Networks and Green: Activities at ESnet

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GLIF RAP Working Group

U.S. DEPARTMENT OF **ENERGY**
Office of Science

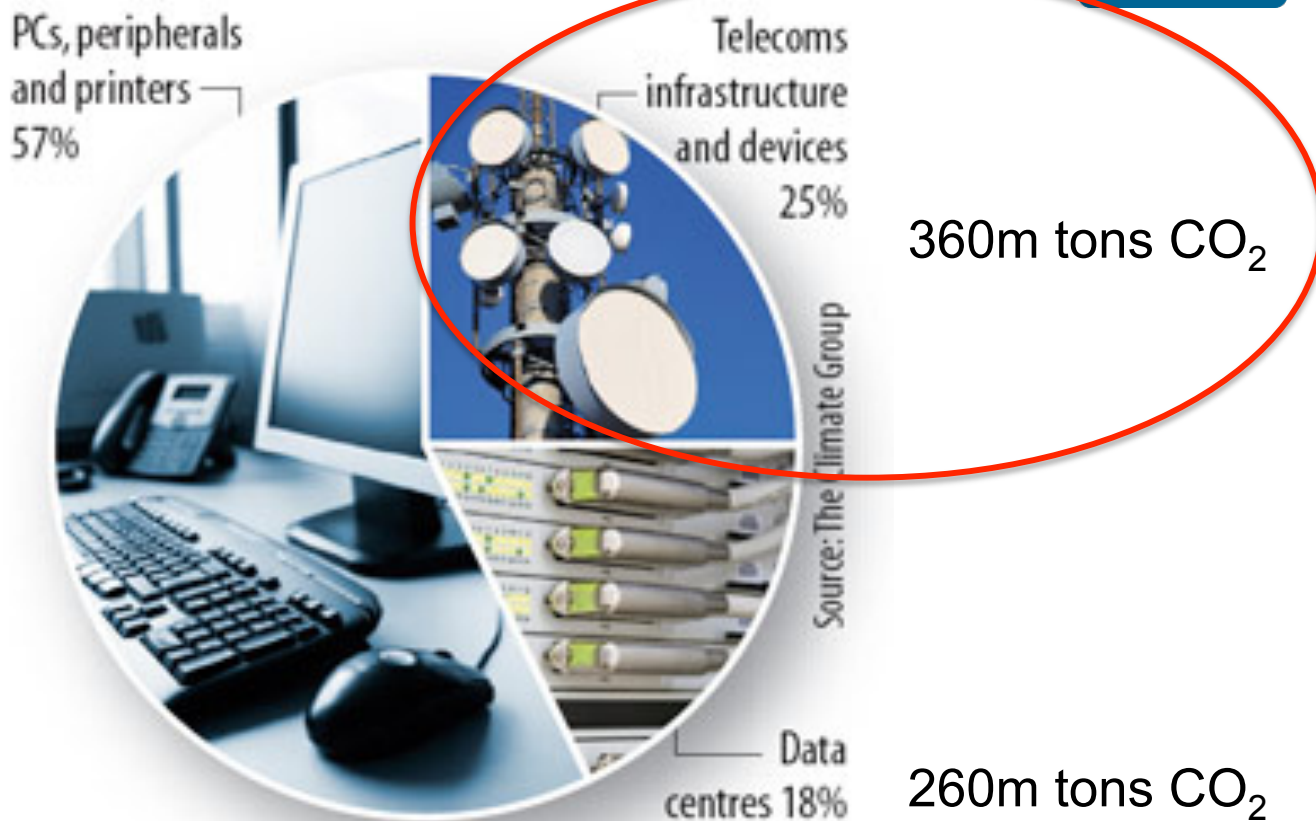**BERKELEY LAB**
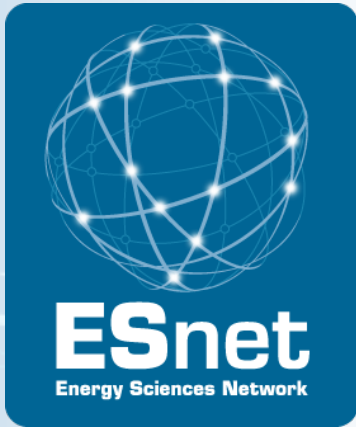
Motivation

2020 ICT Carbon Footprint

820m tons CO_2

2007 Worldwide ICT carbon footprint:
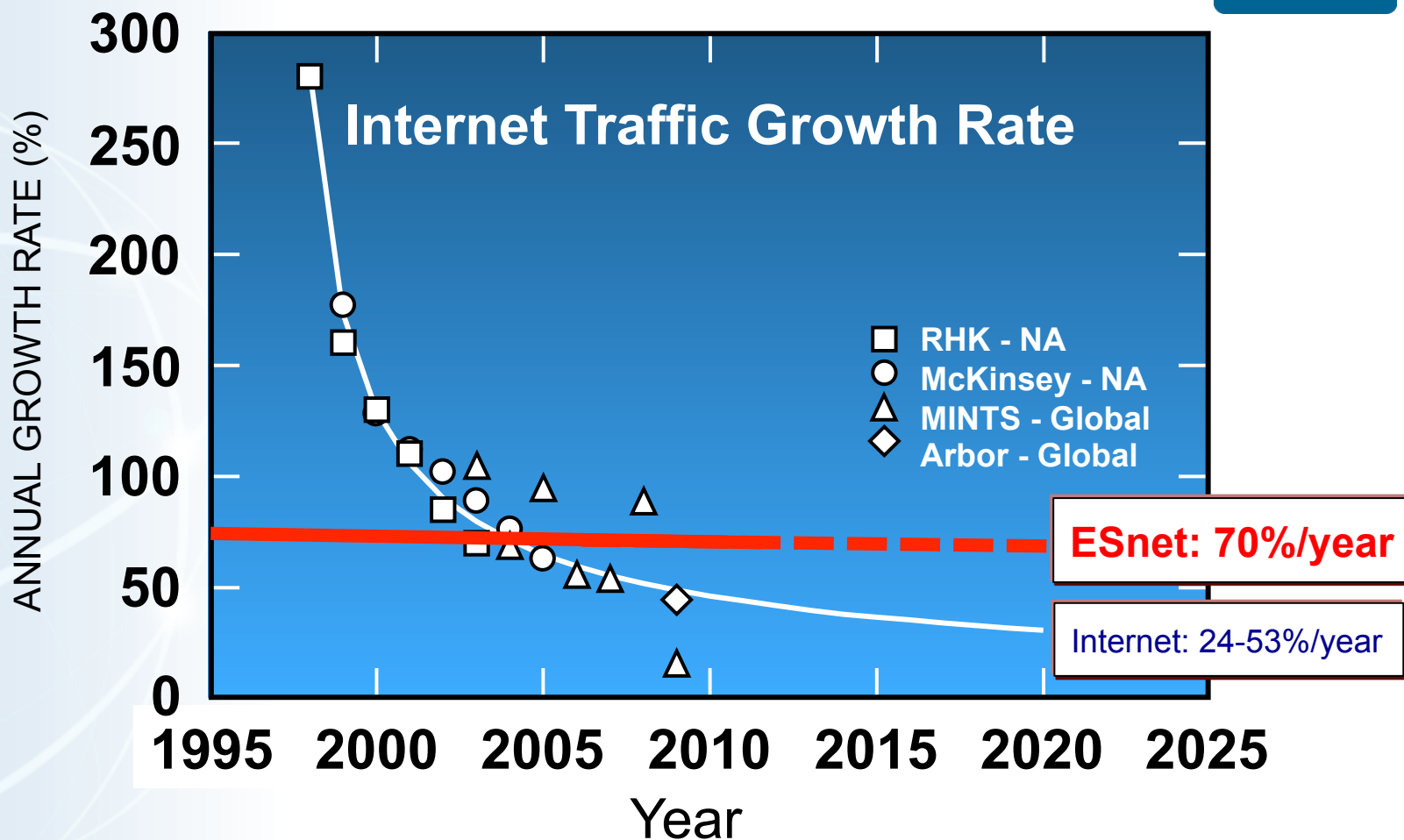2% = 830 m tons CO_2
Comparable to the global aviation industry

Expected to grow to 4% by 2020

PCs, peripherals and printers 57%

Telecoms infrastructure and devices 25%

360m tons CO_2

Data centres 18%

260m tons CO_2

Source: The Climate Group

Total emissions: 1.43bn tonnes CO_2 equivalent

The Climate Group, GeSI report "Smart 2020", 2008

ESnet

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Traffic Growth: ESnet vs. Internet

Internet Traffic Growth Rate

ANNUAL GROWTH RATE (%)

Year

- □ RHK - NA
- ○ McKinsey - NA
- △ MINTS - Global
- ◇ Arbor - Global

ESnet: 70%/year

Internet: 24-53%/year

SKK, 2010 (Sources: RHK, 2004; McKinsey, JPMorgan, AT&T, 2001; MINTS, 2009; Arbor, 2009).   Courtesy of Steve Korotky, Greentouch

The Network Energy Gap
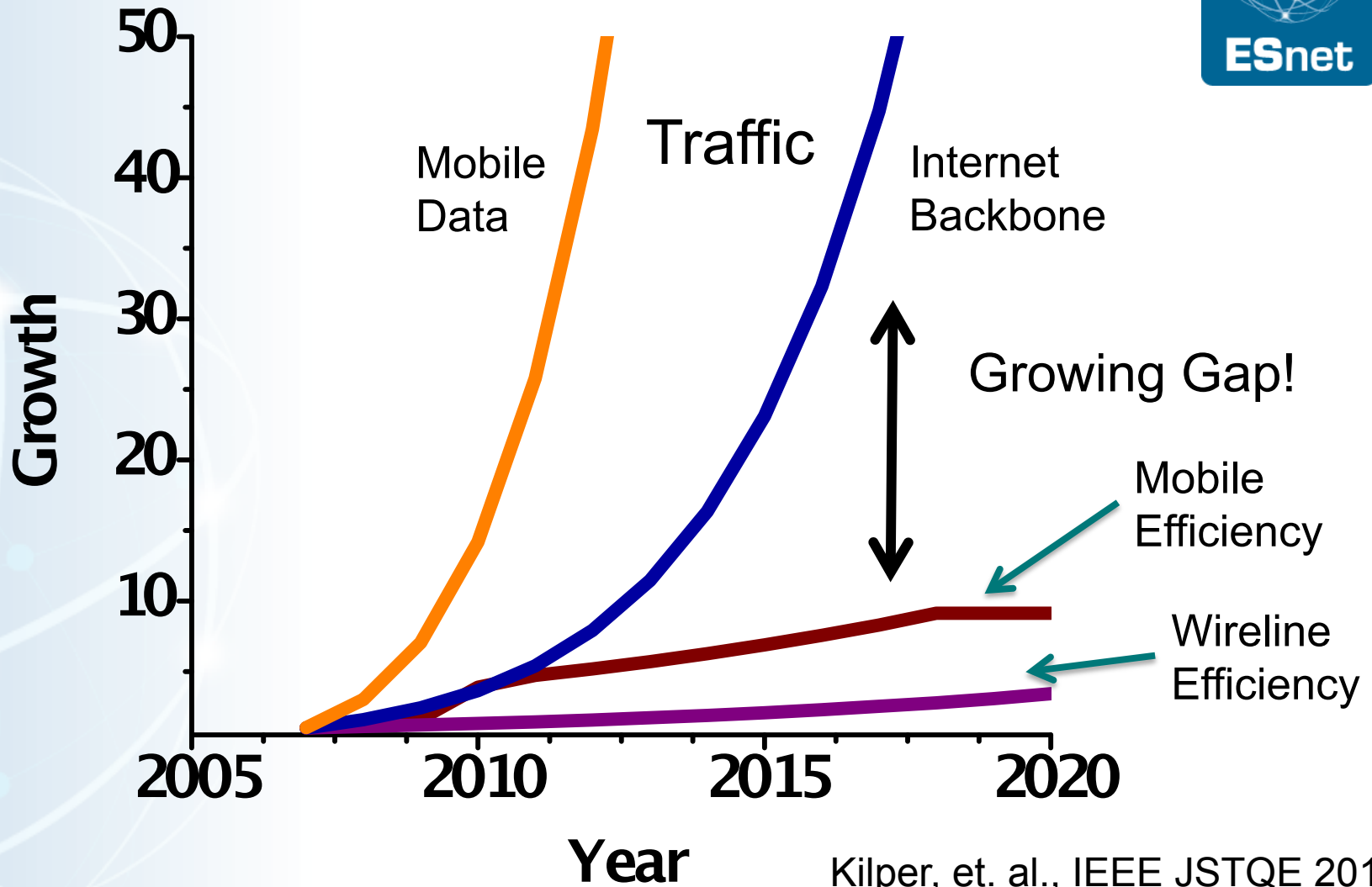
Kilper, et. al., IEEE JSTQE 2011

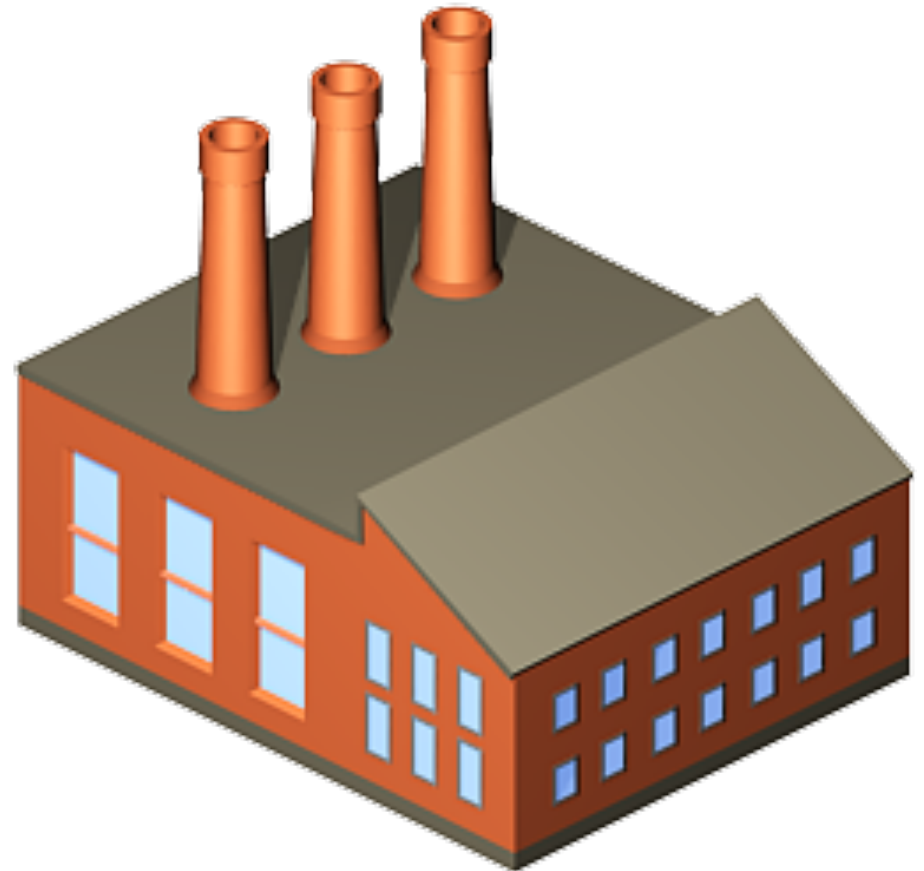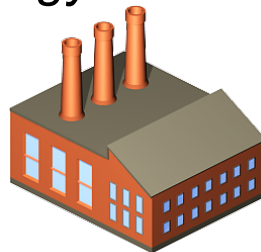# Data Centers vs. Core Networks: Putting it in perspective

Power usage:

- CERN supercollider: 180 MW
- DOE supercomputer: 6 MW
- ESnet: 400 KW

Hypothesis:

Although small in relative terms, end-to-end understanding of the energy consumption will lead to architectural insights with impact on overall energy-efficiency

The Opportunity

Latest generation of data centers quite efficient

- Future efficiencies will come from more-efficient hardware and cleaner sources of energy http://gigaom.com/cleantech/ google-green-czar-no-moores-law-for-data-center-efficiency/

LBNL's Lanzisera, Nordman, Brown report:

- Reductions of ~20% are easily achievable, potential savings >50%

Other research indicates big gains possible

Percentage increase of energy consumption in Telecom networks – double by 2017 of existing 2009 levels
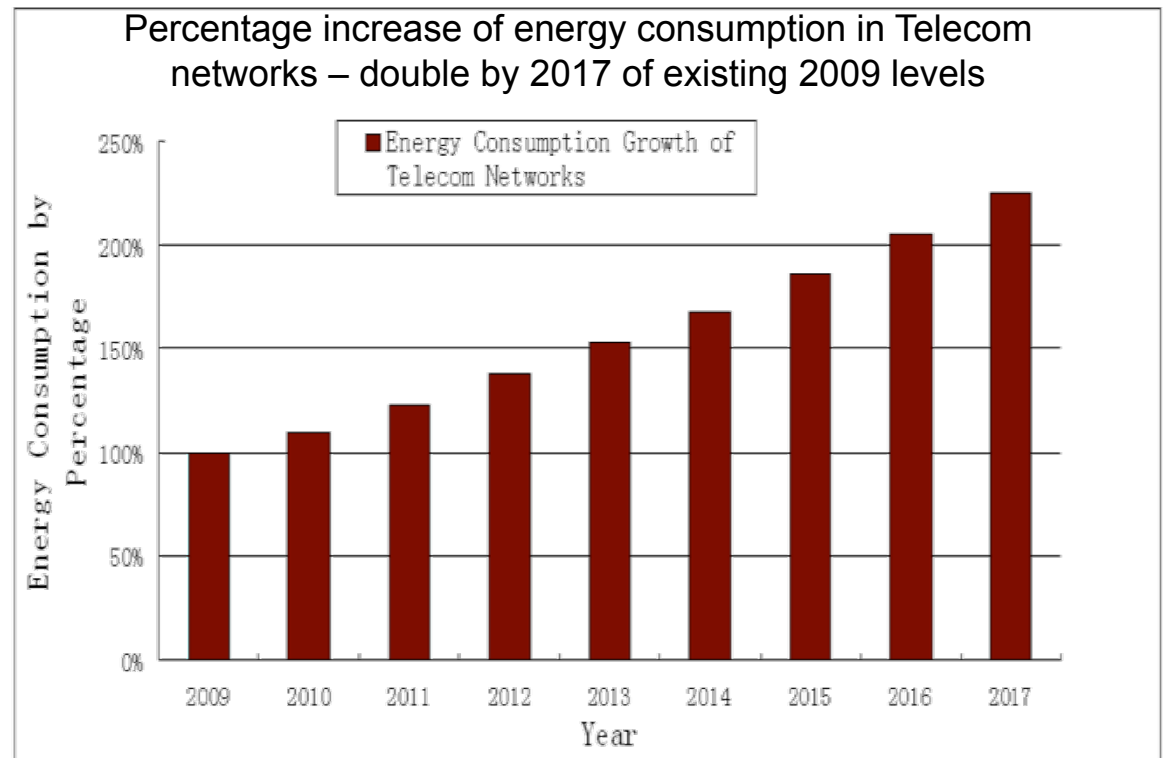
Source: Yi Zhang; Chowdhury, P.; Tornatore, M.; Mukherjee, B.; , "Energy Efficiency in Telecom Optical Networks," Communications Surveys & Tutorials, IEEE , vol.12, no.4, pp.441-458, Fourth Quarter 2010
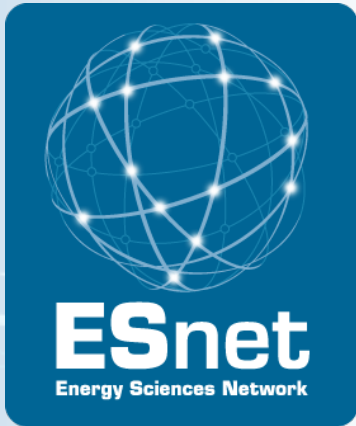
"You Can't Manage What You Don't Measure"
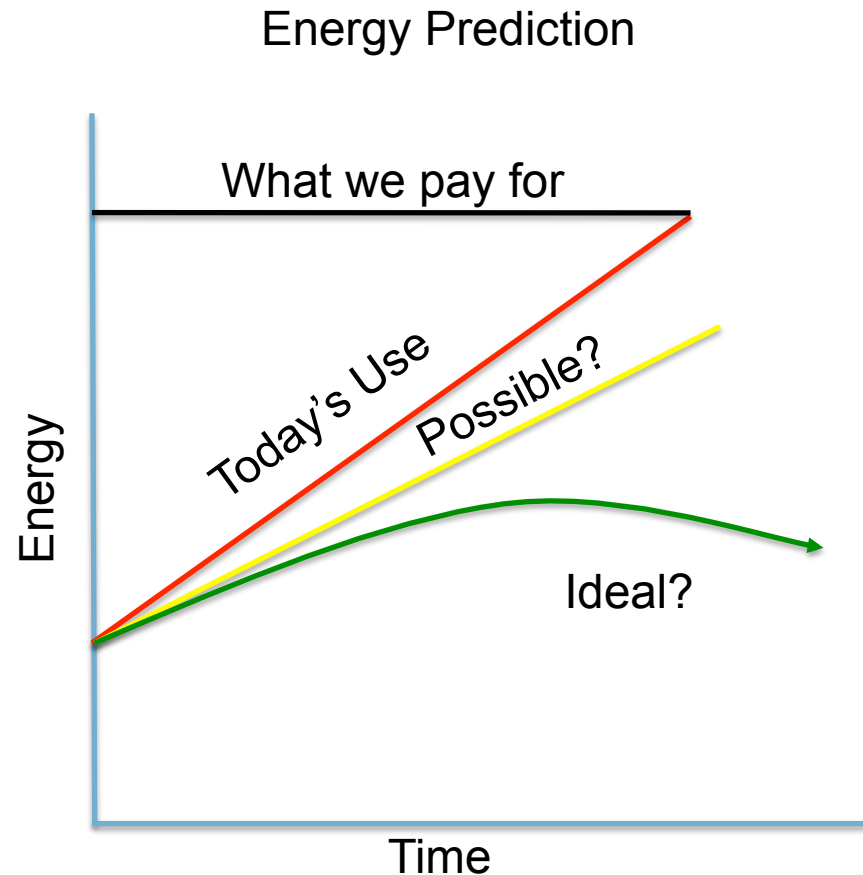
ESnet's 2008 Baseline**: "??"

No incentive to track energy consumption of network

- Focused on meeting demand
- Pay for near-max power day network is commissioned

No good way to track 'real' network energy consumption

- Breaker vs. metered power
- Lack of visibility into equipment

What is the energy curve of my new 100 Gbps network?

ESnet

Energy Prediction

What we pay for

Today's Use

Possible?

Ideal?

Energy

Time

Building power baseline for 100G network

Goals:

- Instrument the 100G ANI for real-time power measurement
  – Power Distribution Units, temperature/humidity sensors

- Build tools to collect and visualize live network energy consumption
  – Flexible meta-data to create customized views.
  – Power consumed per path, per POP, per layer

- Create open datasets for network energy-efficiency research
  – IEEE's EEE, IETF's eMon, GreenTouch etc.
  – Juniper, Broadcom, Bell Labs, Level 3, BBN and others.

- Catalyze adoption of theoretical research/experiments by industry
  – Energy proportionality will require redesign of network equipment
  – Establish metrics based on quantified improvements against baseline

Joint-sponsored all-day workshop with GreenTouch at SC11

- Network and data center efficiency

Demonstration (proof of concept)

[An open-source tool to measure network power consumption](#)

Joint research with UCSD's Tajana Rosing, Baris Aksanli

# Systems approach to energy-efficient networking

More Challenges

Energy efficiency research for networks is still very nascent

- Theoretical models not backed by real live data, Top-down/bottom-up different

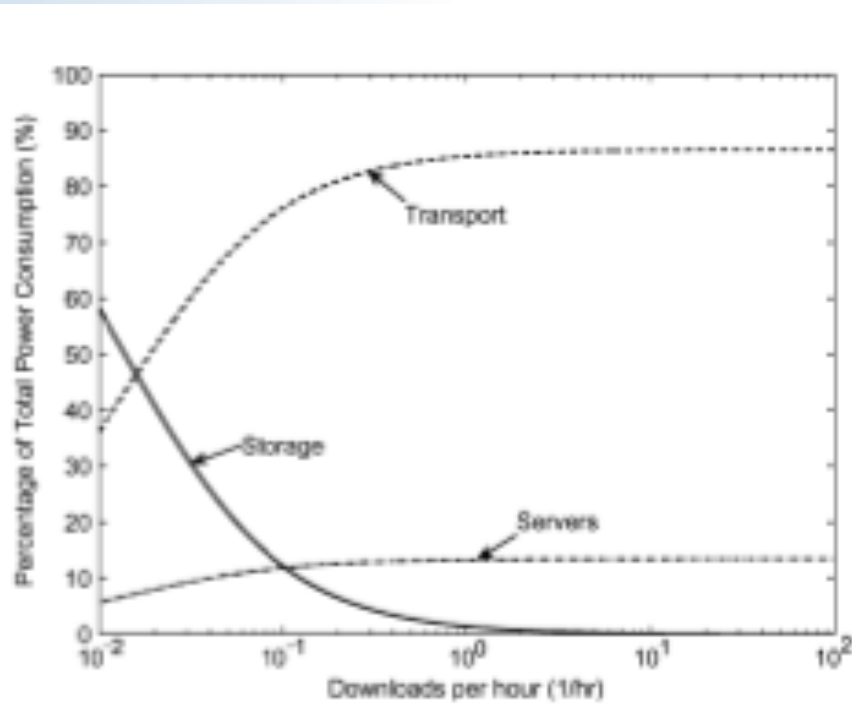What we do know: little correlation between traffic and power

- Power changes little with data utilization and moderately with port utilization

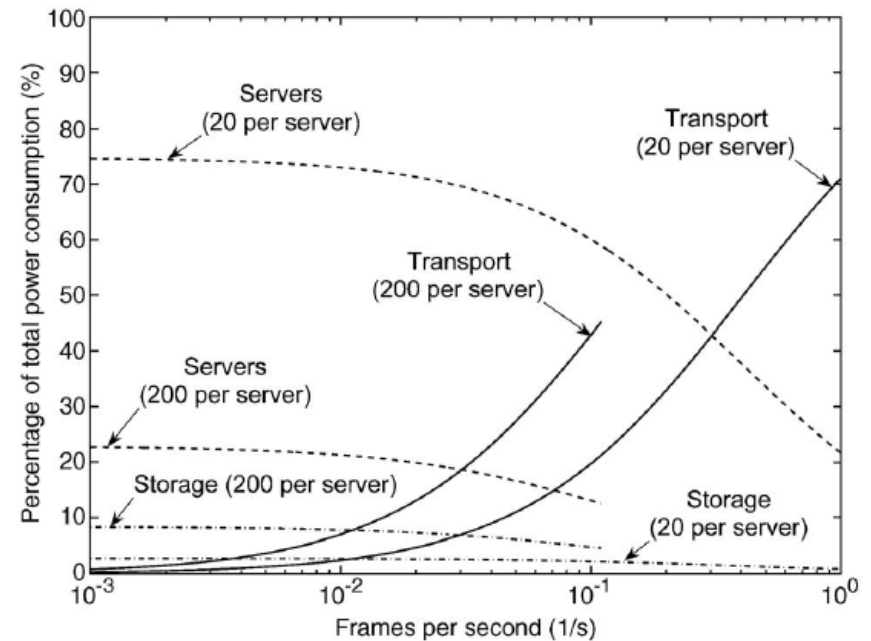Power of a modular network switch under varying conditions
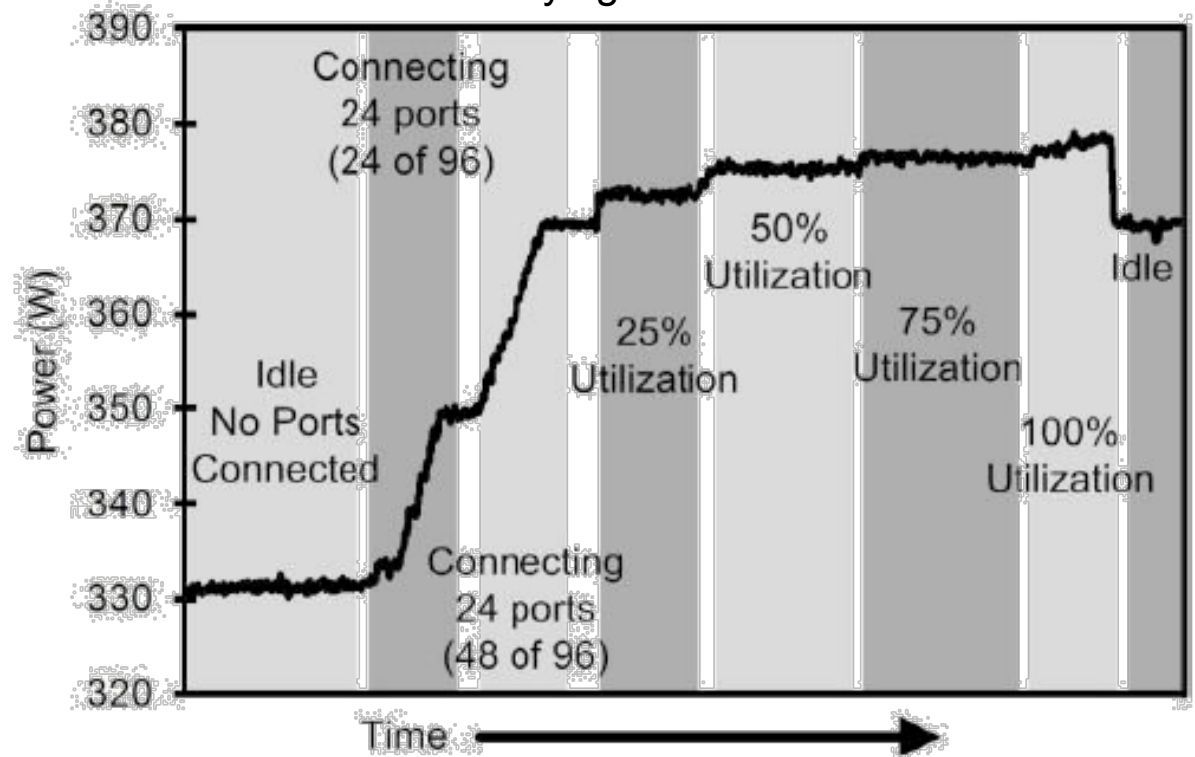
*'Data Network Equipment Energy Use and Savings Potential in Buildings'; Lanzisera, Nordman, Brown

Can we ignore transport costs?

Fig. 2. Percentage of total power consumption of transport, storage, and servers of a public cloud storage service as a function of download rate.

Fig. 5. Percentage of total power consumption of transport, storage, and servers of a public cloud storage service as a function of download rate with 20 and 200 users per server. The percentage of total power consumed by the user terminal is not shown.

* "Green Cloud Computing: Balancing Energy in Processing, Storage and Transport" by Jayant Baliga, Robert W. A. Ayre, Kerry Hinton, and Rodney S. Tucker, Fellow IEEE

Focus on network for a distributed data center case
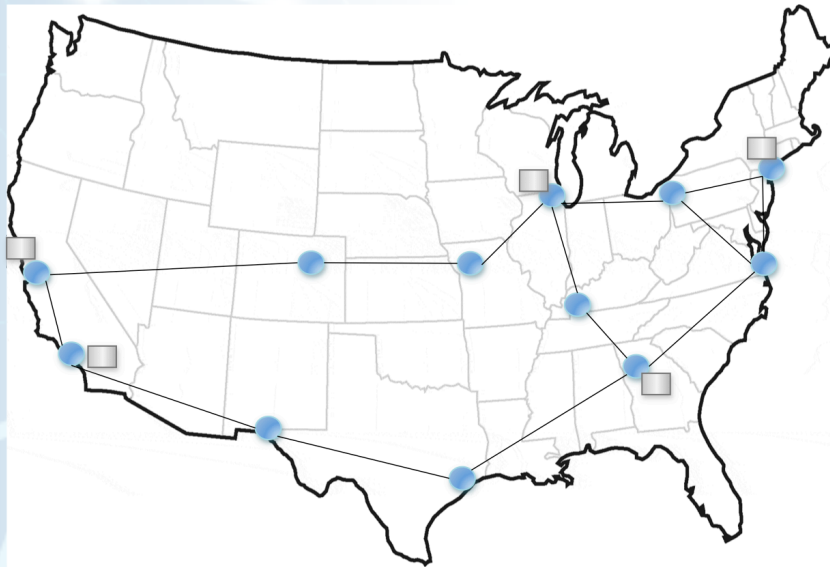
Four case studies*

Non-proportional network elements, no special routing (Baseline)

Networks with ideal proportional power consumption

Networks with step-proportional power consumption

Networks with smooth-proportional power consumption

* Maintain QoS, increase performance

Focus on network for a distributed data center case

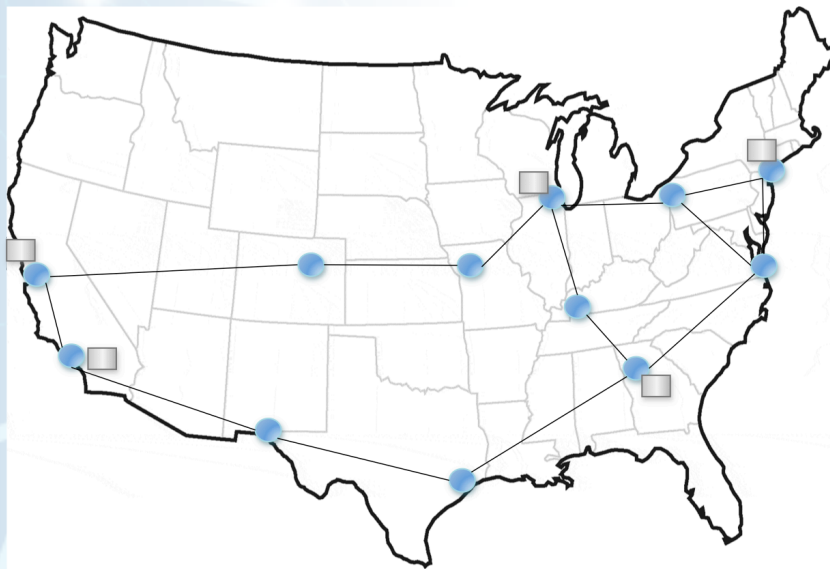**With Green Energy (and new routing algorithms)***

Non-proportional network elements, no special routing (Baseline)

Networks with ideal proportional power consumption

Networks with step-proportional power consumption

Networks with smooth-proportional power consumption

* Maintain QoS, increase performance

Results

Dramatic increases both for Job processing and network energy efficiency. Green energy is definitely beneficial, but with prediction models.

Being written up as a conference paper and submitted.

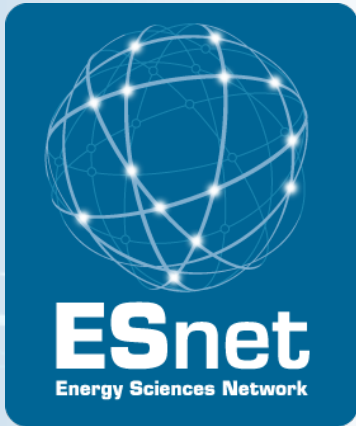Caveat: Energy proportionality is key to harnessing a large part of the savings

Upcoming events @ SC11

Workshop: **"Data Centers Have Gone Green (Or Haven't They?).
When Will Networks Follow?"** Sunday, 8:30 – 5:00 PM

Workshop: "Towards and Beyond Energy Efficiency: HPC System and
Datacenters" Monday, 8:30AM - 5:00PM

**Panel: "Energy Efficient Networks in Next Generation Data and
Compute Centers" Wednesday, 10:30AM - 12:00PM**

http://esnetupdates.wordpress.com

http://fasterdata.es.net

Thank you! Questions?