Energy Efficiency and Future Network Infrastructure

Telecommunication Networks and Telematics Lab

cnit

Department of Naval, Electrical, Electronics and Telecommunication Engineering (**DITEN**)
University of Genoa

Green networking: lessons learned and challenges

Prof. Raffaele Bolla
raffaele.bolla@unige.it
CNIT/University of Genoa

Amsterdam, 22 October 2014
14th Annual Broadband WORLDFORUM2014

Summary

- Previous results: the FP7 experience
- Lessons learned
- Current challenges
- Conclusions

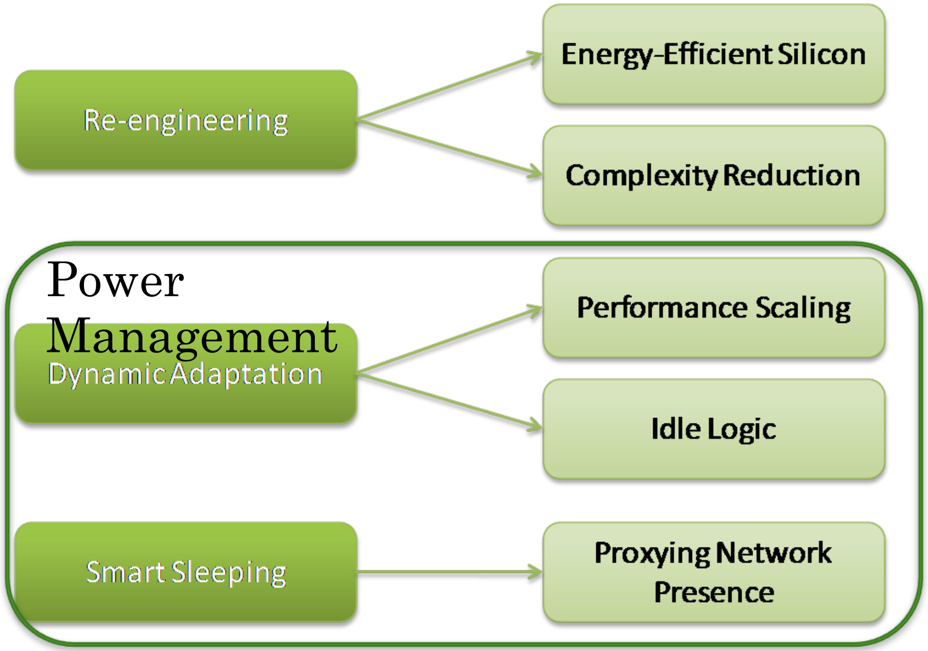
Recent (EU-FP7 projects) approaches in network energy-efficiency

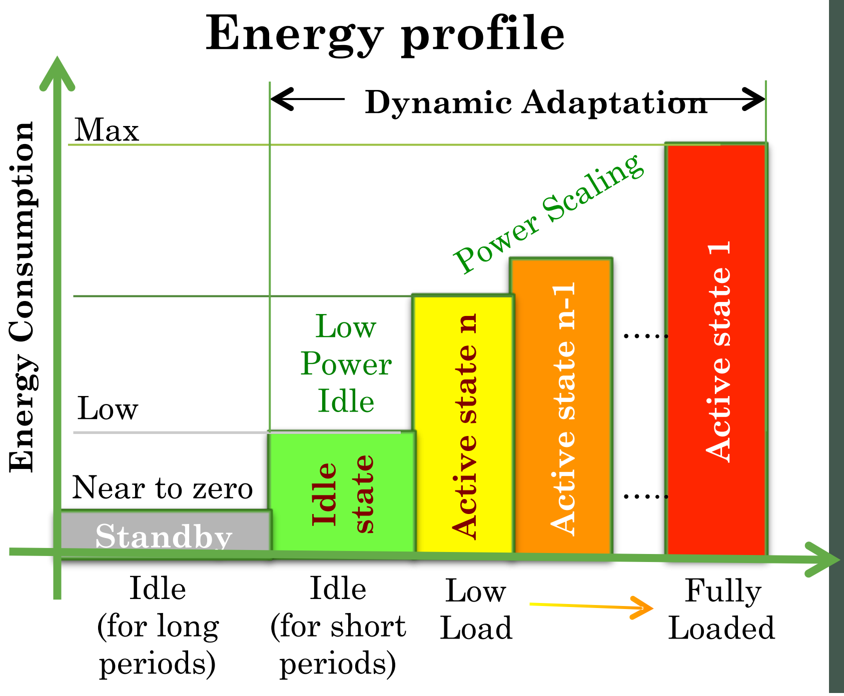
Energy Aware Radio and neTwork tecHnologies – earth

Cooperative Strategies for POWER saving in Multi-standard wireless devices – C2Power

Towards Real Energy-efficient Network Design – Trend

ECOnet – low Energy COnsumption NETworks



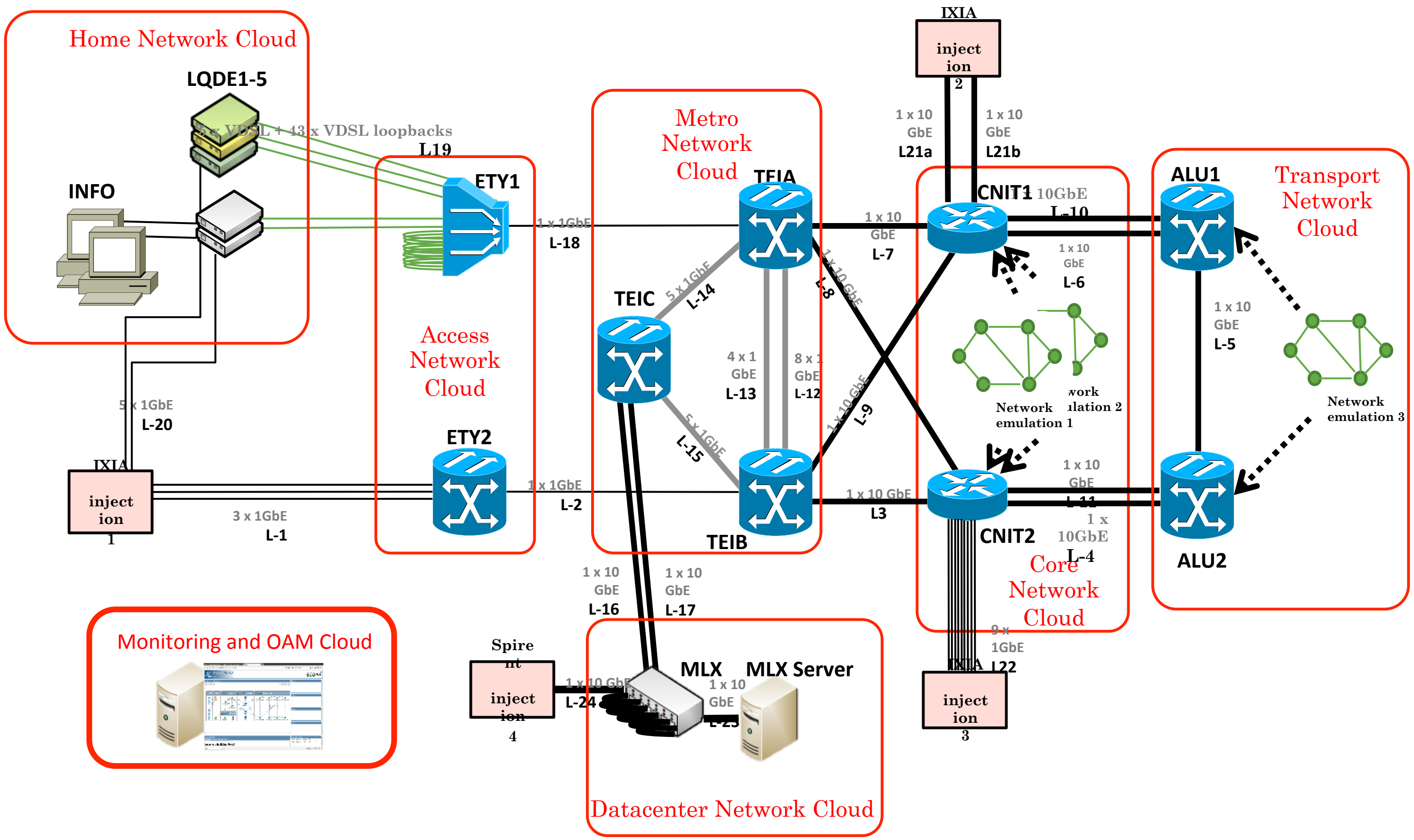


Energy Efficiency and Future Network Infrastructure

CNIT

ECONET experience and results
Demonstration Activities

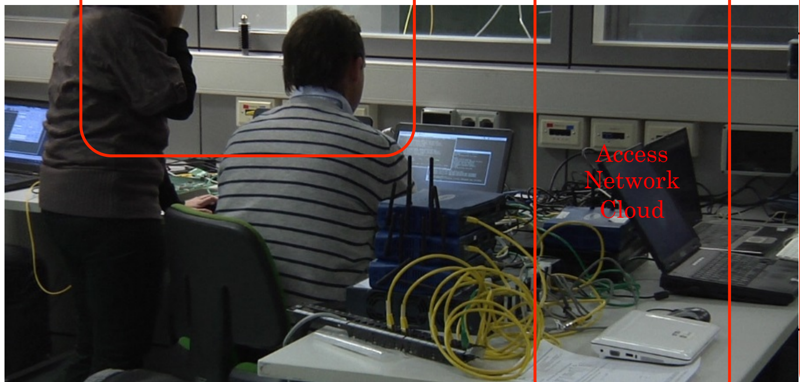
See the online demo portal at https://www.econet-project.eu/demo

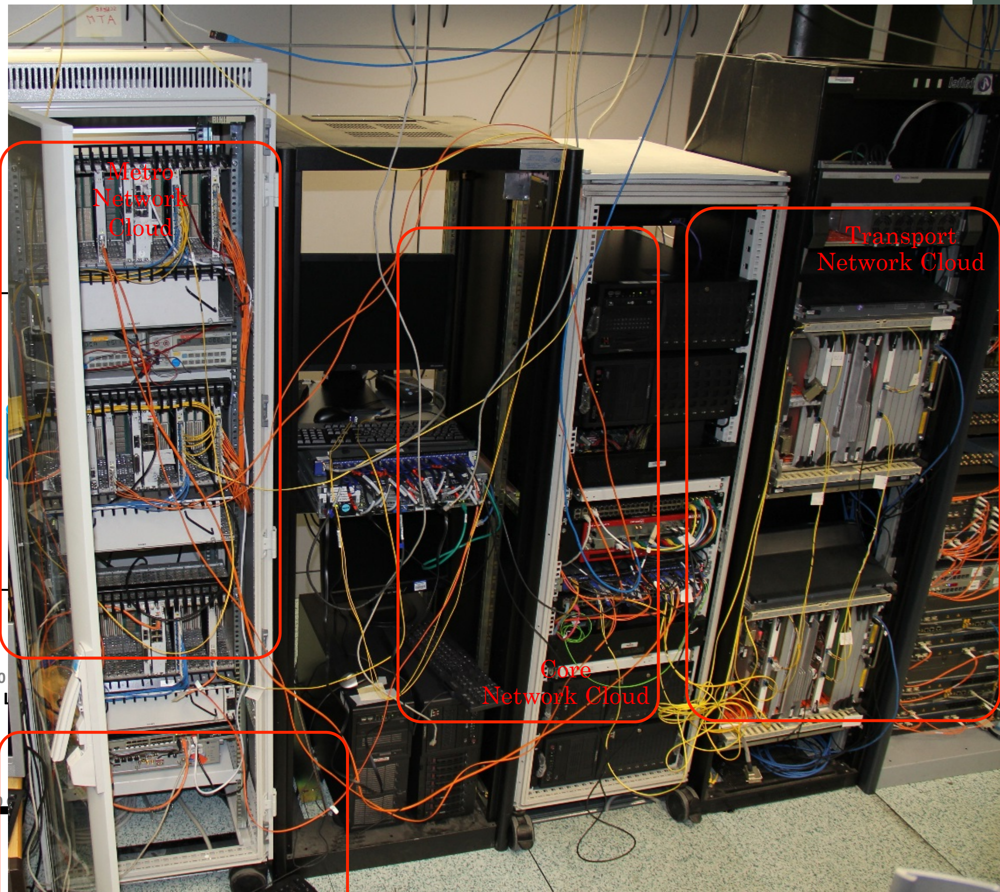


Energy Efficiency and Future Network Infrastructure

ECONET experience and results

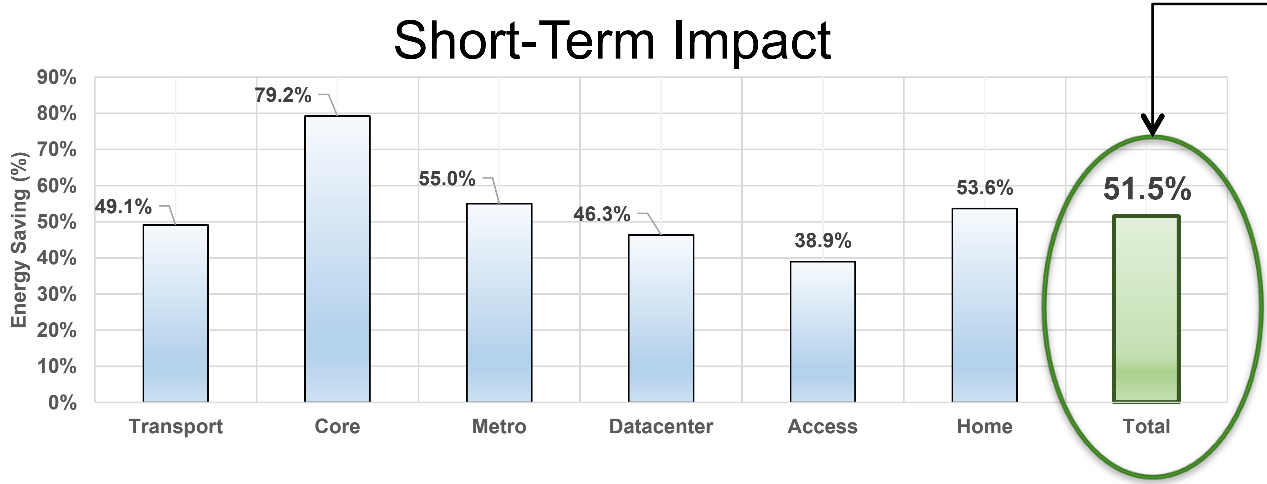
Demonstration Activities





ECONET final results

Impact results

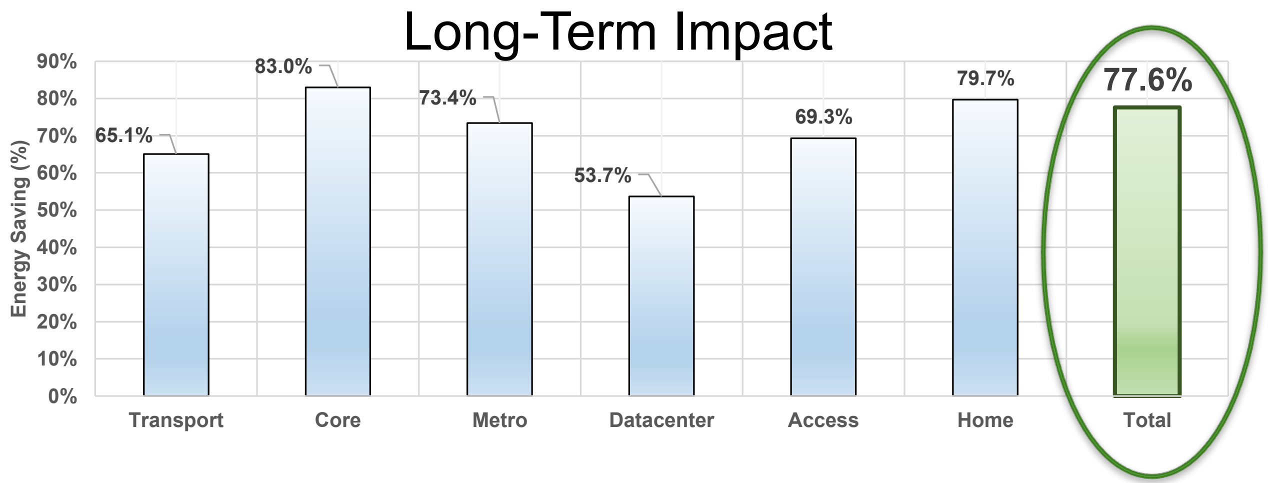


Short term

Average energy reduction of 51.6%.

Saving of more than 190 Million € per year of OPEX.

Carbon footprint emissions reduction equivalent of removing 50,000 cars per year.



Average energy reduction of 77.6%.

Saving of more than 290 Million € per year of OPEX.

Carbon footprint emissions reduction equivalent of removing 75,000 cars per year.

Long term

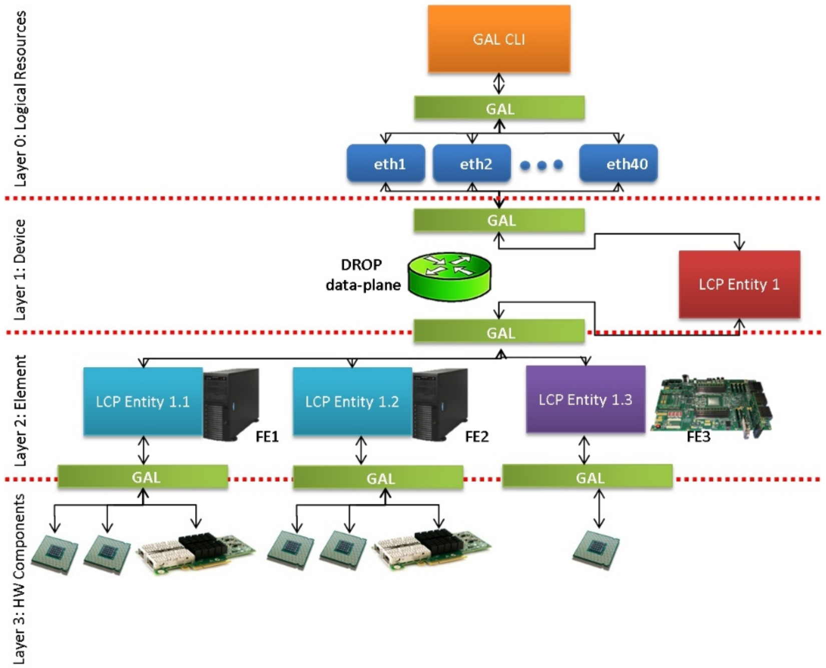
Energy Efficiency and Future Network Infrastructure

Lessons Learned (1/3)

- **Energy-aware hardware and autonomic low level power management mechanisms are mandatory, but definitely not sufficient.**
- **Heterogeneous power-saving mechanisms often interfere among each other, and cause heavy drawbacks:**
  - **Energy savings are not additive by default**
  - Trade-off between energy consumption and network performance
- **Power management needs to be driven by upper levels**:
  - to map their functional/logical resources and configurations with the underlying hardware
  - to find the best energy-aware hardware configuration that optimizes the trade-off between network performance and device/network energy consumption
- **Power management needs to be suitably orchestrated at different levels:**
  - Inside single devices
  - At the device level (logical/physical planes)
  - At the network level
- **Moreover, a relevant push toward standards and regulatory actions is also essential** (e.g., KPIs (Key Performance Indicators)).

Lessons Learned (2/3)
The Green Abstraction Layer

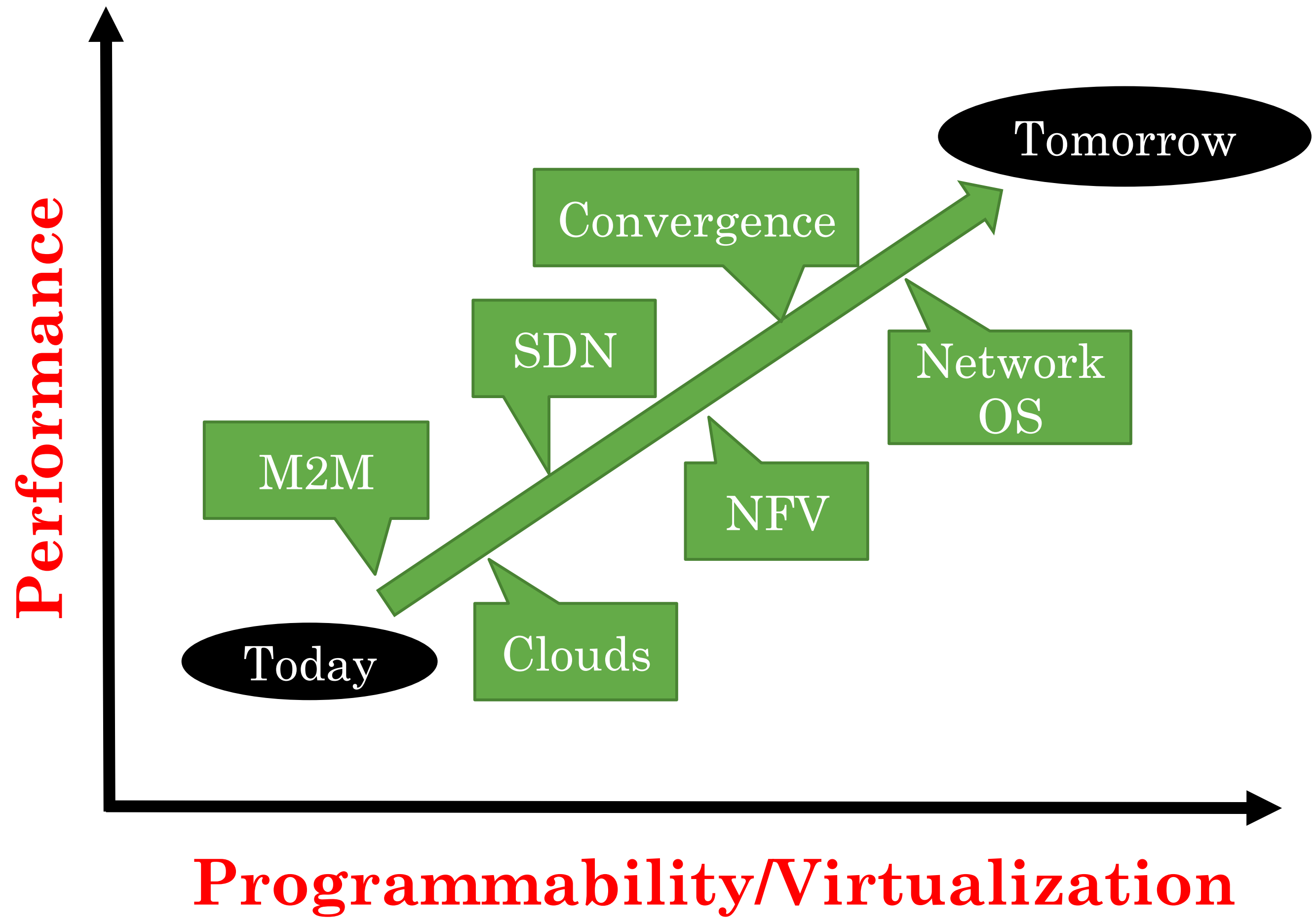
- One of the main achievements of the ECONET project.
- The GAL is a hierarchical interface to control and to orchestrate power management primitives in a network device in a scalable and flexible way.
- The GAL layers allows to divide and conquer the complex process of optimizing the mapping between power management primitives (acting at the HW level) and the network logical/virtual/functional configuration.



- The GAL has been approved in March 2014 as **ETSI Standard 203 237**.

Working Item: Reference operational model and interface for improving energy efficiency of ICT network devices

Future Internet/5G Challenges

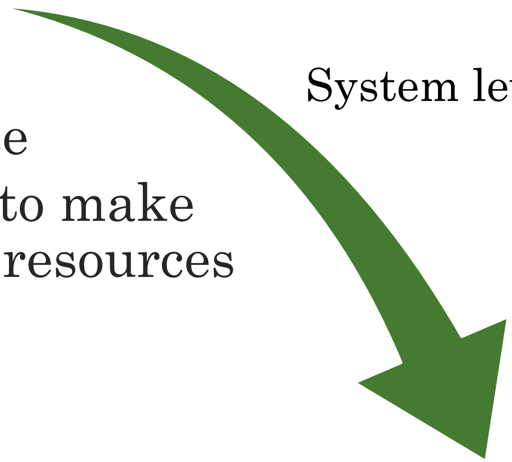


Networks as multi-purpose service-aware infrastructures:

- Zero loss and very low latency services
- Very broadband wireless/fixed accesses
- Terabit transport networks

Future Internet/5G Challenges

- In order to support all these objectives, we need to deeply re-think and re-design network architectures, devices, and base technologies:
  - HW programmability inside networks and devices
  - HW offloading for high performance
  - Extreme virtualization paradigms to make different services sharing network resources
  - Consolidation of services



Tomorrow, classical network protocols like IP will be considered simply as platform-independent virtualized network services

The Future Internet/5G Challenges
The Future Internet basics

Technology Evolution

- **Strong presence of programmable/general purpose HW inside networks and devices**:

  it is the main element for introducing the flexibility necessary for Future Internet architectures development.

Technological Impact

- **Costs & greenhouse gas emissions:**

  sustainability is a must for the Future Internet deployment.

To introduce **effective** **but sustainable** technologies enabling "**network programmability**" and realizing the **complete integration with information technologies** is a cornerstone of the Future Internet architecture

The Future Internet/5G Challenges
Programmability vs Energy Efficiency

- Fixed the silicon technology, energy consumption largely depends on the number of gates in the network device/ chip hardware.

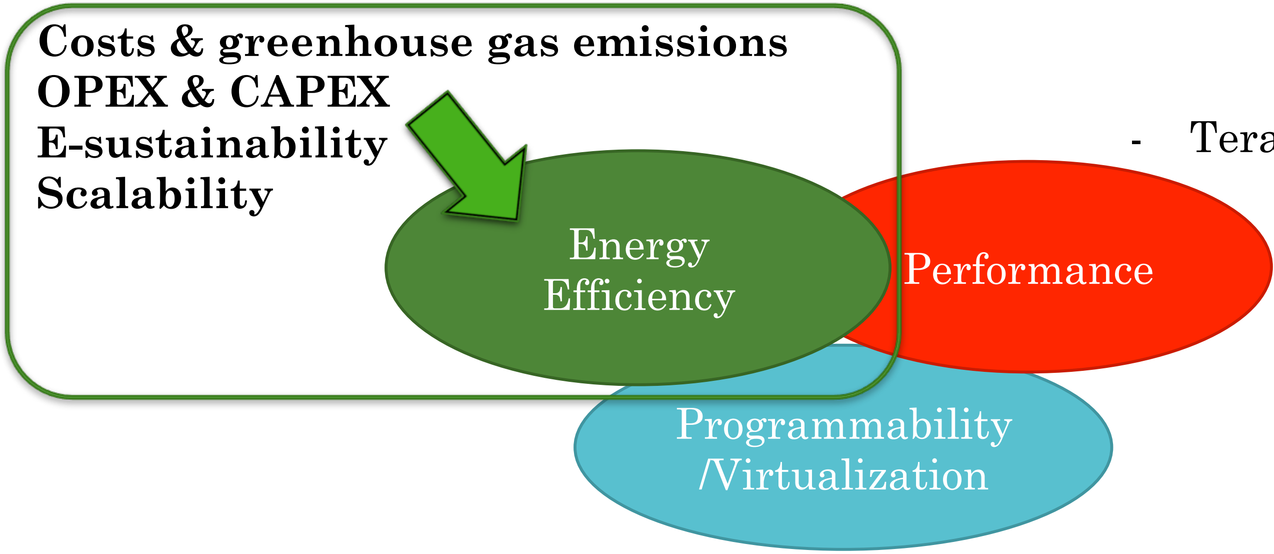
- The number of gates is generally directly proportional to the flexibility and programmability levels of HW engines.

- If we fix a target number of gates by using
  - **General Purpose CPUs, we obtain**:
    - Maximum flexibility,
    - Reduced performance (in the order of 100 Mbps/W)
  - **Very specialized ASICs, we obtain**:
    - Minimum flexibility
    - Greatly enhanced performance (in the order of 1 Gbps/W)
  - *Other technologies (e.g., network/packet processors) provide performance between these boundaries*

Programmability currently is energy consuming!

The Future Internet/5G Challenges

Programmability **for** Energy Efficiency



- Terabit transport networks
- Very broadband wireless/fixed accesses
- Zero loss and very low latency services

Networks as multi-purpose service-aware infrastructures:

- Internet of Services
- Internet of Things
- Network integrated Cloud Services (SDN)
- Network-as-a-Service (NFV)

An example: a new project in H2020

INPUT

In-Network Programmability for next-generation personal cloUd service supporT

Participant No	Participant organisation name	Short Name	Country
1 (Coordinator)	Consorzio Nazionale Interuniversitario per le Telecomunicazioni	CNIT	Italy
2	Ericsson Telecomunicazioni S.p.A.	TEI	Italy
3	Gioumpitek Meleti Schediasmos Ylopoiisi Kai Polisi Ergon Pliroforikis Etaireia Periorismenis Efthynis	UBITECH	Greece
4	Dublin City University	DCU	Ireland
5	HOP Ubiquitous S.L.	HOPU	Spain
6	Infocom S.r.l.	INFO	Italy
7	Cosmote Kinites Tilepikoinoneis AE	COS	Greece
8	Telecom Italia S.p.A.	TI	Italy
9	Julius-Maximilians Universitaet Wuerzburg	UWUERZ	Germany

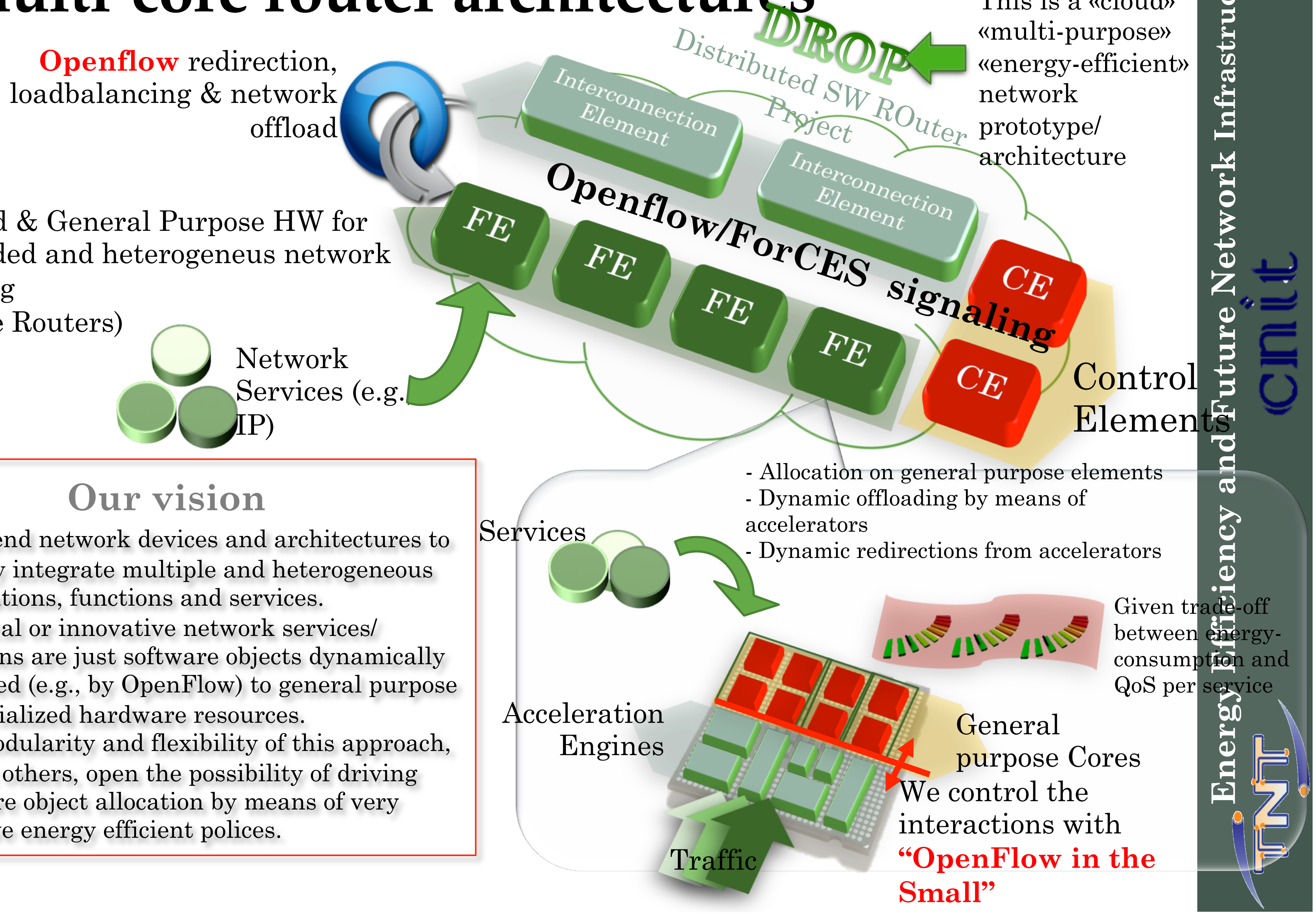
INPUT will enable cloud applications

- to go ***beyond classical service models*** (i.e., IaaS, PaaS, and SaaS)
- and to ***replace physical Smart Devices*** (SD) with their "***virtual images***,"

providing them to users "***as a Service***" (*SD as a Service – SDaaS*)

The virtual image will allow to reduce the carbon footprint of appliances of 50% - 75%.

An example: SDN, NFV and distributed/ multi-core router architectures

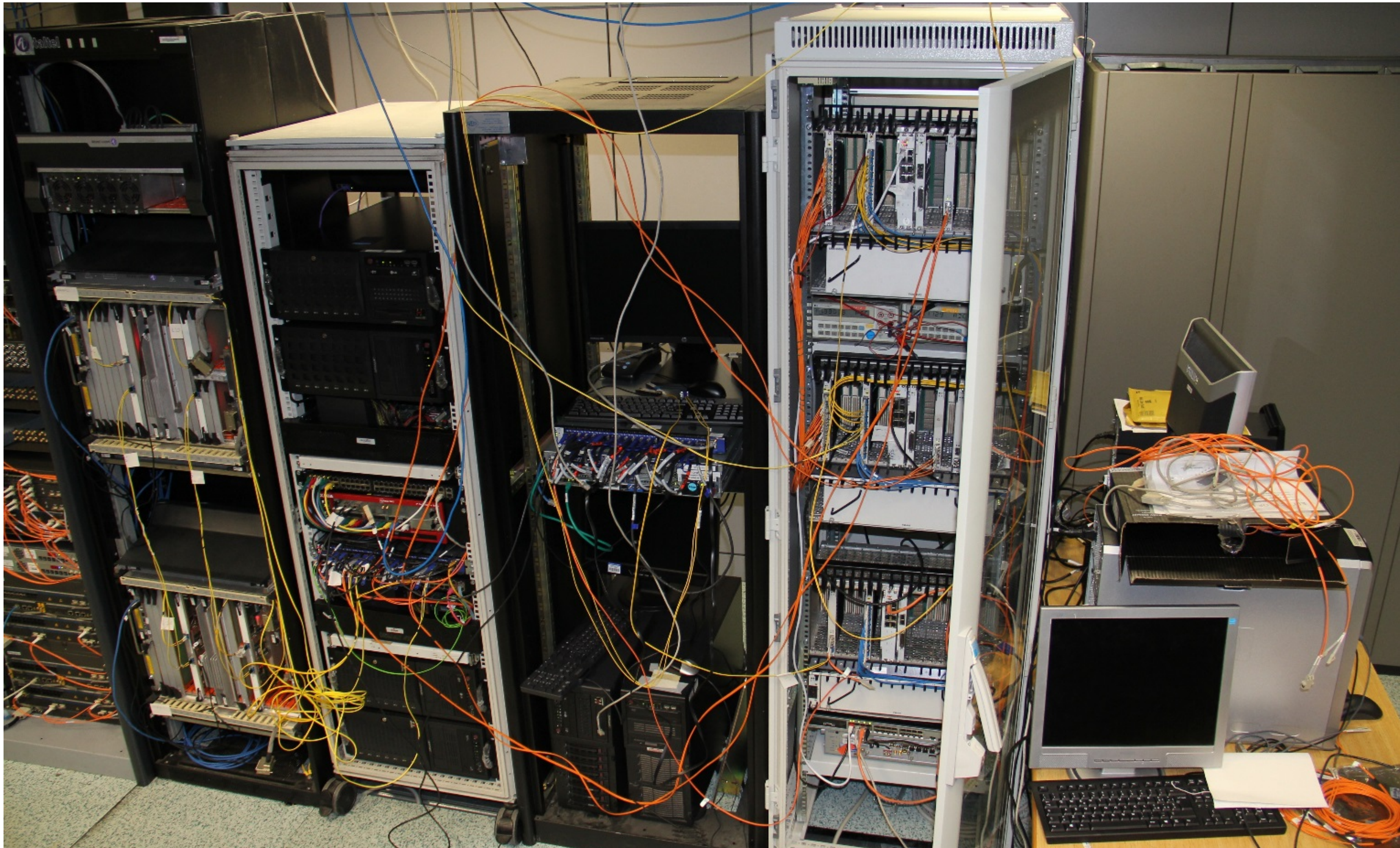


Our vision

- To extend network devices and architectures to directly integrate multiple and heterogeneous applications, functions and services.
- Classical or innovative network services/ functions are just software objects dynamically allocated (e.g., by OpenFlow) to general purpose or specialized hardware resources.
- The modularity and flexibility of this approach, among others, open the possibility of driving software object allocation by means of very effective energy efficient polices.

Conclusions

- The energy consumption in Networks (and more in general in ICT) is currently still a very relevant issue
- Trend based on both recent technologies and especially new innovation challenges (virtualization and performance) are moving the motivations from environmental impact and cost reduction to sustainability/scalability
- Smart power management should be able to give affordable solutions, but
  - **Energy efficiency should be a main target of the new technologies, not a "simple" constraint.**
  - **The energy consumption management has to be natively integrated in network control and management systems** like, e.g., performance and fault recovery.
  - The integration process acting in **Network and IT** strongly suggests to manage this issue (or may be everything) with **integrated approaches** (within same unified "tools")
  - **Standard and regulatory actions are essential (including KPI)**



Thanks for Your Kind Attention

Any Questions?