ECO net

Energy COnsumption NETworks

Contribution to Greentouch

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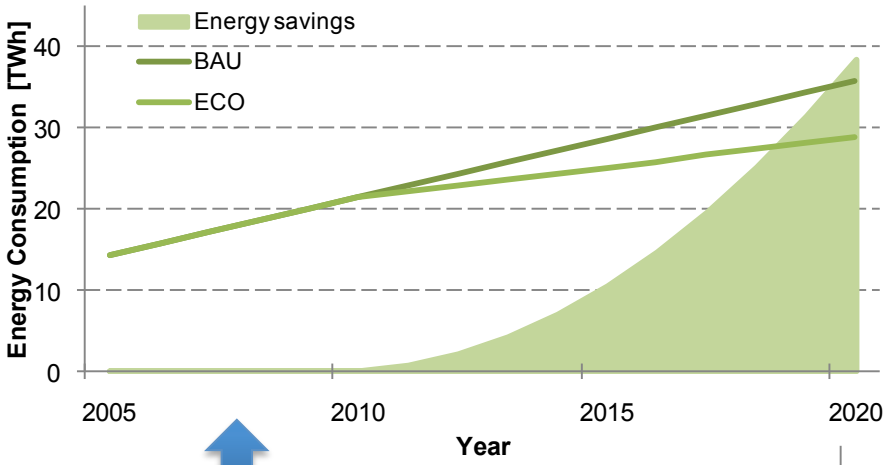
On behalf of the ECONET Consortium

GreenTouch™

FP7-ICT-258454 ECONET

Where did the idea of ECONET stem from? …Potential saving

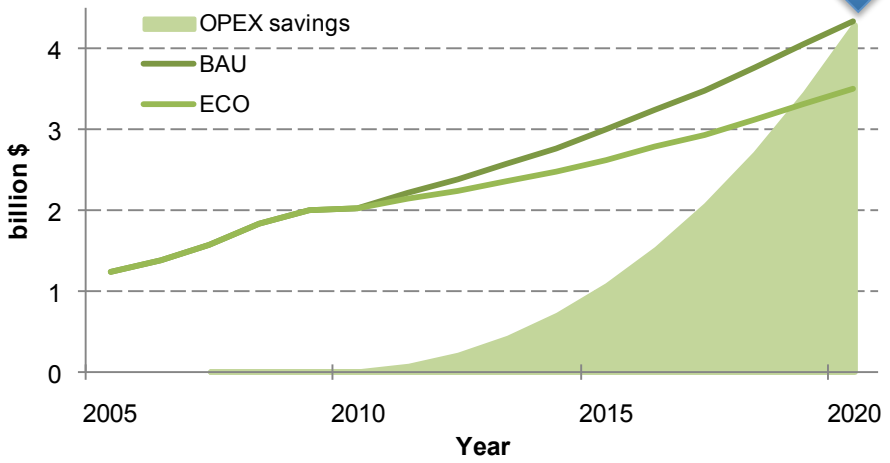


Energy consumption estimation for the European telcos' network infrastructures in the "Business-As-Usual" (BAU) and in the Eco sustainable (ECO) scenarios, and cumulative energy savings between the two scenarios.

Source: European Commission DG INFSO report

OPEX estimation related to energy costs for the European telcos' network infrastructures in the "Business-As-Usual" (BAU) and in the Eco sustainable (ECO) scenarios, and cumulative savings between the two scenarios.

Source: R. Bolla, R. Bruschi, F. Davoli, F. Cucchietti, "Energy Efficiency in the Future Internet: A Survey of Existing Approaches and Trends in Energy-Aware Fixed Network Infrastructures," IEEE Communications Surveys & Tutorials, vol. 13, no. 2, pp. 223-244, 2nd Qr. 2011.



ECO net low Energy COnsumption access/core NETworks

Networks, links and devices are well-known as provisioned for busy or rush hour load, which typically exceeds their average utilization by a wide margin. While this margin is generally filled in rare and short time periods, the overall power consumption in today's networks remains more or less constant with respect to different traffic utilization levels.

Research Objectives

The **ECONET** project aims at reducing the carbon footprint of wired network equipment and infrastructures. To this purpose, ECONET is structured around two main research threads:

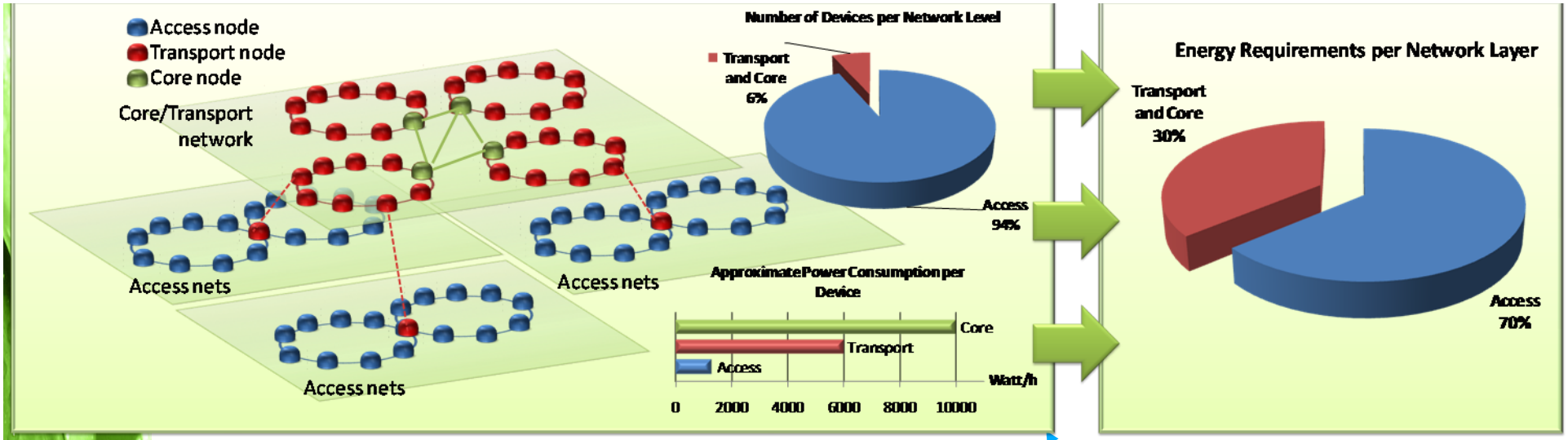
- Development of novel energy-aware device architectures and technologies, able to modulate their power consumption with respect to the actual workload;

- Effective exploitation of such device capabilities by introducing new control frameworks and policies, devoted to optimize the energy/performance profiles both at the local (single device) and the network-wide level.

Participants and Workplan

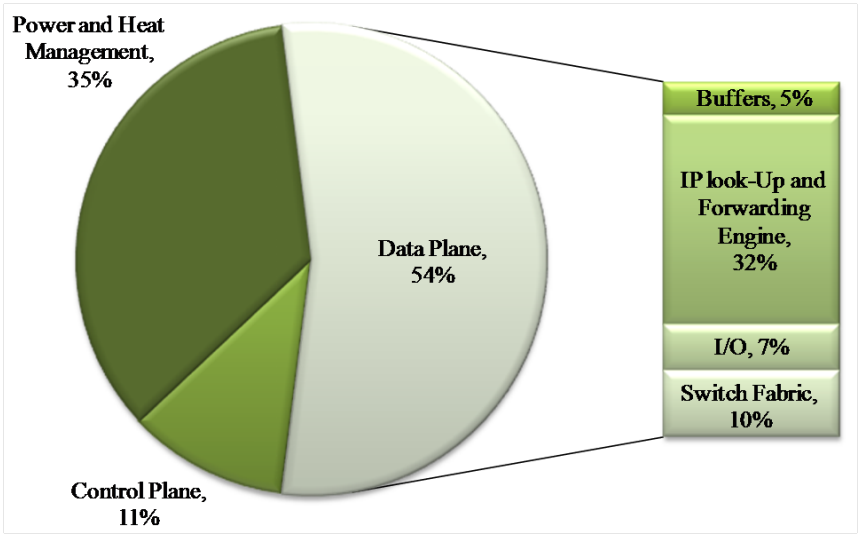
Participant organisation name	Short name	Country
Consorzio Nazionale Interuniversitario per le Telecomunicazioni – DIST-University of Genoa Research Unit (Coordinator)	CNIT	Italy
Mellanox Technologies	MLX	Israel
Alcatel Lucent	ALU	Italy
Lantiq	LQDE	Germany
Ericsson Telecomunicazioni S.p.A.	TEI	Italy
Telecom Italia	TELIT	Italy
Greek Research & Technology Network	GRNET	Greece
Research and Academic Computer Network	NASK	Poland
Dublin City University	DCU	Ireland
VTT Technical Research Centre	VTT	Finland
Warsaw University of Technology	WUT	Poland
NetVisor	NVR	Hungary
Ethernity	ETY	Israel
LightComm	LGT	Italy
InfoCom	INFO	Italy
Portland State University	PSU	USA
University of South Florida	USF	USA

Work package	Work package title	Type of activity	Leader
WP0	Project management	MGT	CNIT
WP1	User Requirements and Manufacturing Specifications	RTD	GRNET
WP2	Green Technologies for Network Device Data Plane	RTD	LQDE
WP3	Green Abstraction Layer	RTD	CNIT
WP4	Green Strategies at the Control Plane	RTD	ALU
WP5	Integration, experiments and performance evaluation	DEM	MLX
WP6	Dissemination, training and standardisation	RTD	TELIT



SOURCE: FP7 ECONET

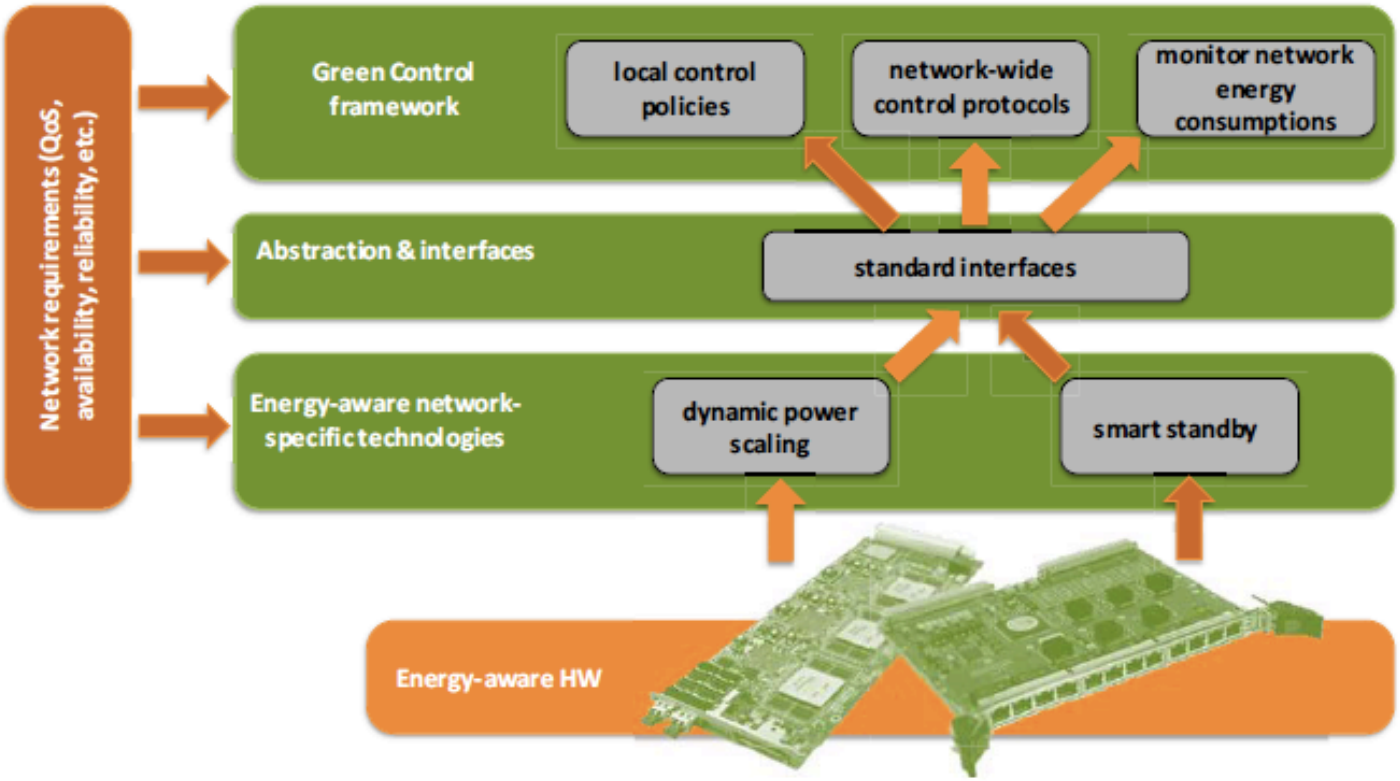
Examples of device density, relative power requirements and overall power consumption per network layer



Example of energy requirements of components of multi-chassis routers

The main challenge is to design, develop and test novel technologies, integrated control criteria and mechanisms for network equipment enabling energy saving, by **dynamically adapting network capacities and resources to current traffic loads and user requirements, while ensuring end-to-end Quality of Service.**

The ECONET vision and its main research threads



The ECONET project will address such challenge, by focusing its research and development efforts along three main research axes, namely:

- Green Technologies for Network Device Data Plane
- Green Strategies at the Control Plane
- Green Abstraction Layer concept.

The project approach
Green control framework

Autonomic and short-term on-line optimizations →

Routing & Traffic Engineering

Given:
- The traffic matrix
- Service requirements
- The energy-aware capabilities of network nodes and links

Dinamically move the traffic flows among network nodes in order to minimize the overall network consumption

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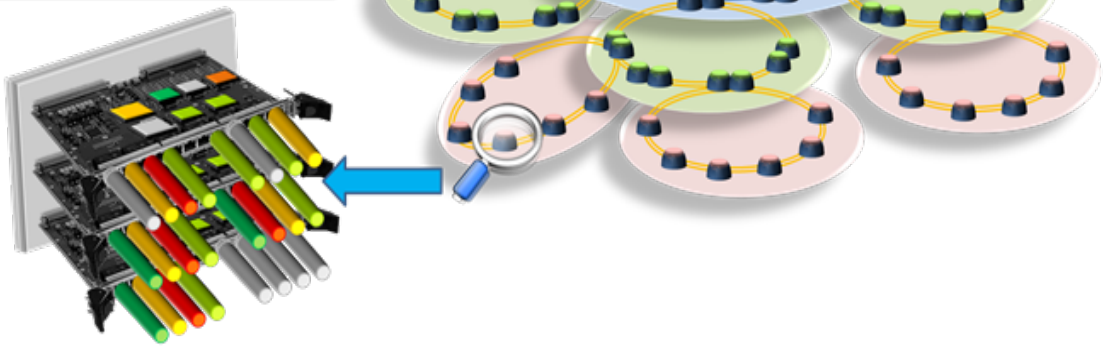
Local Optimization Policies

Given:
- the actual traffic workload from input links
- Local service requirements

dinamically find the best energy-aware configuration



Operator-driven long-term off-line optimizations

↓

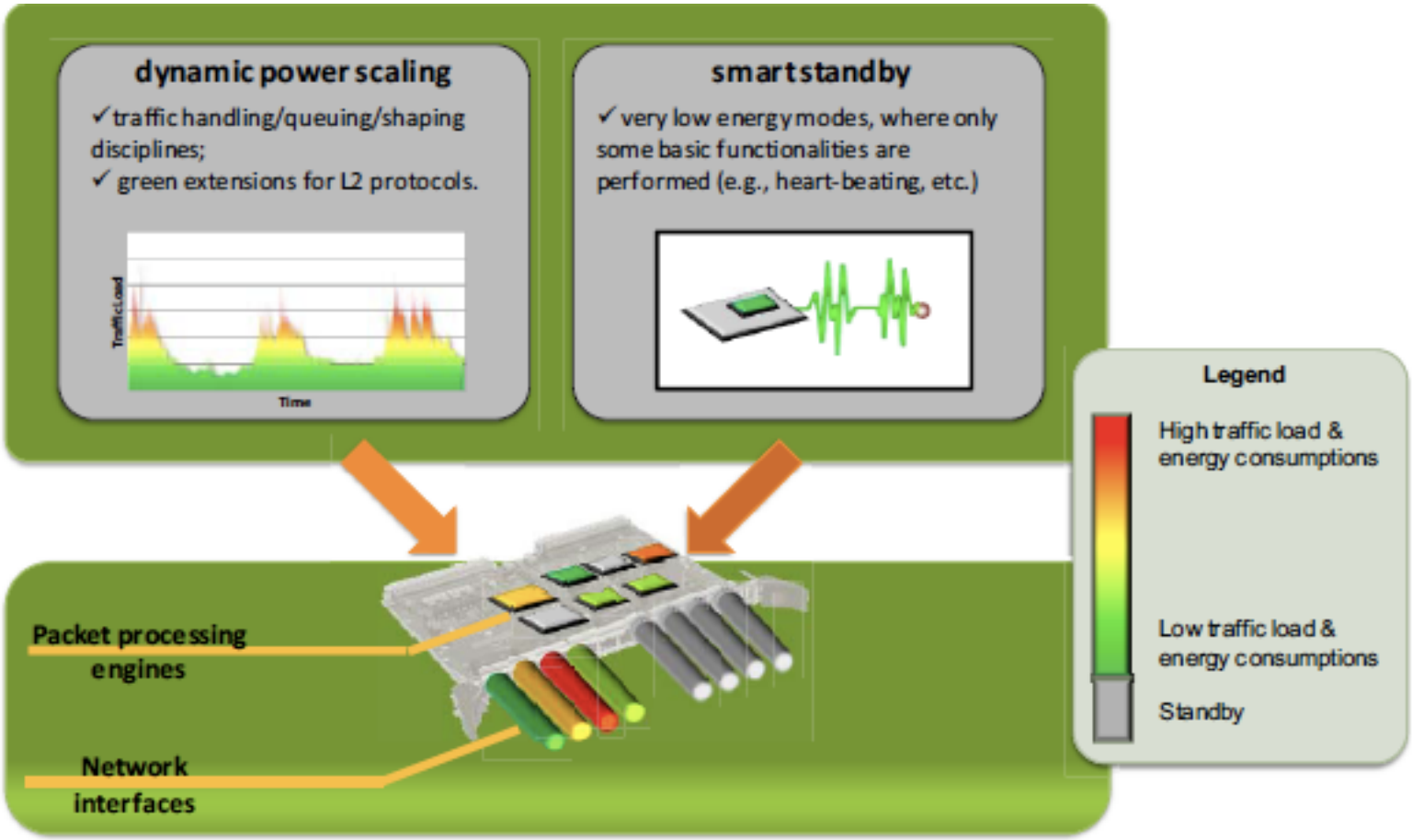
Network-wide Monitoring

Given the history of measurements regarding:
- network performance
- energy consumption

The operator can explicitly plan and/or reconfigure the settings of:
- single device
-Traffic engineering and routing.

The Network Operations Center (NOC)

The project approach
Energy aware specific technologies

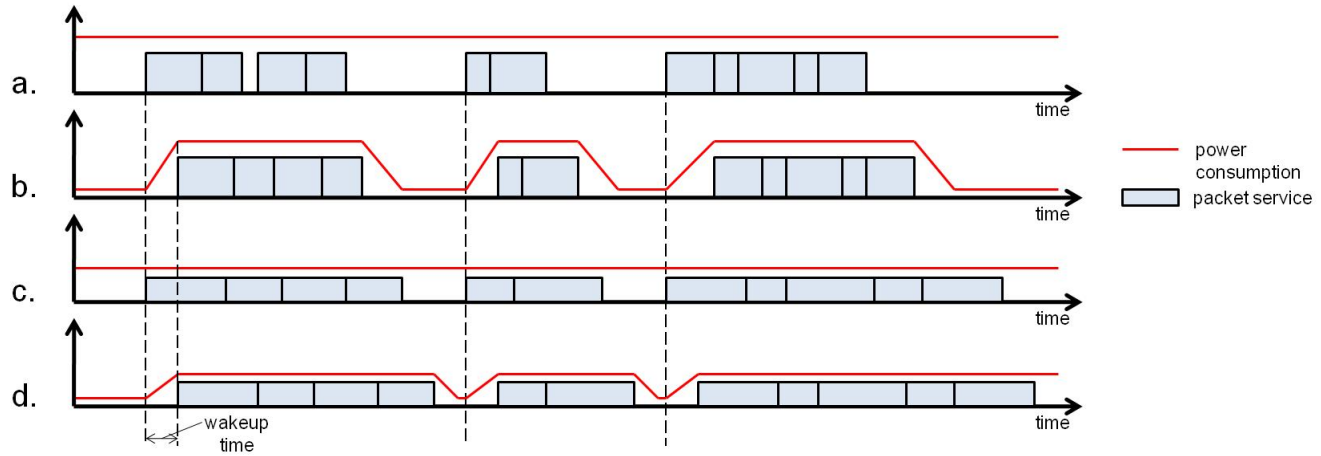


Dynamic adaptation

Dynamic adaptation approaches are aimed at modulating capacities of network device resources (e.g., link bandwidths, computational capacities of packet processing engines, etc.) according to current traffic loads and service requirements.

Power management capabilities

- power scaling (clock freq tuning)
- idle logic, sleep mode



(a) no power-aware optimizations,(b) only idle logic, (c) only performance scaling, (d) performance scaling and idle logic

Green Technologies for Network Device Data Plane

Dynamic adaptation (Multiple areas of interventions)

ASIC level (Processors)

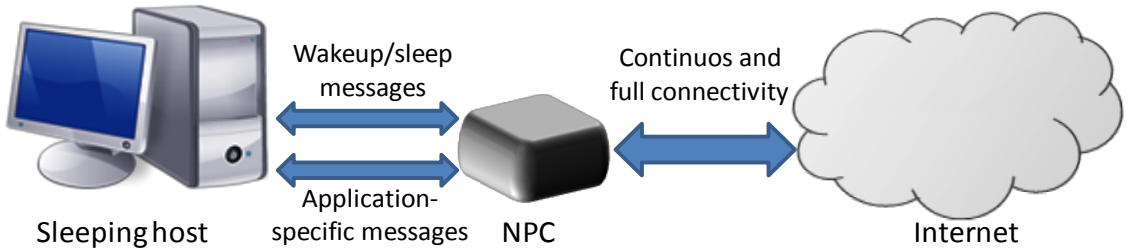
- Voltage and power scaling for Processing units, Memory units
  Logical units
- Dynamic FPGA code swap

Link layer

- Width/ Speed Reduction based on actual traffic load
  (reduce power consumption of processors)
- Network management to aggregate links

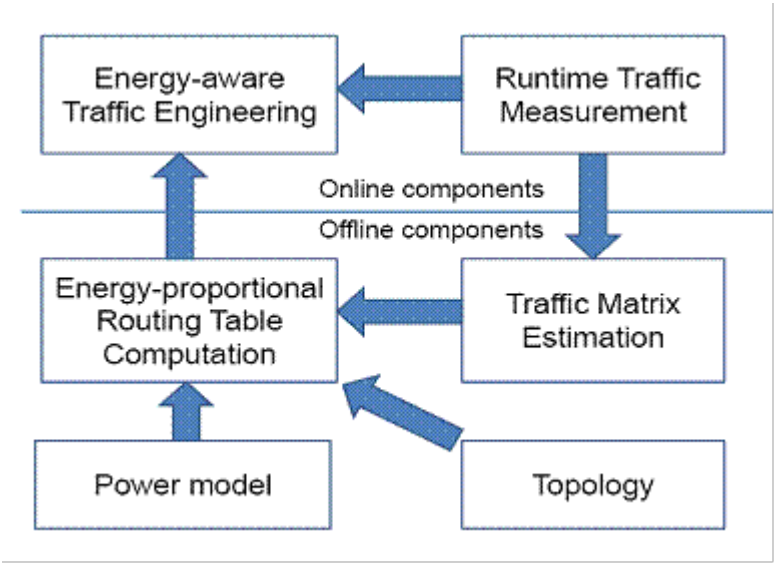
System level (switch, router, NIC)

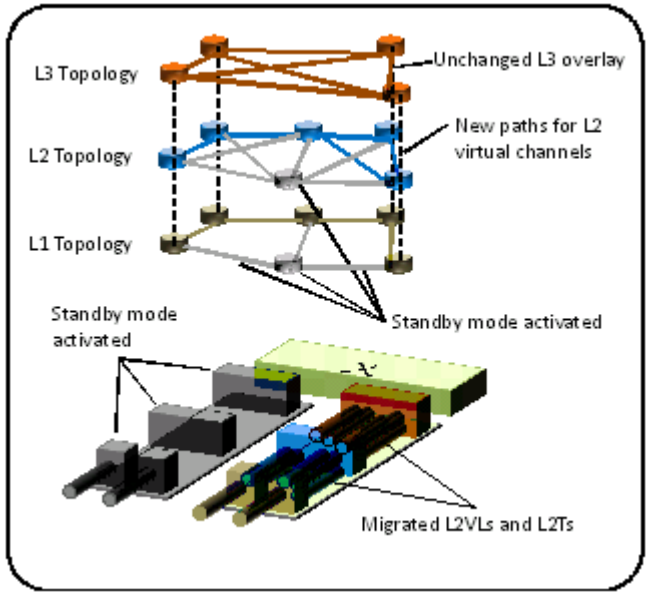
- Wake On LAN (network interfaces Cards active w/o systems)
- Port Shutdown on no traffic
- Module Shutdown, smart routing mechanism to shut down an entire network module.
- Full System Standby
- Smart cooling systems



Future energy-aware mechanisms on the control plane

- **Energy aware Traffic engineering - GreenTE**





To dynamically adapt the power consumption of a network by selecting the minimal subset of network elements which satisfies the current traffic demand.

Viable approach to introduce standby primitives into next generation devices.
To exploit two features: network resource virtualization, and modular architecture of nodes

- **Energy Efficient Ethernet – IEEE 802.3az**

This protocol reduces the power consumption of network processors during low traffic.
Standard Power scaling mechanism that allows speed reduction while maintaining fast recovery time.

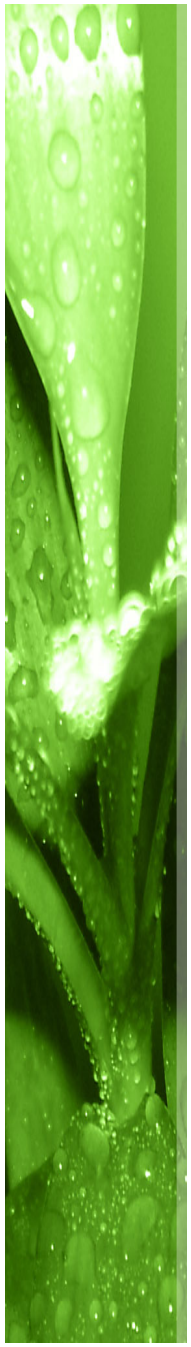
Future energy-aware Optical Networks

Power consumption varies significantly across the different layers of the transport network with exponential increase in IP traffic.

It would be advantageous for operators to remain at lower layers to keep their energy bills under control.

The most eco-efficient architecture is a multilayer one that can automatically direct traffic to the lowest level of switching required according to service requirements (the proposed approach when implementing transport solutions).

Future energy-aware technologies to be deployed are:
1. T-ROADM and OTN
2. Intelligent Network Control Plane
3. Incorporating new technologies for devices (ECONET Device level)
4. Innovative photonic OAM features (e.g., Zero-Touch Photonics)
5. Power Scaling



Future energy-aware Optical Networks

1. T-ROADM and OTN

Multiple IP-traffic grooming options at the wavelength, port and sub-port-levels. Elastic network. GMPLS to the photonic layer, leveraging its resilience features and capacity for resource optimization.

2. Intelligent Network Control Plane

An ASON/GMPLS optical control plane simplifies network operations with the goal of creating a 'self-running' network in which 'the network is the database'. With ASON/ GMPLS, the network has the intelligence to choose the most power-efficient layer for transport. With GMPLS provisioning and restoration capabilities at the photonic level, operators can improve their SLA (service level agreement) performance and the quality of their wavelength services.

3. Incorporating new component technologies (ECONET Device level)

Lower power cooling fan units, Power-efficient DC/DC converters and chips, Lower power optical components, Dynamic power and thermal management technologies

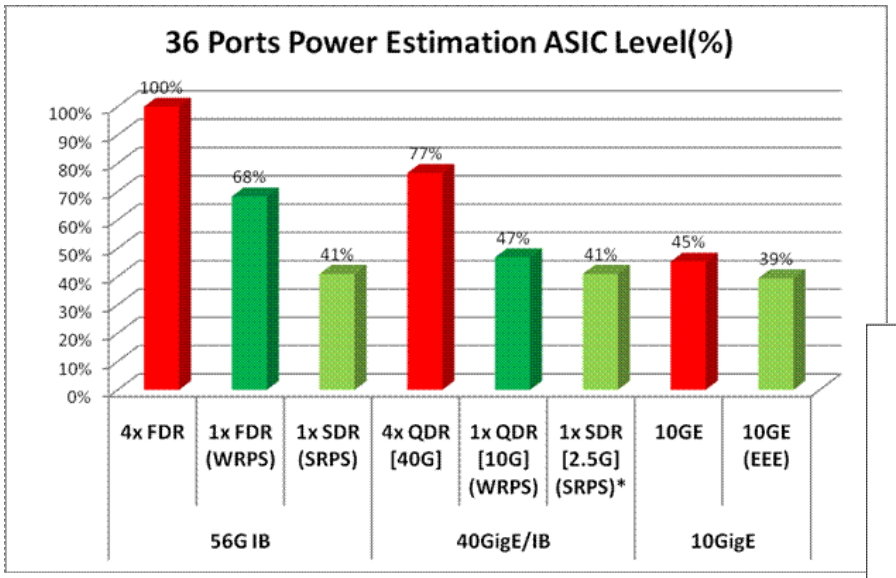
4. Innovative photonic OAM features (e.g. Zero-Touch Photonics)

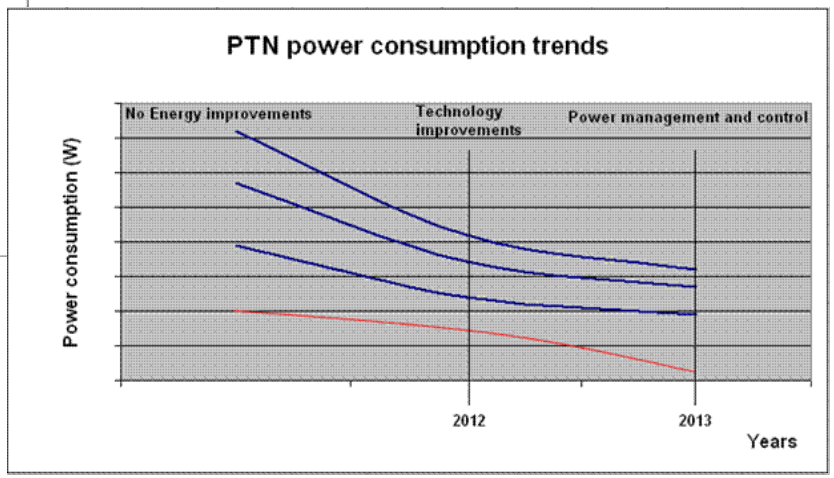
The Zero Touch Photonics (ZTP) is a new concept. It consists of OAM features for complete networking capabilities at the photonic layer without requiring on-site intervention. New Green OSS features shall be introduced to cope with new green features of the optical network.

5.Power Scaling

Current OTN is migrating from 2.5 to 10 Gb/s. 40 Gb/s to 100 Gb/s per-channel data rates have been accepted by standards bodies for the next-generation Ethernet. Further evolution to 400 and 1000 Gbit/s is also expected next.

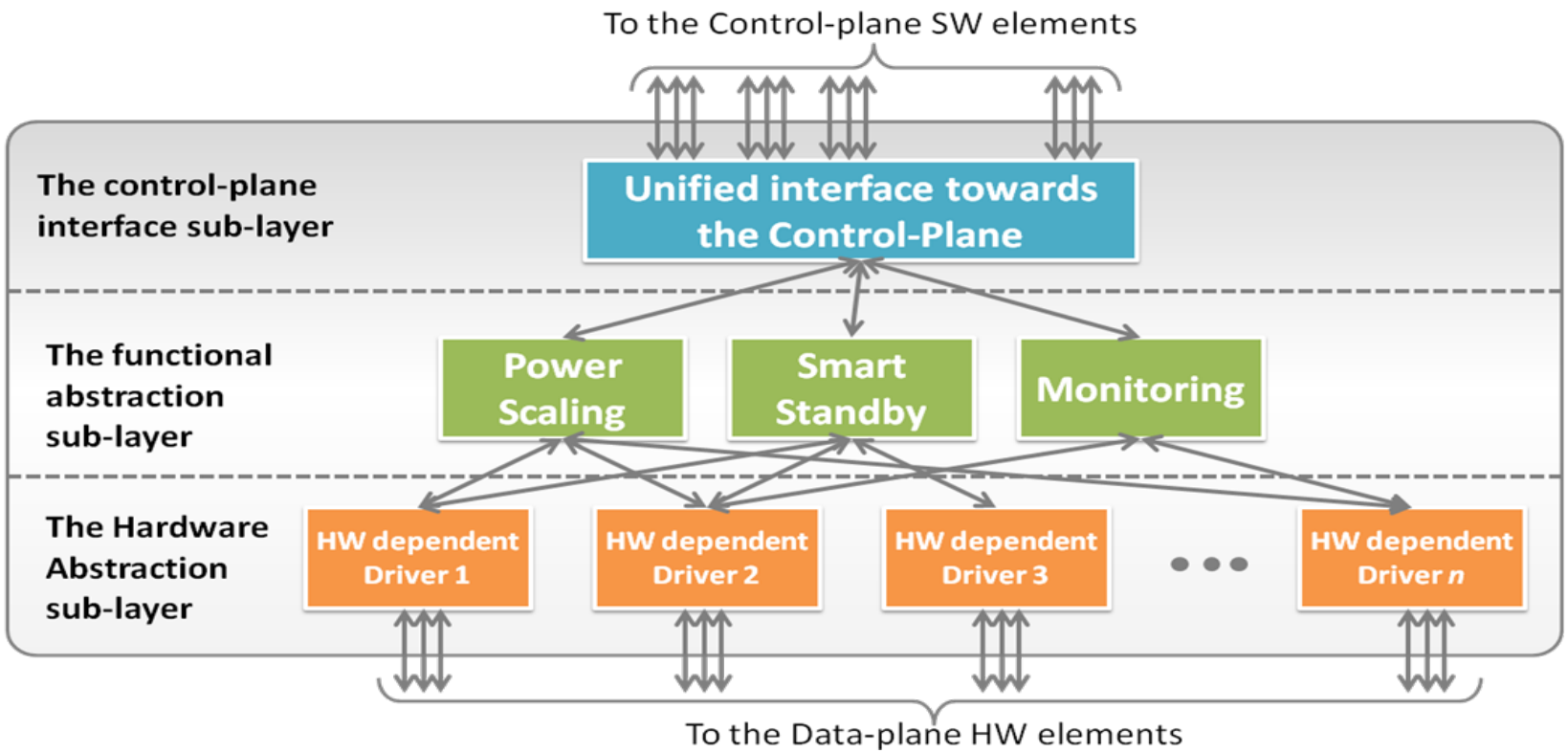
By applying smart adaptation of power consumption of each port to the actual traffic it serves, we can accomplish power reduction up to 50% of the maximum power consumed by today switching systems. In the figure below we can assess the power benefit of applying width/speed reduction techniques.





The project approach

Green Abstraction Layer



Closing the Standardization Gap

Project Level - EC FP7 SO1.1 ECONET

ECONET Rationale

- To investigate, develop and test new capabilities for the Future Internet devices that can enable the efficient management of power consumption so to strongly reduce the current network energy waste.
- Re-thinking and re-designing wired network equipment and infrastructures towards more energy-sustainable and eco-friendly technologies and perspectives.
- Green Strategies at the Control Plane and Green Abstraction Layer

ECONET and Standardisation

What?

- extending the low power mode concept to the "active standby" one and to propose extensions towards power scaling and other link protocols for broadband access.
- energy-aware extensions and new scope for network-wide control protocols (i.e. routing and traffic engineering)

Why?

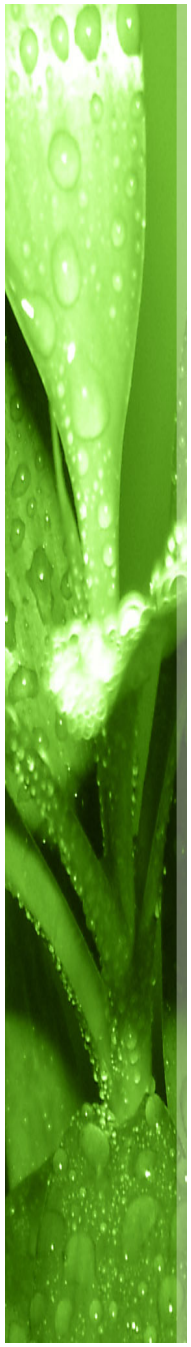
- there are no specific standardization activities allowing to suitably coordinating the energy savings and performance profiles of each network node.

Where?

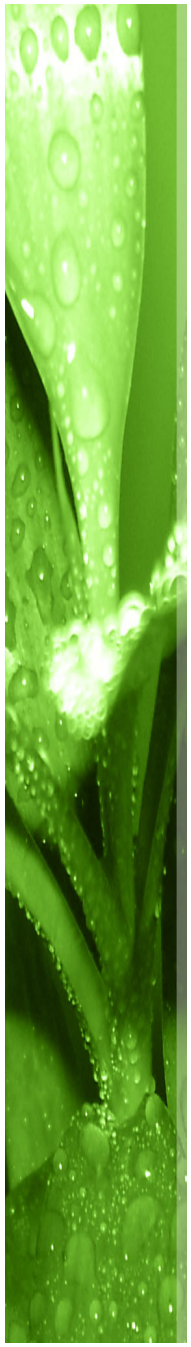
- ETSI ATTM (Global KPIs), ETNO/HGI
- ETSI EE and ATIS for measurement techniques
- IETF (as LMP), ITU SG15, EMAN

ECONET Contributions

ECONET result	Planned steps for introducing new technologies
Data Plane Capabilities	Strengthen the modular design of commercial network devices. Update the ECONET prototypes with the guidelines of novel green standards. Introduce new packet processing engines and link interfaces to commercial platforms.
Green Abstraction Layer	Transform the Green Abstraction Layer into a widely adopted standard. Deliver the ECONET SW implementing the abstraction layer to the specific commercial platforms of partners.
Control Plane Strategies	Integrate the SW produced by ECONET with the control frameworks used in commercial platforms.
Energy-aware OAM frameworks	Integrate the HW/SW produced by ECONET with the OAM frameworks used in commercial platforms.



Questions to address to the ECONET Project?



Thank you