



| Cloud | Fog | Edge | IoT |
|----------------------------|-------------------|------------------------------|----------------|
| Thousand of DC | Millions of nodes | Billion of devices | |
| Infrastructure | | End-devices | |
| High bandwidth, e.g. wired | | Low power, possibly wireless | |
| Linux or equiv. | | | RTOS/baremetal |

Edge computing device

Rugged → Home box
 Esthetic → Industrial device
 Small → Station hall → Just a PC inside?

Power → Compute/energy tradeoff → Optimized hardware?

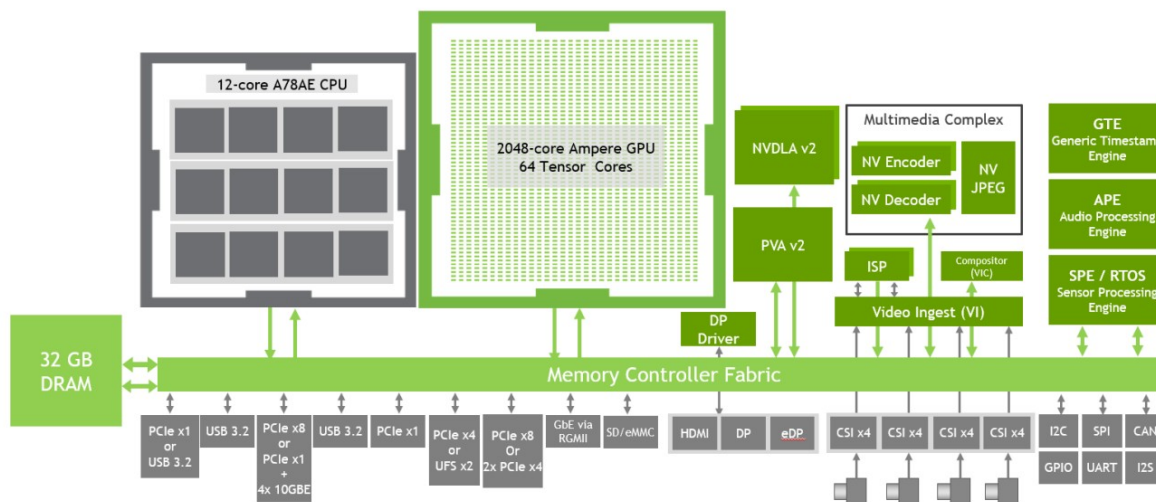
Network → Close to IoT
 In the wild → Highly distributed
 Wireless?

Edge computing devices?



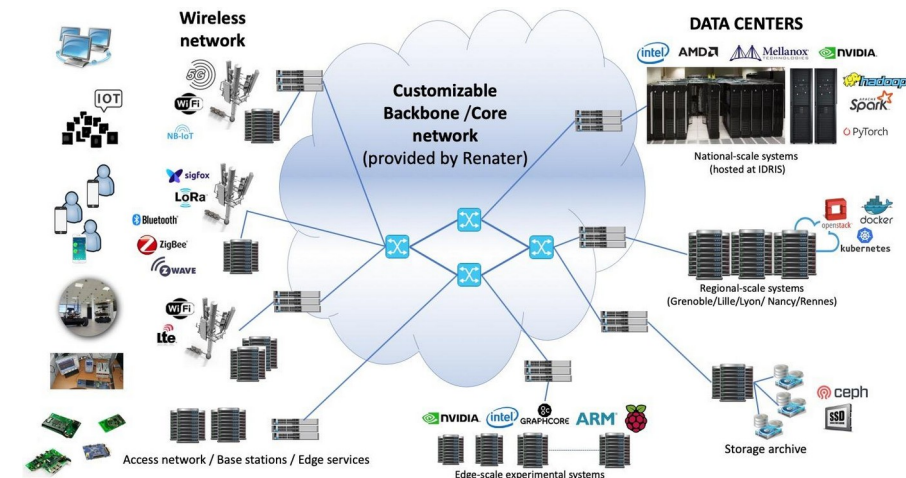
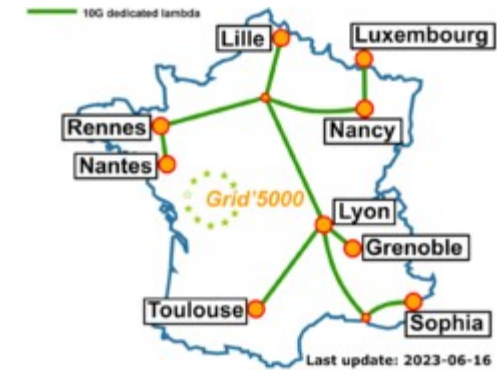
- Typical edge computing device: **Nvidia Jetsons**

- ▣ System on Chip (SoC) – CPU+GPU+... all in one
- ▣ ARM CPU – Low power, fewer cores (4 → 16) than servers
- ▣ Nvidia embedded GPU – smaller/one gen behind servers
- ▣ Other accelerators (DL, Vision, ...)



Platforms for research 1/2

- Grid'5000
 - 2004...
 - Large scale experiments, distributed clusters : 750 nodes
 - Various hardware: CPUs, Accelerators, Memory/Disks, Network
 - Services for research: HPC, Grid, Cloud, P2P, Network, ..., IA, ...
→ an experimental data-center: **only server-class machines**
 - Form-factor: rackable
 - Server components: e.g. only server-class CPU, GPU, RAM, Network
 - Locality: centralized places (regional DC)
- Toward “Slices”
 - ... 2040
 - Continuum from Cloud to IoT
 - Work-in-progress



Platforms for research 2/2

- Slices builds from other platforms also:

- Fit-IoT-Lab

- The Grid'5000 of IoT
- Grid of sensors, mobile devices, ...

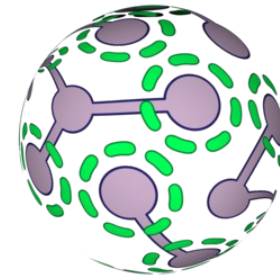
- Walt (Drakkar)

- Networked devices deployment

- Others...

- Integrating Edge computing devices is pretty new

- → *How does it fit in the Grid'5000 model ?*



Grid'5000 integration

Technical challenges

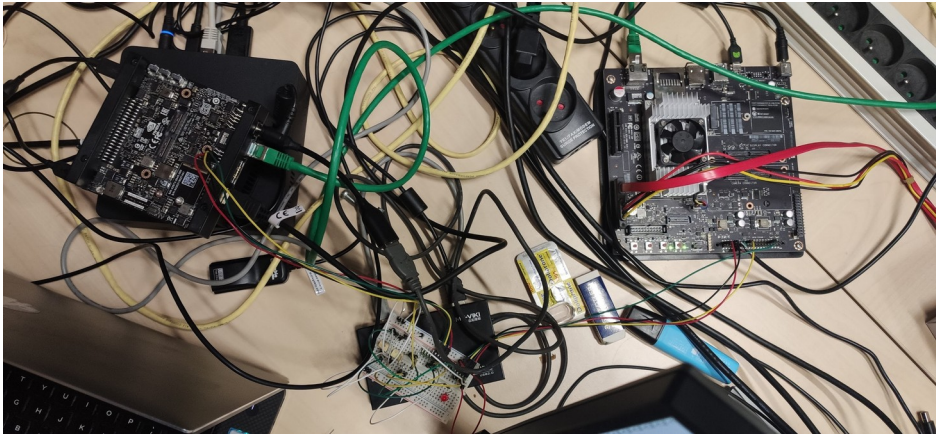
- Device constraints

- Exotic purchase
- Exotic form factor
- Exotic architecture
- Exotic/lack of components
- Exotic/lack of boot mechanism
- Exotic OS stack

- Grid'5000 constraints

- Datacenter hosting
- Control over network
- OS reconfiguration **X 1000 ?**
- Hardware validation
- Network topology reconfiguration
- Power meters

Grid'5000 integration make it to the data-center!

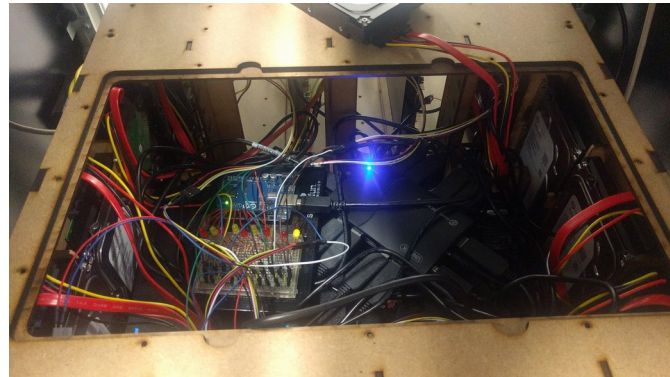


From the devkit to a ***data-center compatible*** chassis

- With out-of-band control (on/off, serial console)
- With out-of-band power meters

2 considered options:

- fablab made chassis → more work
- industrial solution → less flexible



Grid'5000 Integration

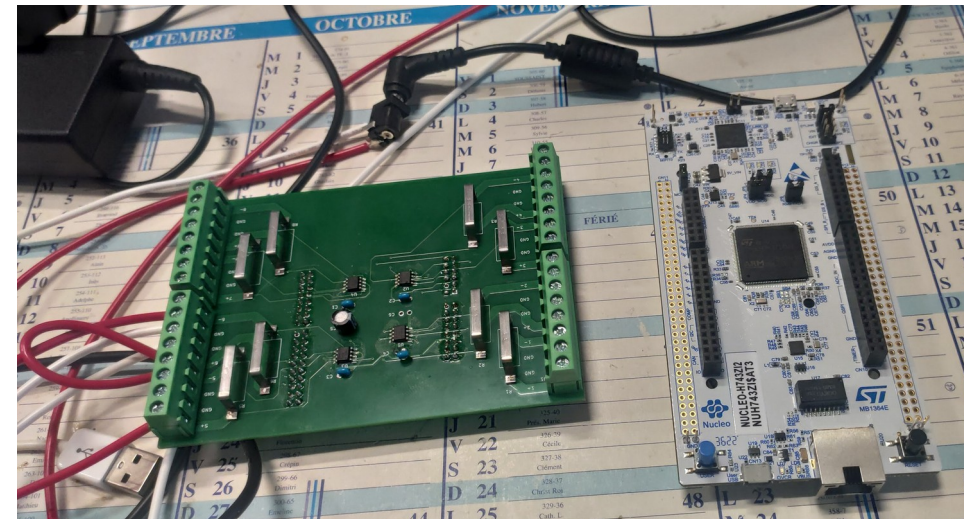
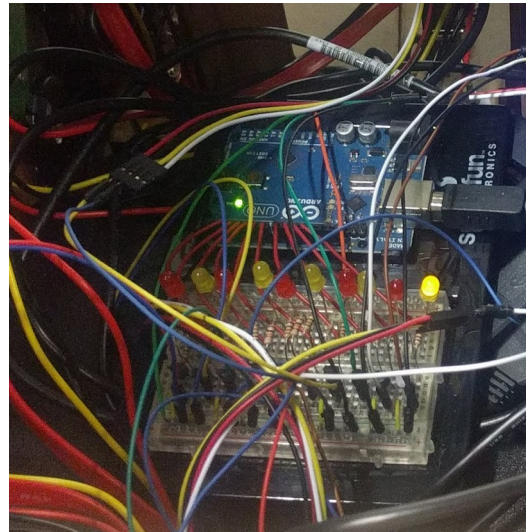
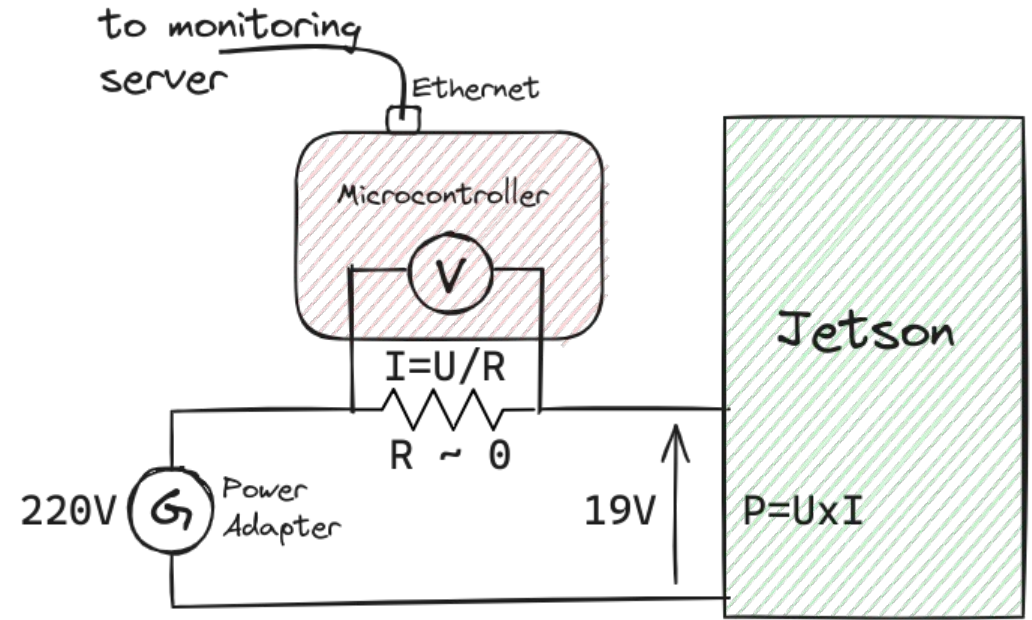
Out-of-band control

Data-center servers come with a BMC. What about Edge devices ?

Required functions:

- On/Off
- Serial console (if no network)
- Recovery
- **Power meter**

No on-the-shelf solution ?
DiY with microcontroller ?



Grid'5000 Integration OS swing – Boot switch

Datacenter servers come with PXE network boot

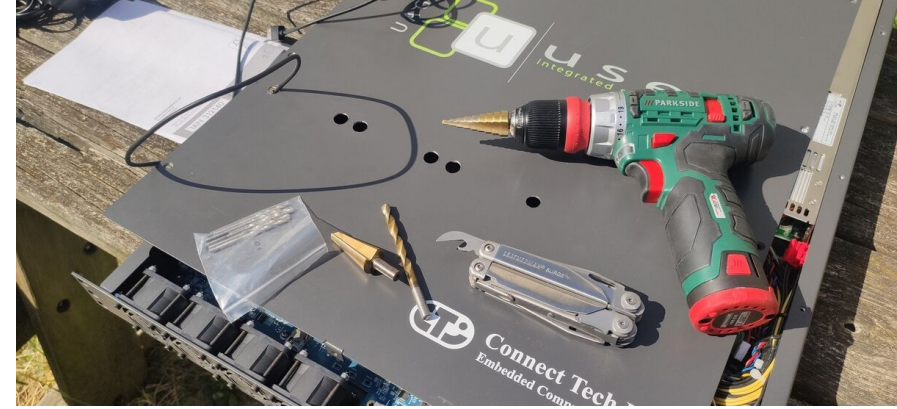
→ allow to remotely choose what to boot (**key to kadeploy**)

Embedded devices boot mechanism varies...

- Some have U-boot with network support: **good!**
- Nvidia happened to have a vendor bootloader without network: **bad**
- UEFI without working PXE: **bad**

Boot switch over USB ? Programmable USB device ? **wow**

Post Linux kernel swing ? (giving up on allowing to change kernel)... **mmm**



Grid'5000 Integration

OS reconfiguration

Edge == Embedded Linux devices come with exotic software stacks.

E.g. for Nvidia Jetson: ***Complex stacking of software layers***

- Base OS (e.g. Ubuntu)
- Nvidia layer, with specific kernel, libs (cuda, ...), services
- + Nvidia Partner layer: custom device description, additional drivers, ...

Non-standard machinery for installation (flash)

Required to ***reverse-engineer*** the installation process.

Need to automate: ***Kameleon*** to the rescue with build recipes!

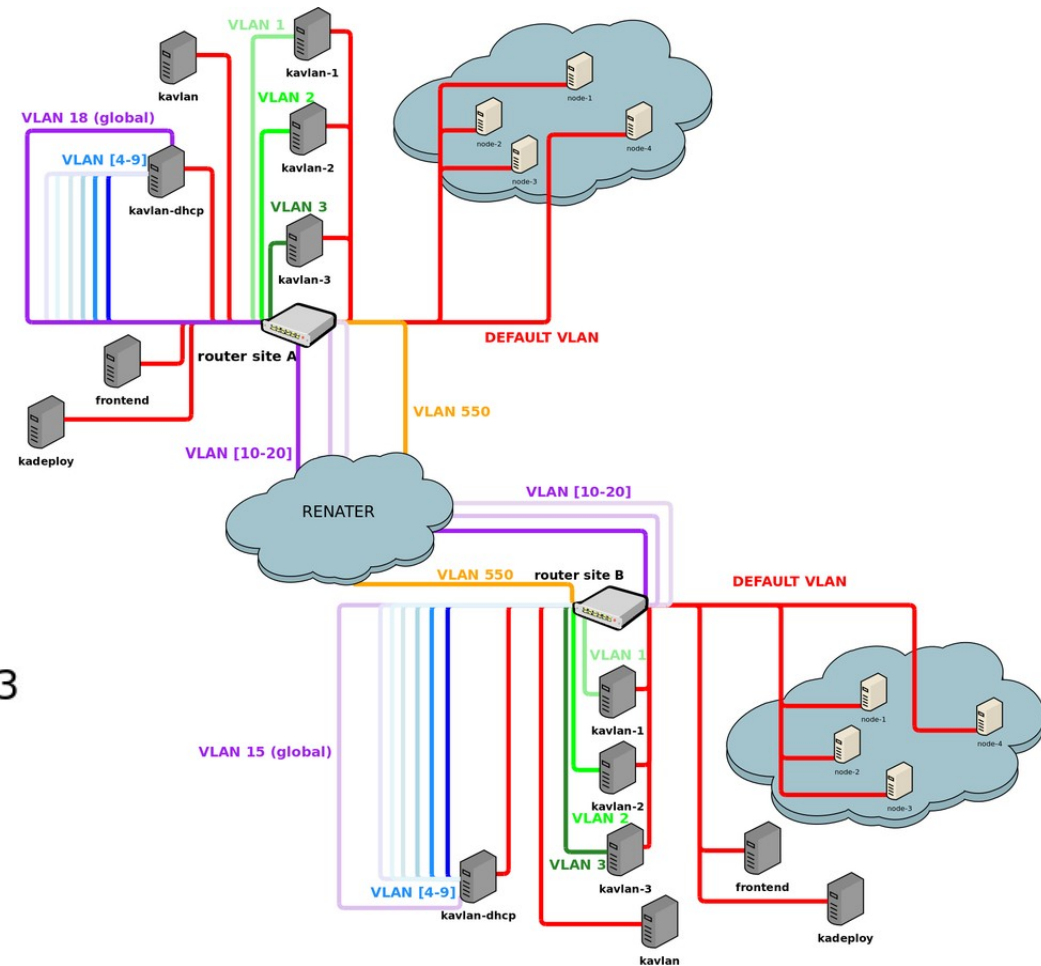
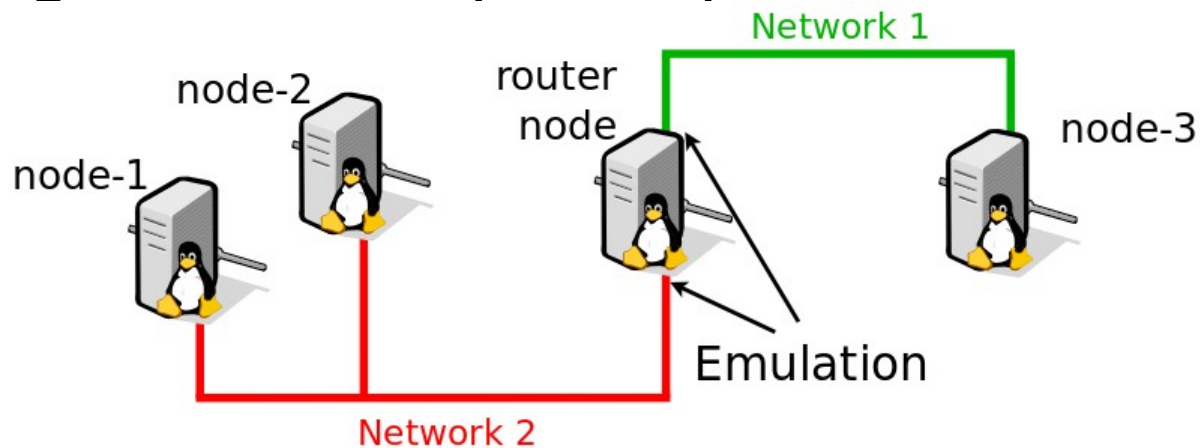


Grid'5000 Integration

Network topology emulation

User control of the physical network topology of hundreds of devices is out of the scope of Grid'5000.

→ Emulation with the G5K network reconfiguration tool (kavlan) + Linux tools



Take away message

- Hard technical work (years!) but:
 - 12 Edge nodes in “production”, available in G5K Toulouse
 - A few services missing:
 - Many platform tests → need reworking the whole Grid’5000 test infra
 - Network topology emulation → kavlan-ng in dev, should support it
 - Out-of-band power meters → go custom design if still not on the shelf?
 - Used for Mathilde & Tuan’s work: federated learning
 - 100 nodes better → what about 1000 ?
- More to come in Slices...