Energy-awareness in Fixed Network Infrastructures
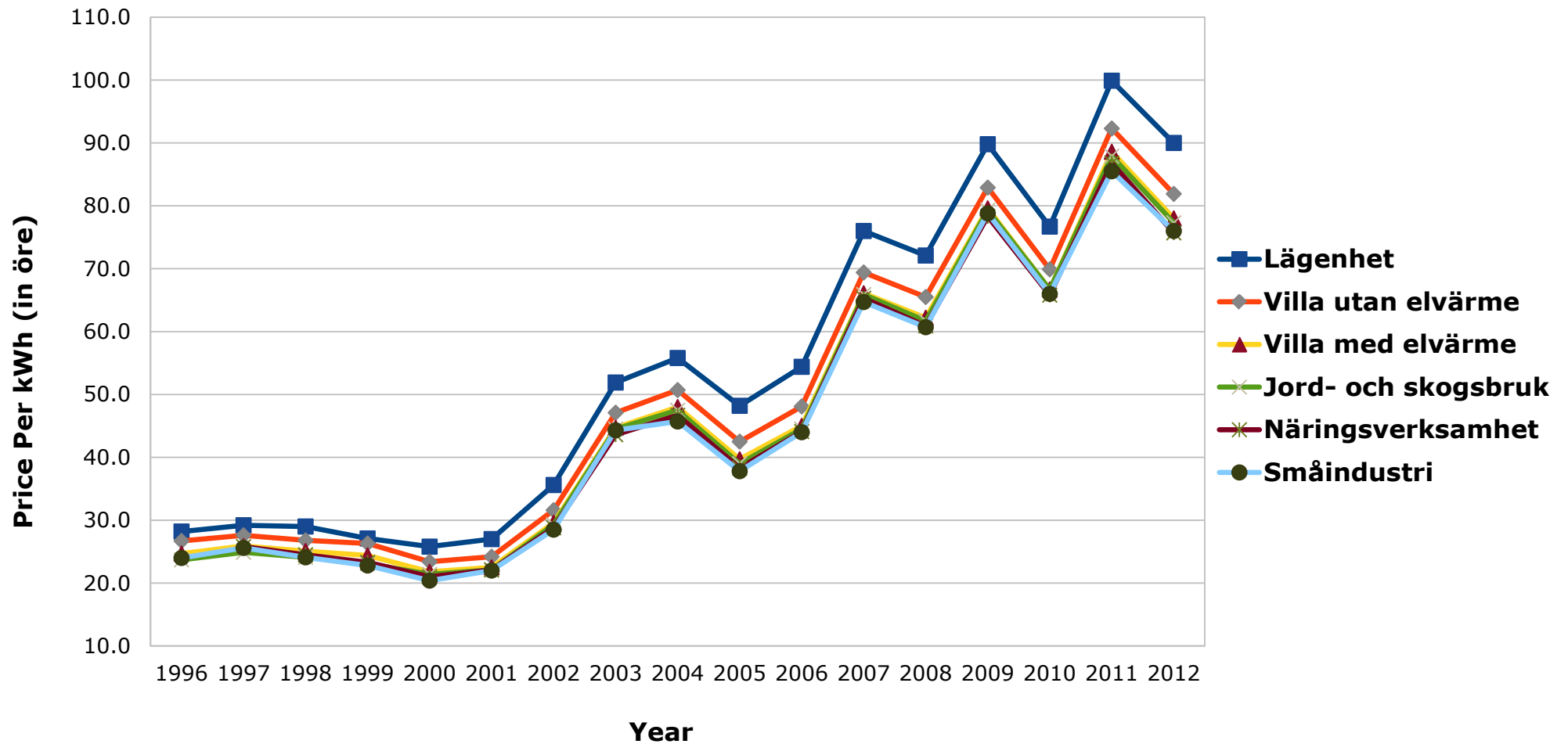
Voravit Tanyingyong

Why do we want to save energy?

Economic Incentives

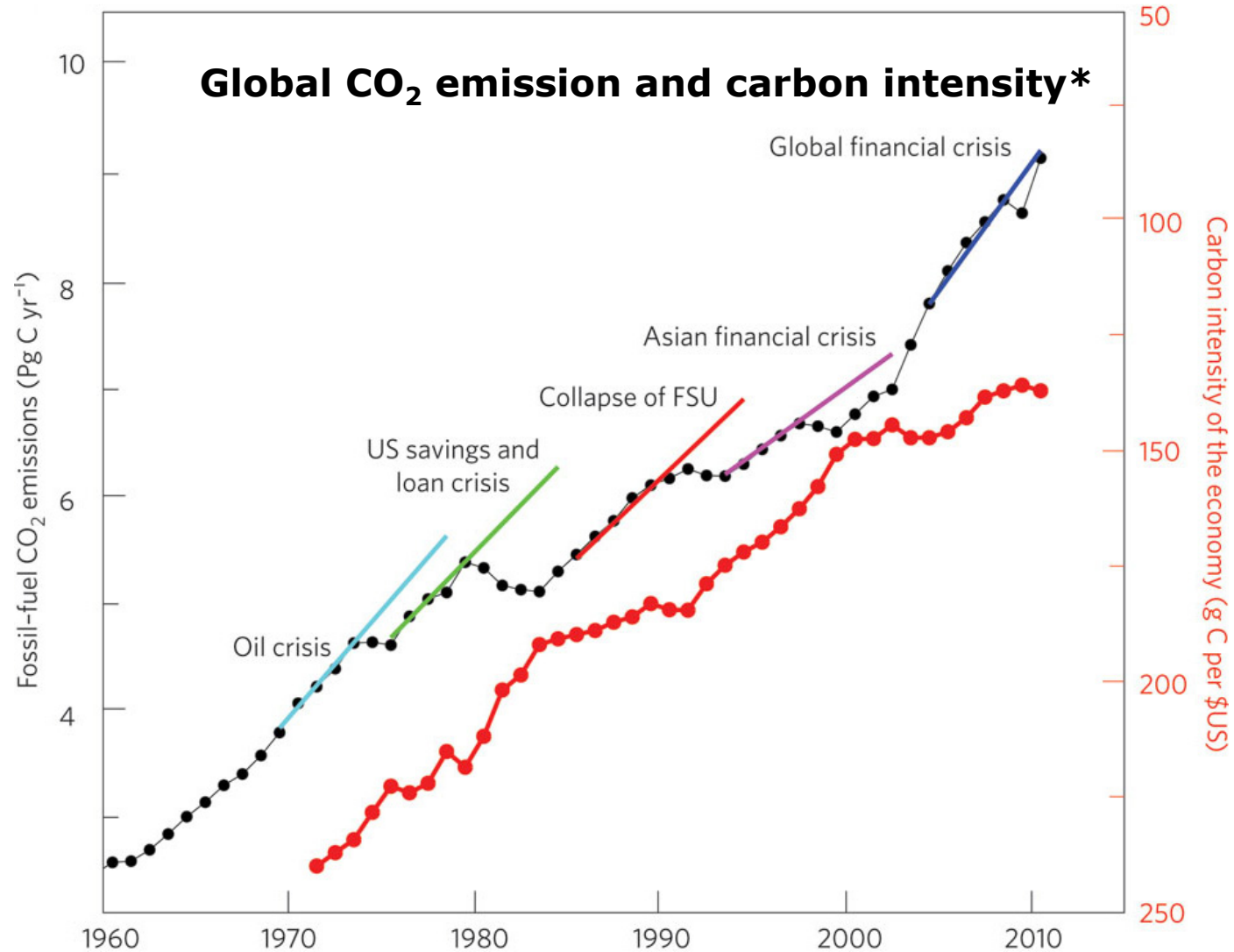**Average Electricity Price on January 1st***

Legend:
- Lägenhet
- Villa utan elvärme
- Villa med elvärme
- Jord- och skogsbruk
- Näringsverksamhet
- Småindustri

Y-axis: Price Per kWh (in öre)

X-axis: Year

*Data from Statistiska centralbyrån

Environmental incentives

Global CO$_2$ emission and carbon intensity*
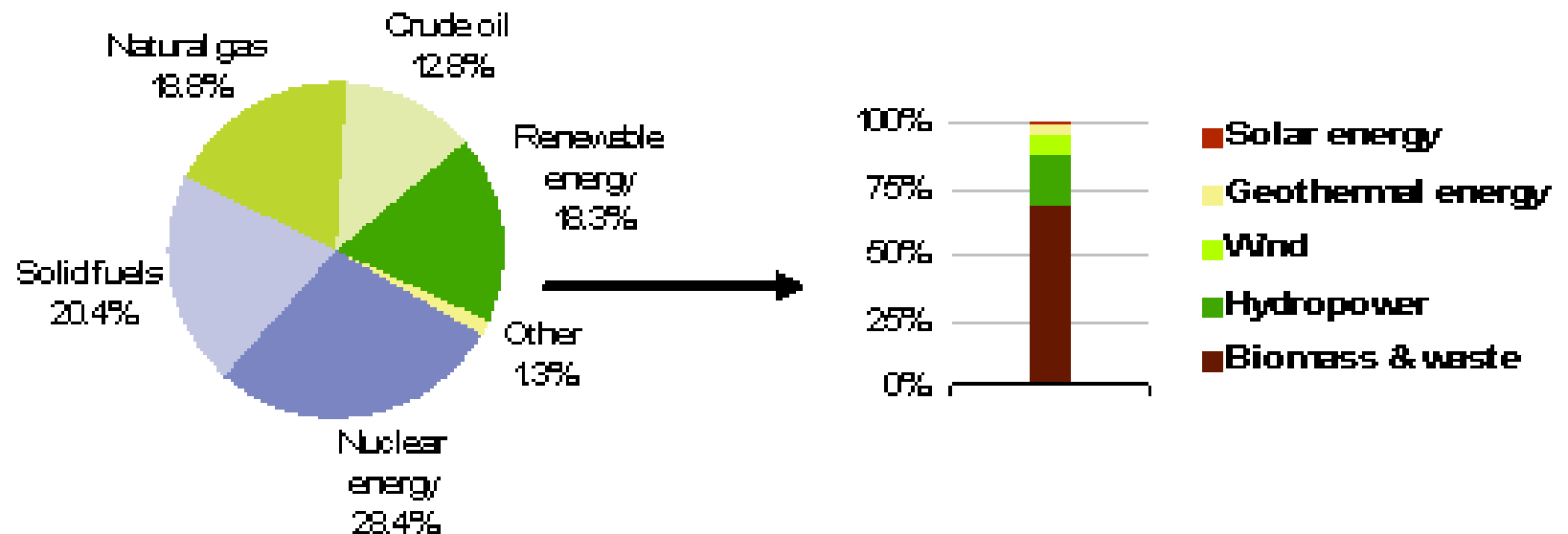
*Figure from Nature Climate Change
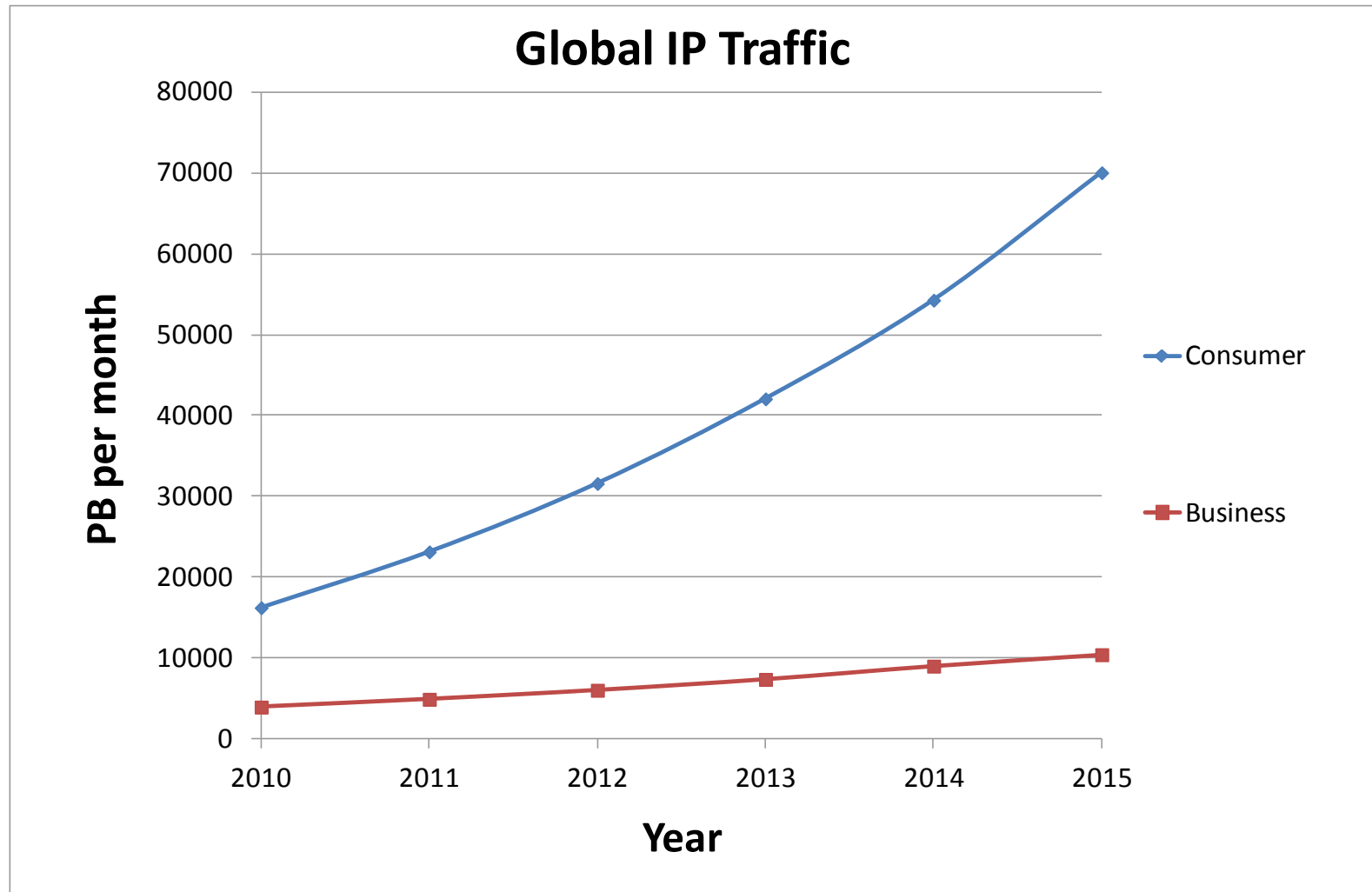
Enforced Legislations

- European Energy Policy (published 10 Jan 2007)
  - 20% cut in CO_2 emission by 2020
  - 20% energy consumption reduction by 2020
  - 20% increased in the proportion of renewable energies in its energy mix by 2020
  - Develop energy technologies
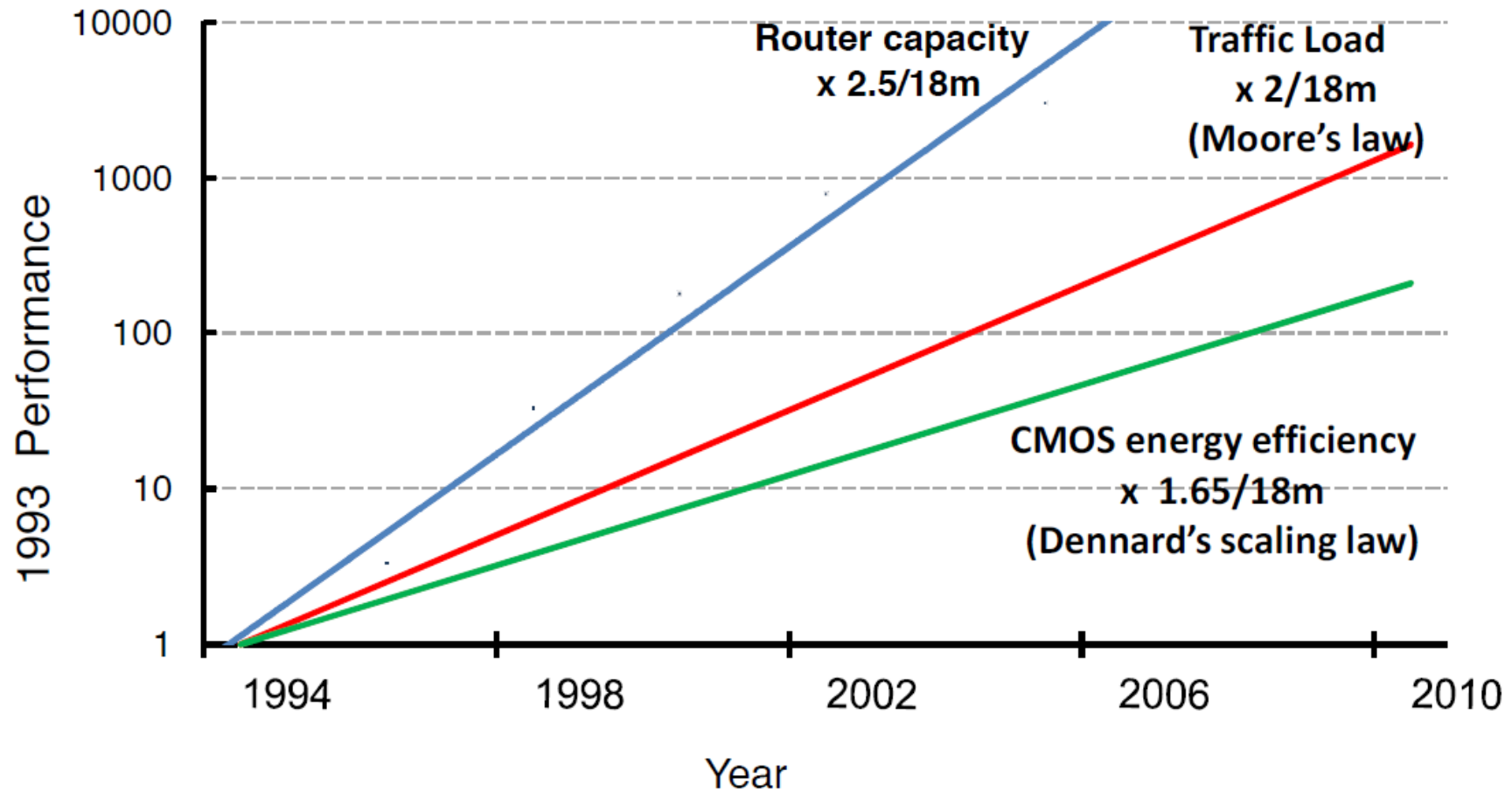
How do we do in the ICT sector?

- GeSI's Smart2020 report (published in 2008)
  - 2% of global carbon emission from ICT*
  - 6% increase per year is expected
- CO_2 emission comparable to aviation industry
- Total electricity consumption
  - 5-10 % in a typical business
  - up to 75% in a business that relies heavily on ICT

* Estimated by Gartner – ICT includes PCs, telecoms networks and devices, printers and data centers

Cisco Forecast 2010-2015*

Global IP Traffic

*source from Cisco Visual Networking Index

Energy Efficiency still lacks behind

Evolution of high-end IP routers's capacity (per rack) vs. Traffic volumns and energy efficiency in silicon technologies*

*Figure from *Energy Efficiency in the Future Internet: A survey of Existing Approaches and Trends in Energy-Aware Fixed Network Infrastructures*
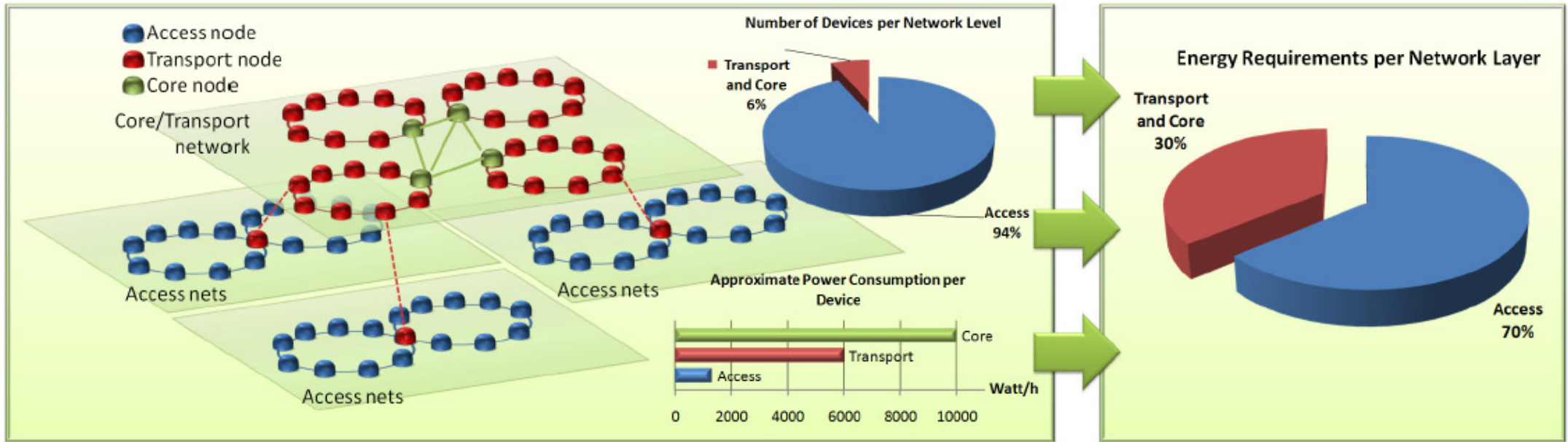
What can we do?

- Handheld devices and wireless networking
  - Energy efficiency is high priority
- End users' infrastructure
  - No big impact on the end user
- Fixed network infrastructure
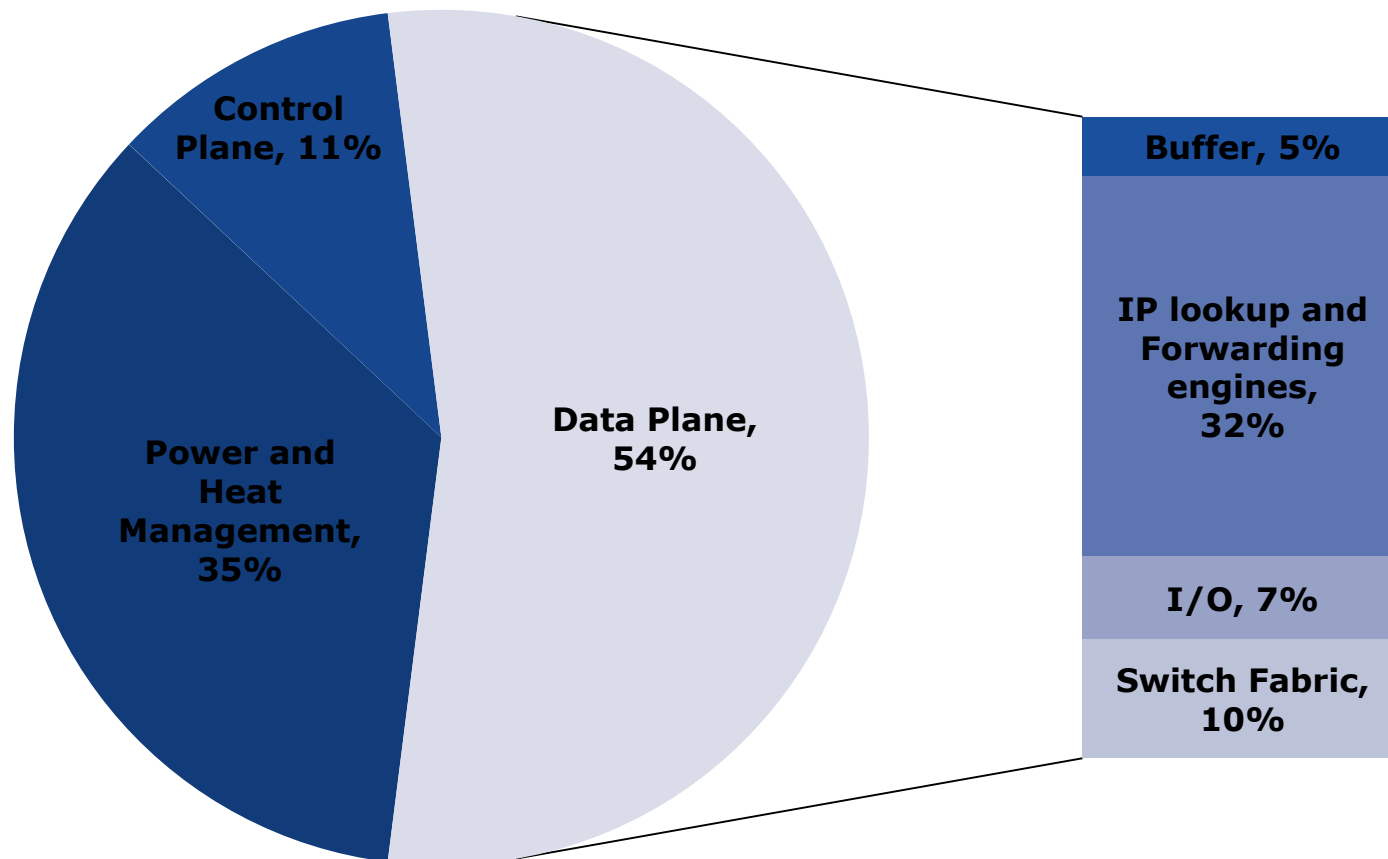 - High performance throughput/capacity
  - Power hungry
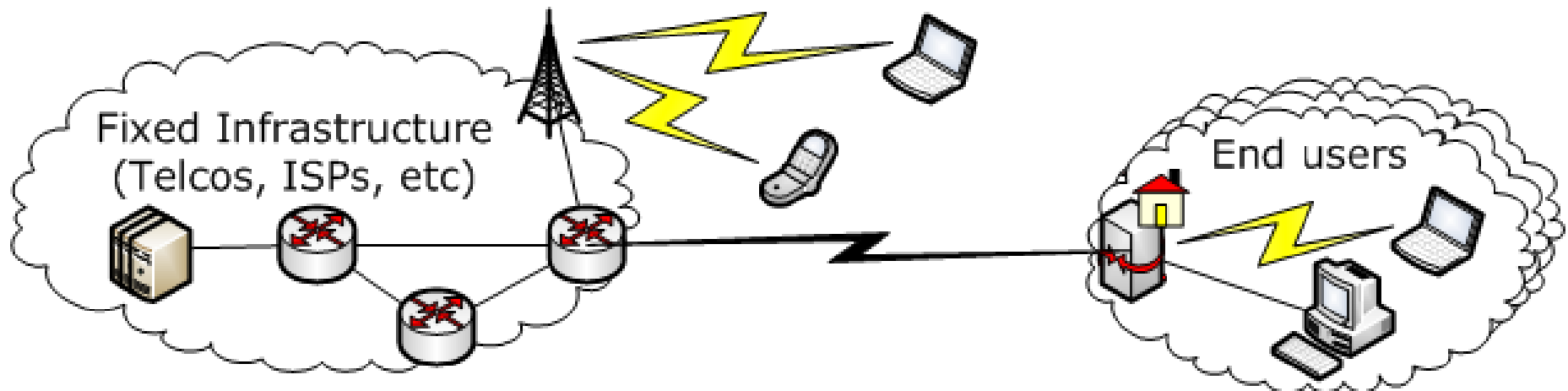
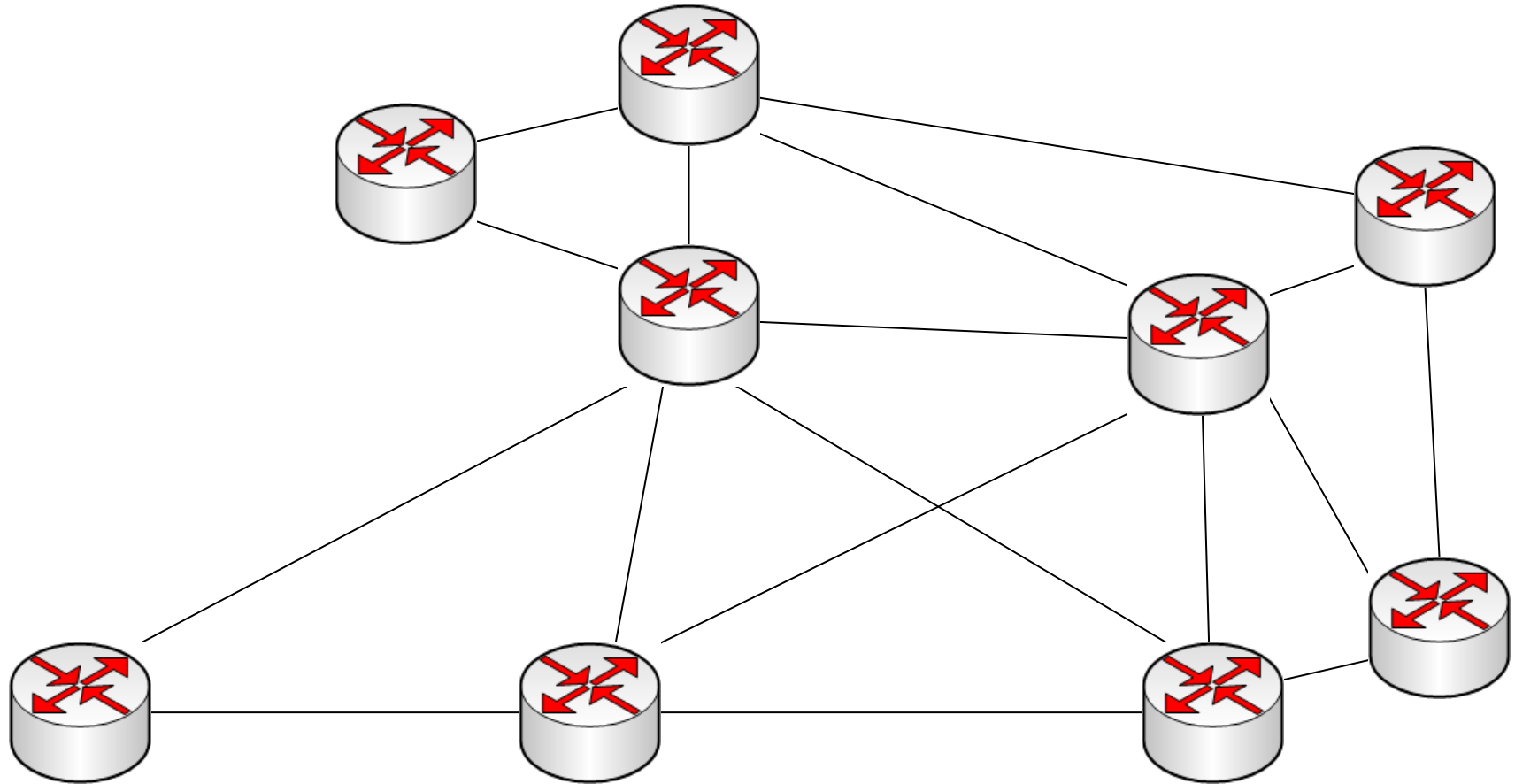# Device density and energy requirements in today's telecom networks*

Estimate of power consumption sources in a generic platform IP router*

Taxonomy of current approaches in Fixed Network Infrastructures
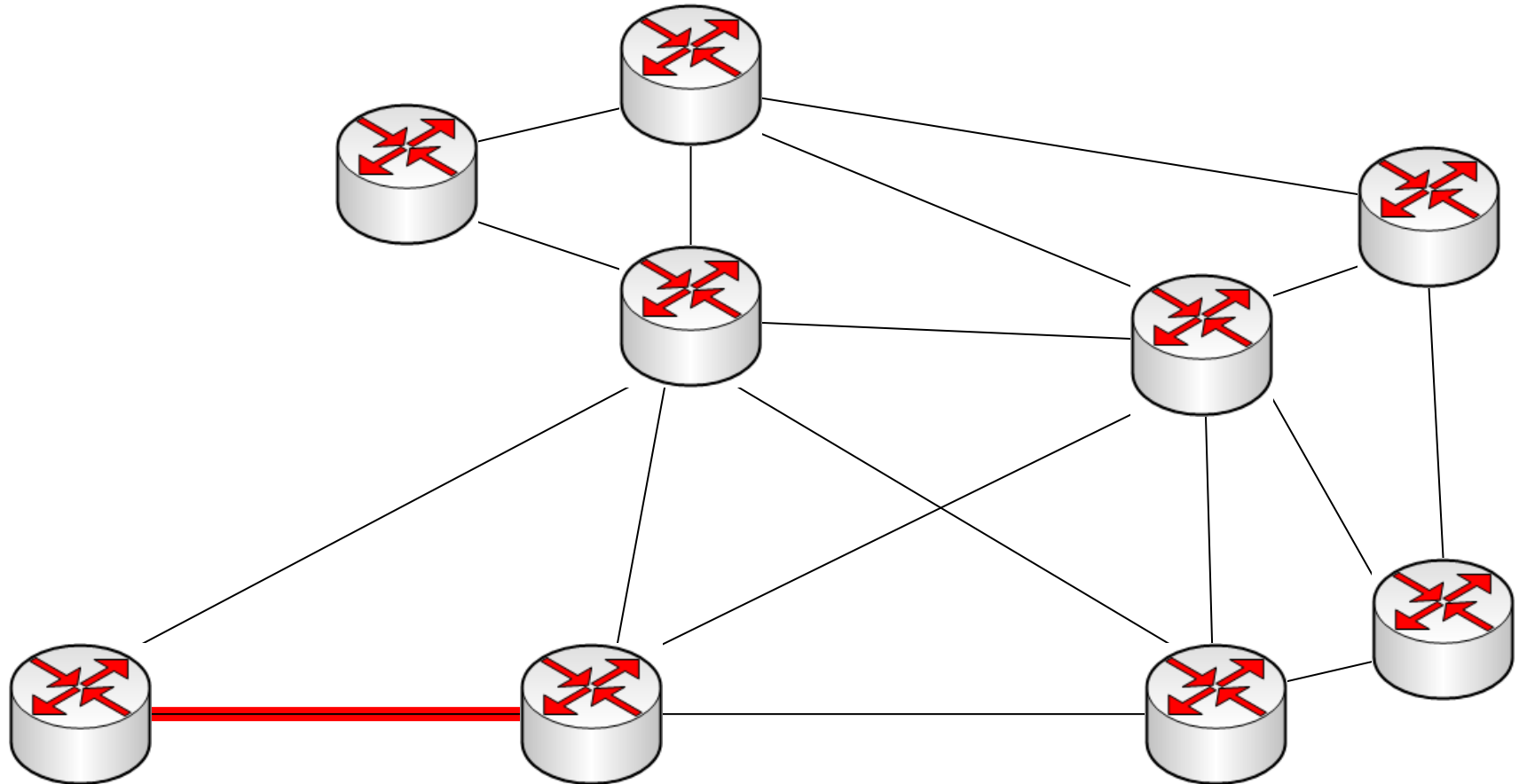
Taxonomy of current approaches in Fixed Network Infrastructures
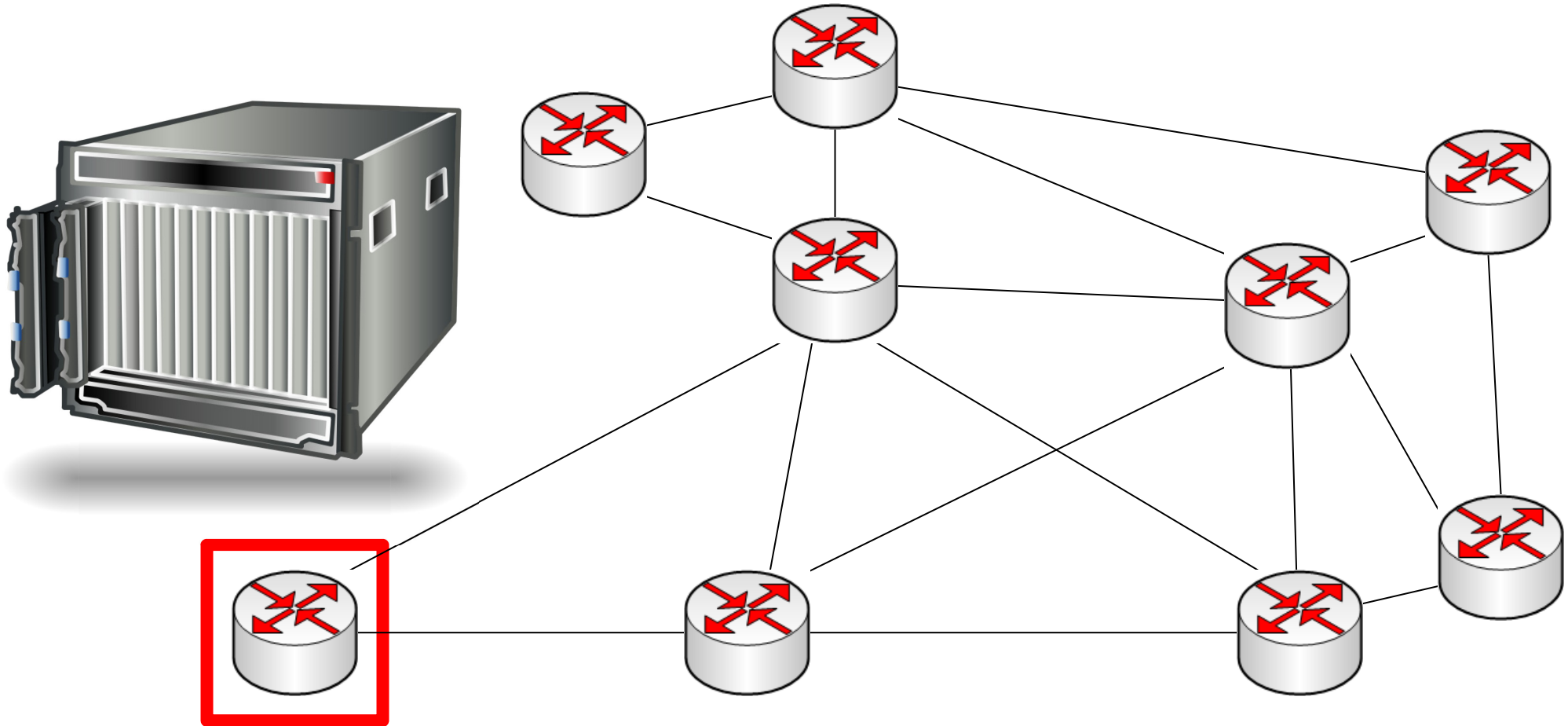
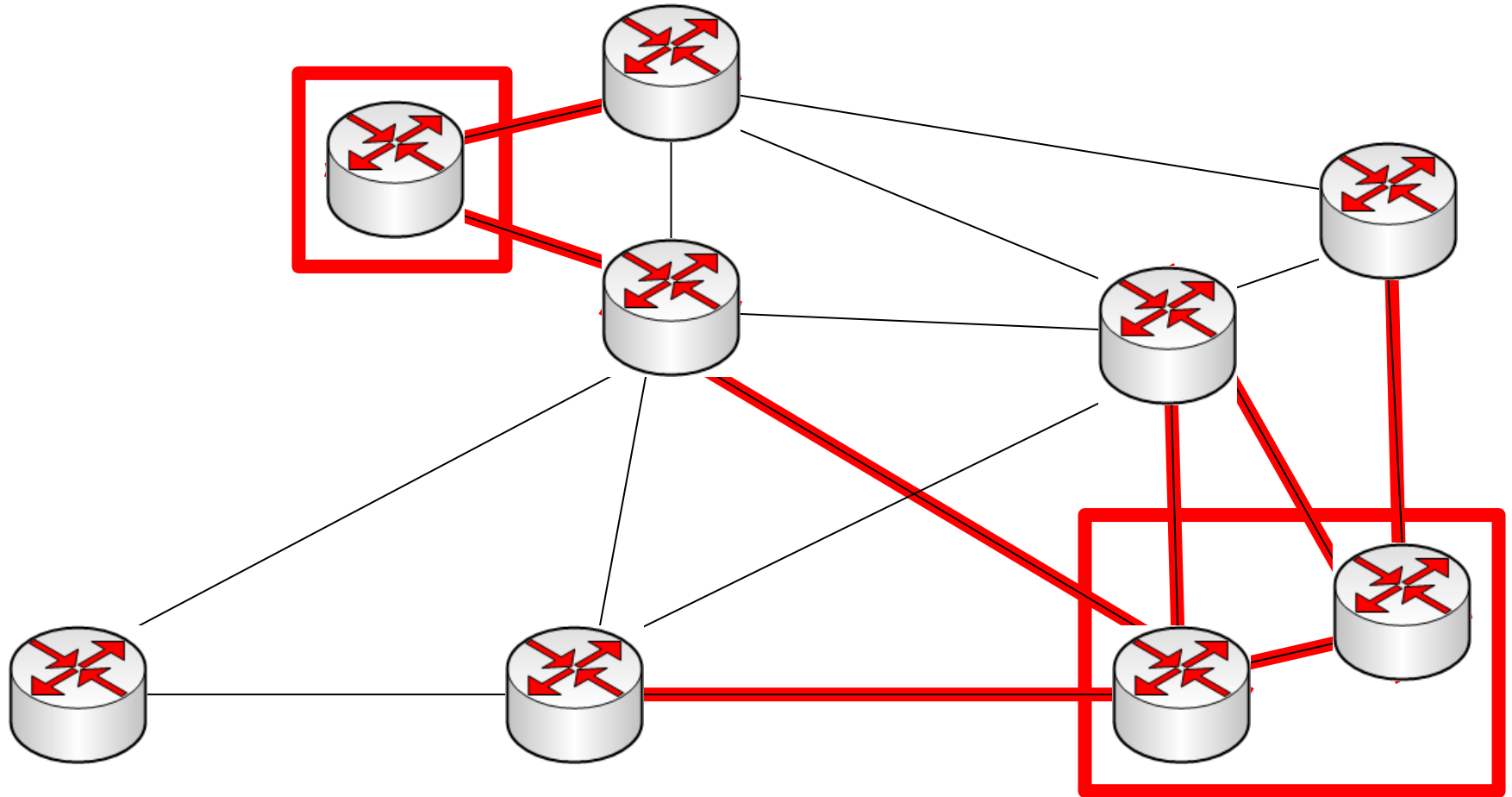# Taxonomy of current approaches in Fixed Network Infrastructures

Taxonomy of current approaches in Fixed Network Infrastructures

Network node

- Energy-Efficient components
  - Power-adjustable components (CPU, Memory, PCIe)
  - New silicons (ASICs, FPGAs)
  - Optical components (fiber modules, optical packet switching)
- Complexity Reduction
  - Reduce/remove functionalities
  - Turn-off unused components
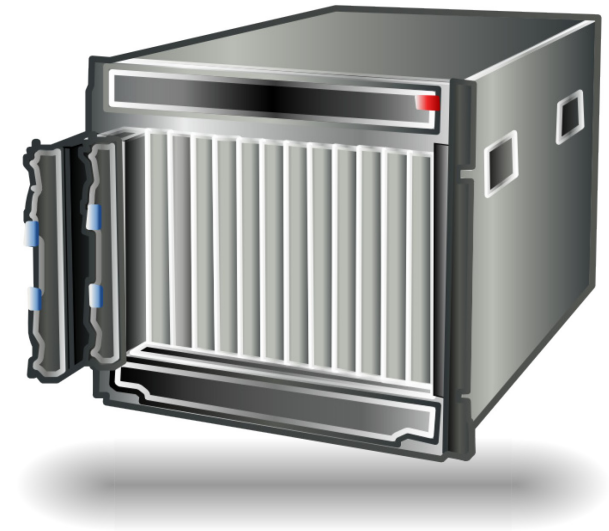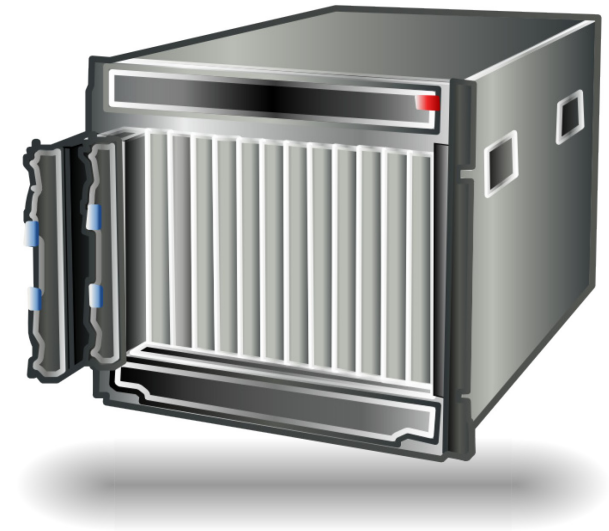
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New network device architectures?

Link between two adjacent nodes

- Dynamic adaptation (according to traffic load)
  - Adaptive Link Rate (ALR)
  - Dynamic voltage scaling (and adjustable frequency)
- Sleep/Standby mode
  - Idle logic (turning off preselected sub-elements)
  - Wake-on-packet
  - Predictive model (with buffer)
  - Service delegation (through a proxy)
    - Smart NICs, Network Connectivity Proxy (NCP)
- New energy-efficient access technologies
  - IEEE 802.3az - Energy-efficient Ethernet (EEE)
  - FTTx, xDSL (ADSL2+, VDSL2), Mobile broadband, etc.

Link between two adjacent nodes (cont'd)
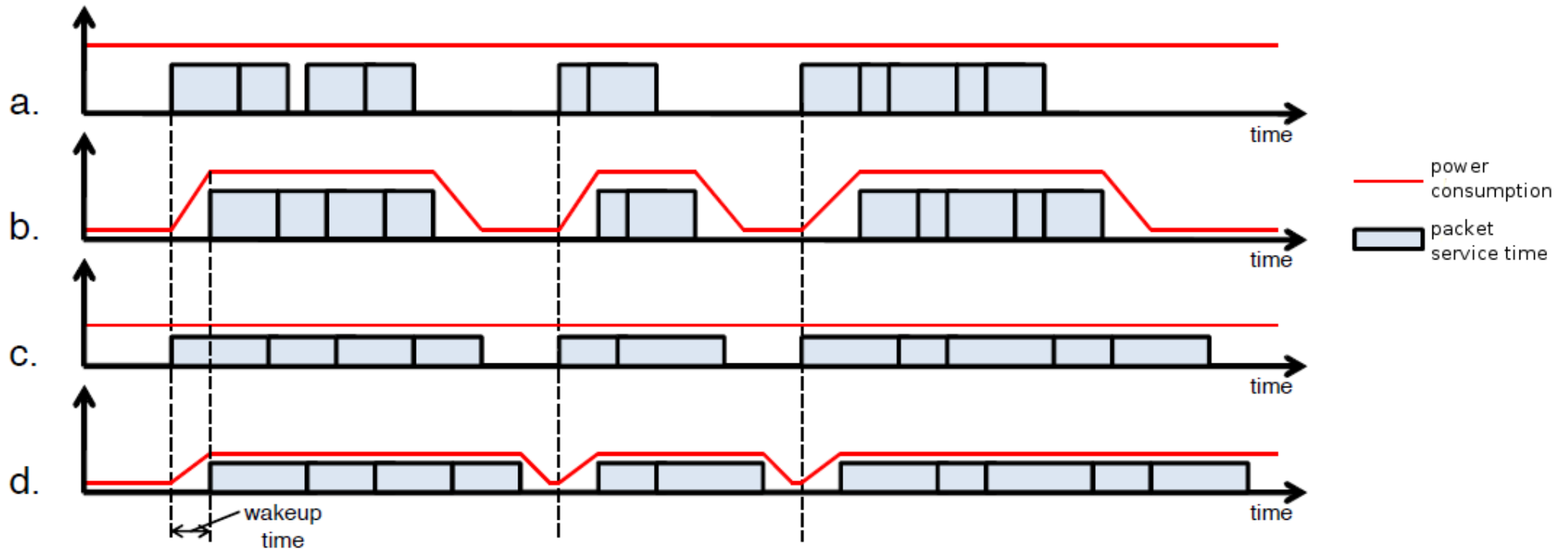
a. No power-aware optimization
b. Sleep/Standy mode (with wake-up delay)
c. Dynamic adaptation (voltage scaling/ALR)
d. Sleep/Standy mode + Dynamic adaptation

*Figure from *Energy Efficiency in the Future Internet: A survey of Existing Approaches and Trends in Energy-Aware Fixed Network Infrastructures*

Link between two adjacent nodes (cont'd)
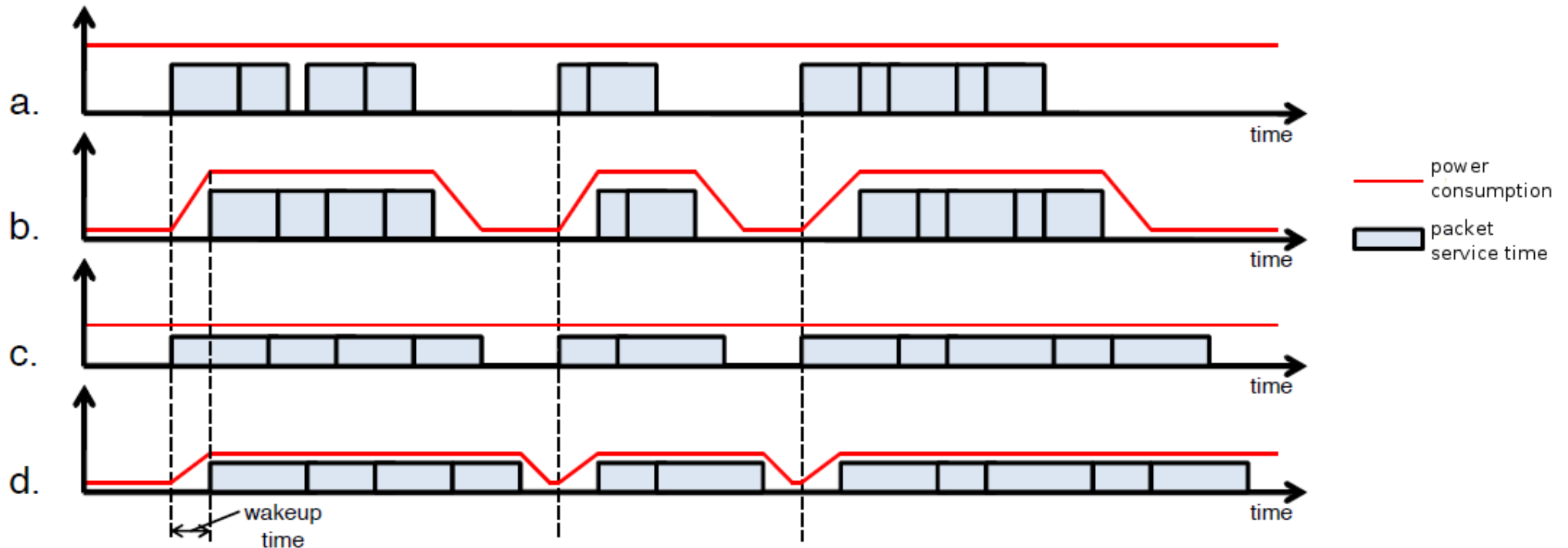
a. No power-aware optimization
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Alternative link technologies/protocols?

Coordination among nodes

- Energy-aware routing/infrastructure
  - Power consumption as part of the cost matrix
  - Reliability/Performance/Power
- Approaches with offline/pre-defined input
  - Design and operation decision
  - Pre-defined knowledge
    - Fixed components (nodes, topologies, traffic history)
  - Traffic pattern
    - Predictive models (multicommodity flow)
- Approaches with online/realtime input
  - Coordinate events (data transfer/sleep synchornization)
  - Real-time monitoring (SNMP Green Extension)

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How to deal with backward compatibilities?

What else?

- Standardized models and measurements
  - How to evaluate and compare different approaches
- Green data/control planes abstraction layer
  - How to manage and control the novel green capabilities/functionalities
- Other green opportunities
  - Green energy source
  - Cooling/heat-absorption technologies
  - Transmission technologies

Thank you for listening!