Bits-to-energy or energy-to-bits?

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University of Amsterdam

On behalf of the ‘bits-nets-energy’ collaboration.

Science and education today

- Scientists, students, lecturers have many choices when deciding where to process or store data.

On the desk

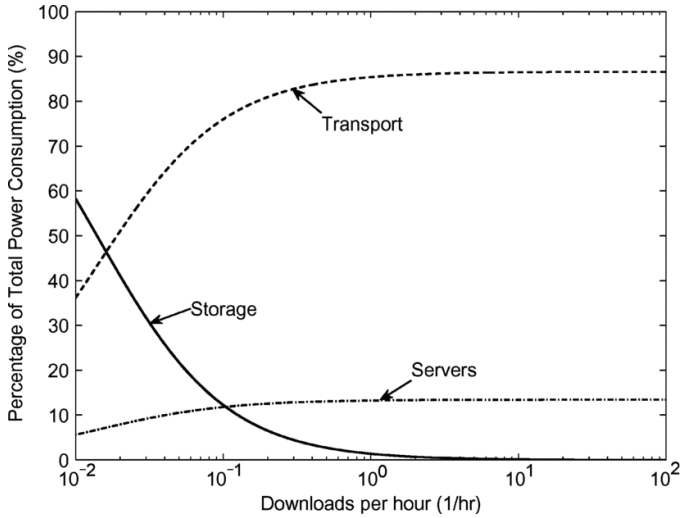
In the server room/data center

In the cloud

Clouds: green or gray?

Complex question.

- Need knowledge of the carbon footprint
- Need knowledge of all contributing components, also of the network contribution between clouds, between user and cloud center



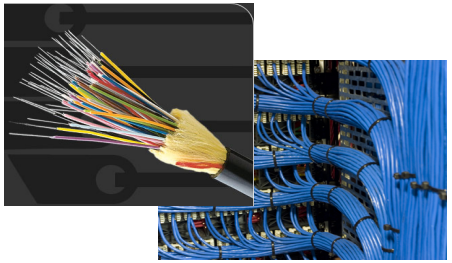
Green Cloud Computing:
Balancing Energy in Processing, Storage, and Transport

Baliga, J.; Ayre, R.W.A.; Hinton, K.; Tucker, R.S.

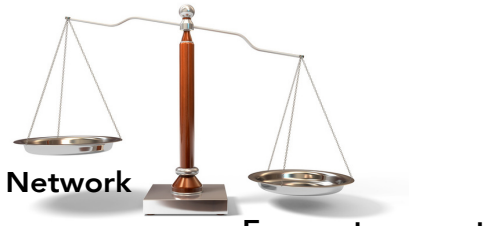
Proceedings of the IEEE , vol.99, no.1, pp.149-167, Jan. 2011

The core question

Network infrastructures

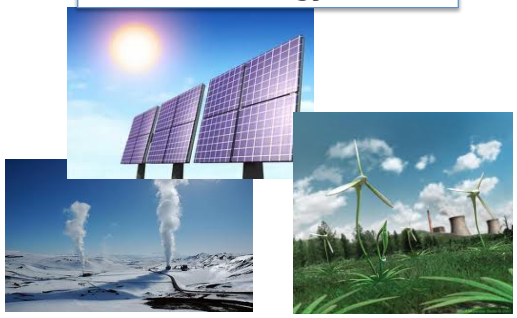


CO_2 footprint;
Energy needed and lost

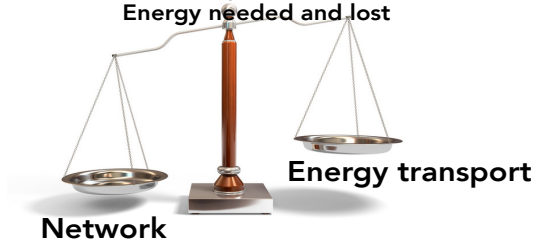


Bits to energy!

Green energy sources



CO_2 footprint;
Energy needed and lost



Energy to bits!

Collaboration

- Funded by

Agentschap NL
Ministerie van Infrastructuur en Milieu

- Participants

UNIVERSITEIT VAN AMSTERDAM

SURF SARA

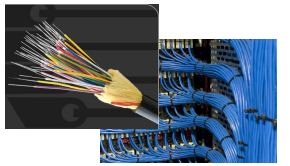
TNO innovation for life

Greenit amsterdam region

SURF NET

SURF

Network infrastructures

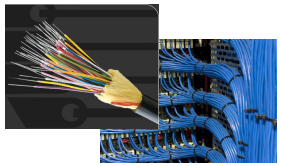


CO_2 footprint;
Energy needed and lost

Bits to energy!

SURFnet

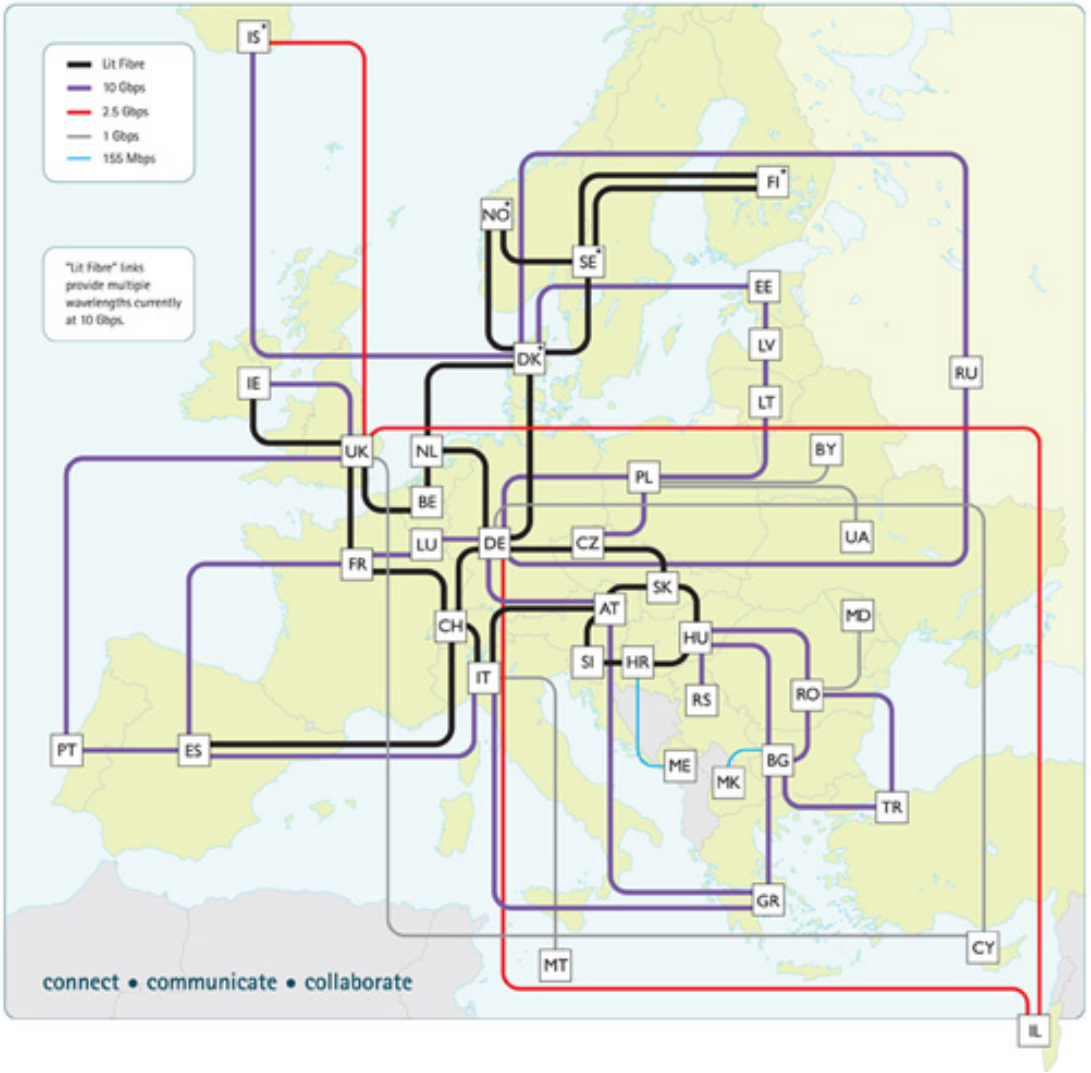
Network infrastructures

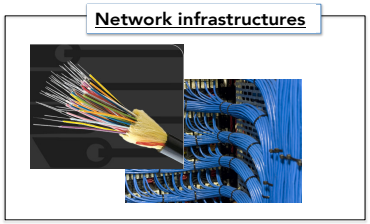


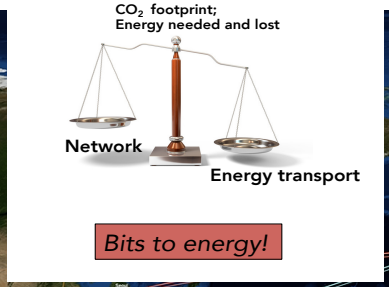
CO_2 footprint;
Energy needed and lost

Bits to energy!

GEANT



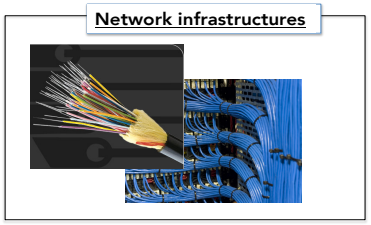

Network infrastructures

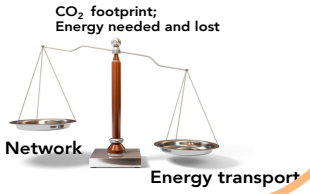

CO_2 footprint;
Energy needed and lost
Network
Energy transport
Bits to energy!

GLIF

GLIF Map 2011: Global Lambda Integrated Facility
Visualization by Robert Patterson, NCSA, University of Illinois at Urbana–Champaign
Data Compilation by Maxine D. Brown, University of Illinois at Chicago
Texture Retouch by Jeff Carpenter, NCSA
Earth Texture, visibleearth.nasa.gov
www.glif.is

Decision matrix



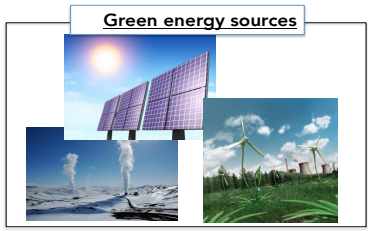


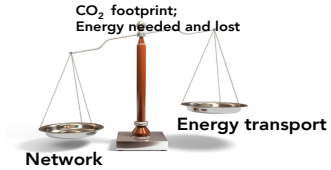
Bits to energy!

Identify realistic scenarios

Identify the variables relevant to each scenarios

Determine the cost of:
transport of bits
transport of energy





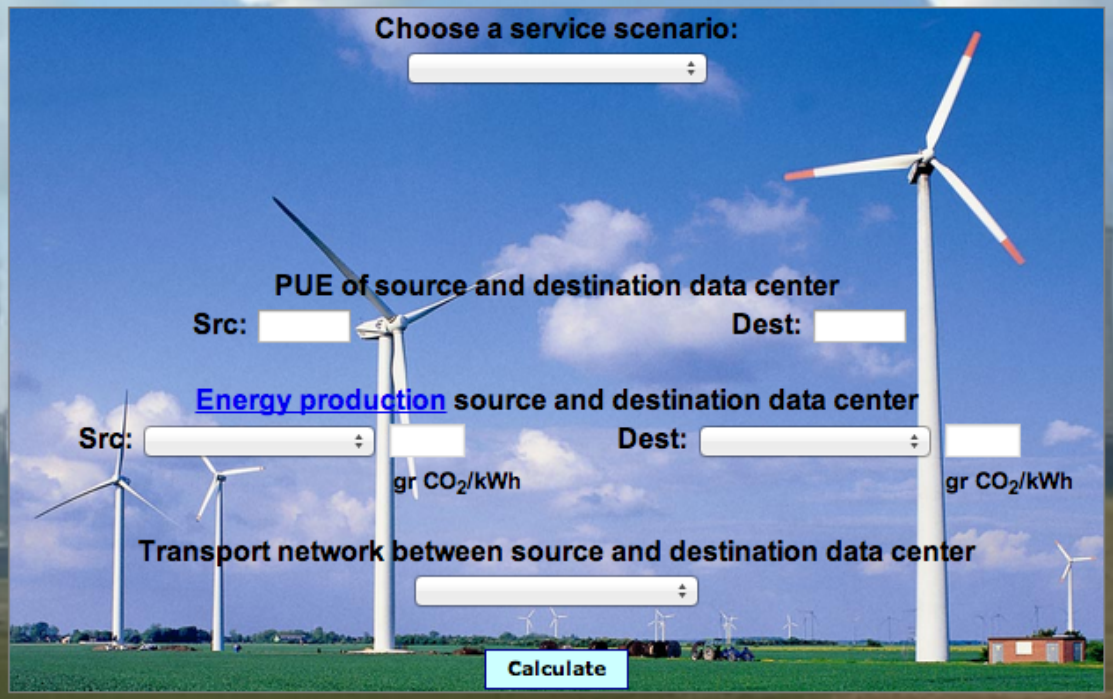
Energy to bits!

Scenario	Variables 1	Variable2	Variable 3	…	….
Scenario1					
Scenario2					
Scenario3					

Bits-to-nets	Energy-to-bits

Bits to Energy or Energy to Bits

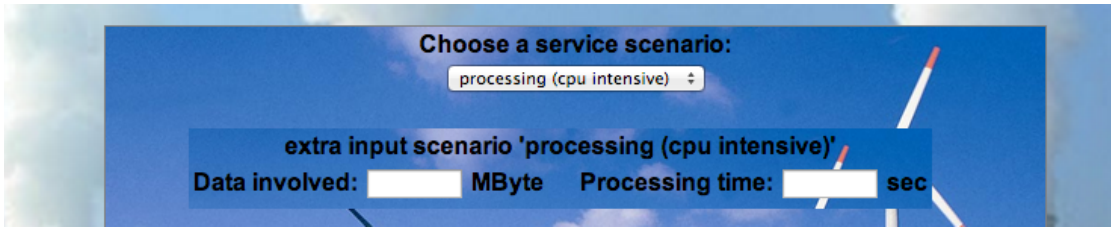
a calculator for a road to cleaner computing



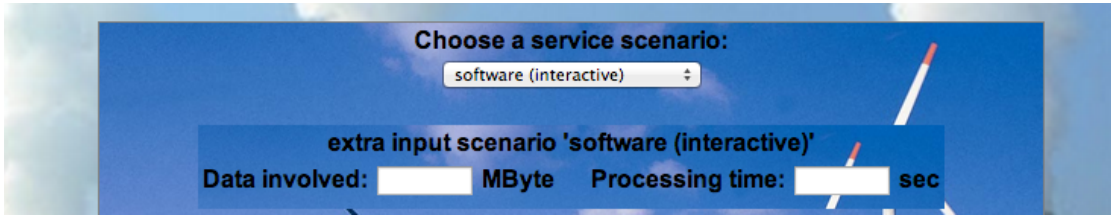
Scenarios

We focus on three scenarios typical in higher education:

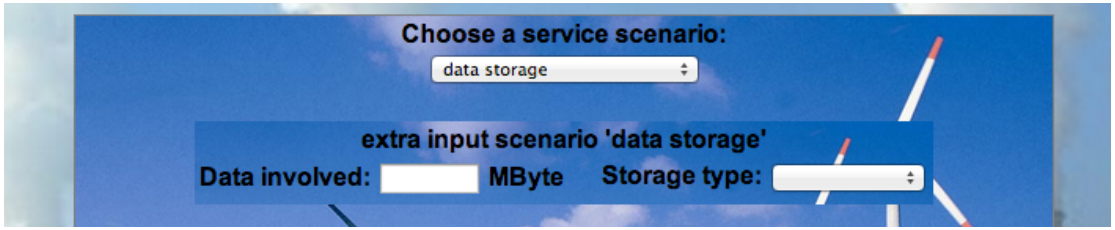
1. storage as a service

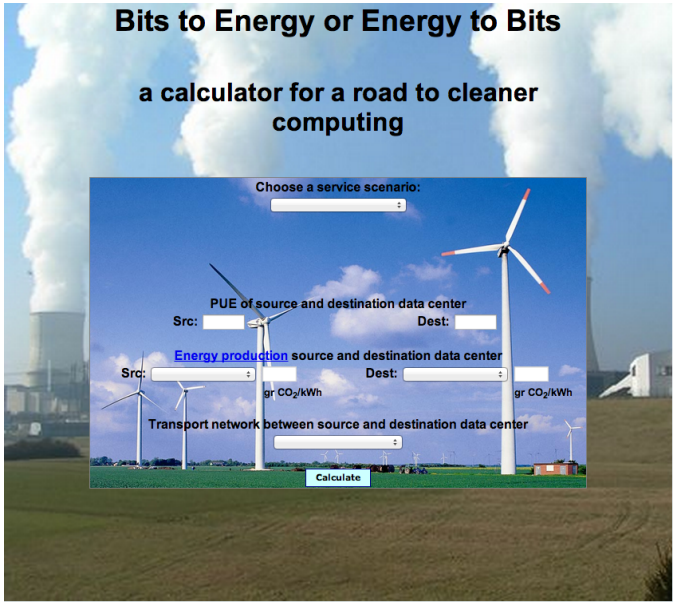


2. software as a service / interactive work



3. processing as a service / computing intensive

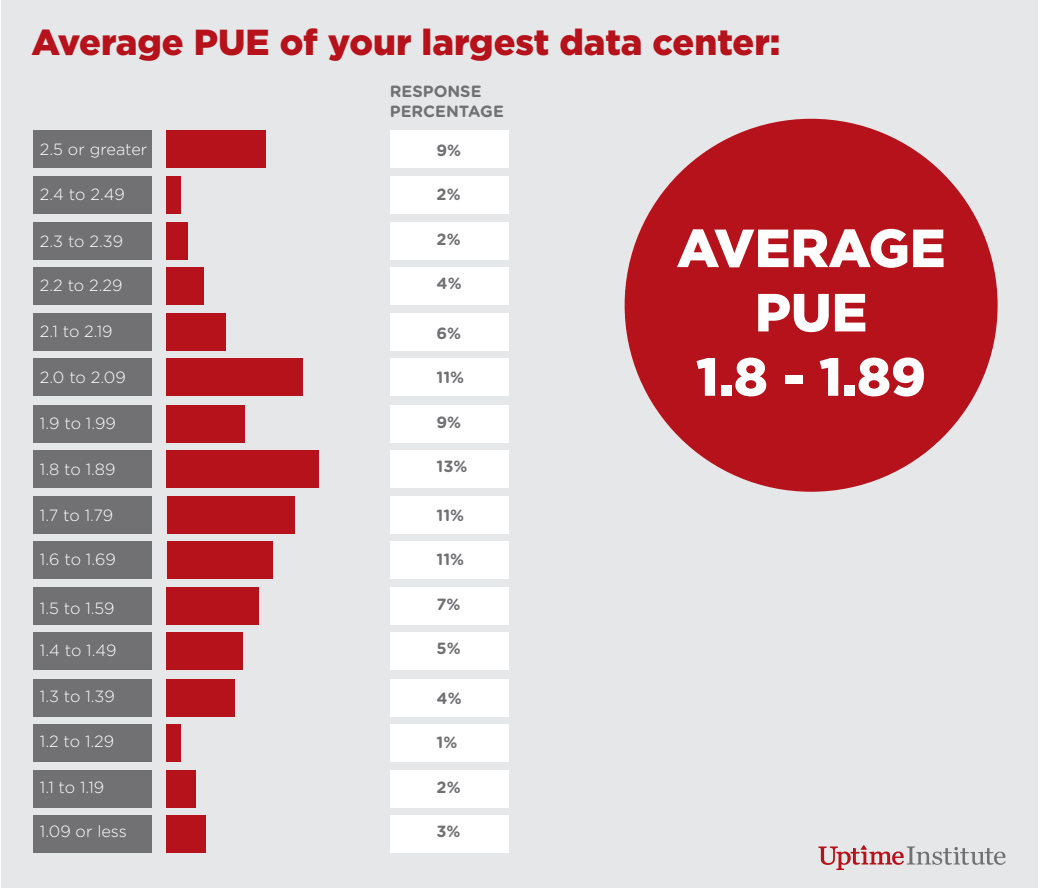




PUE

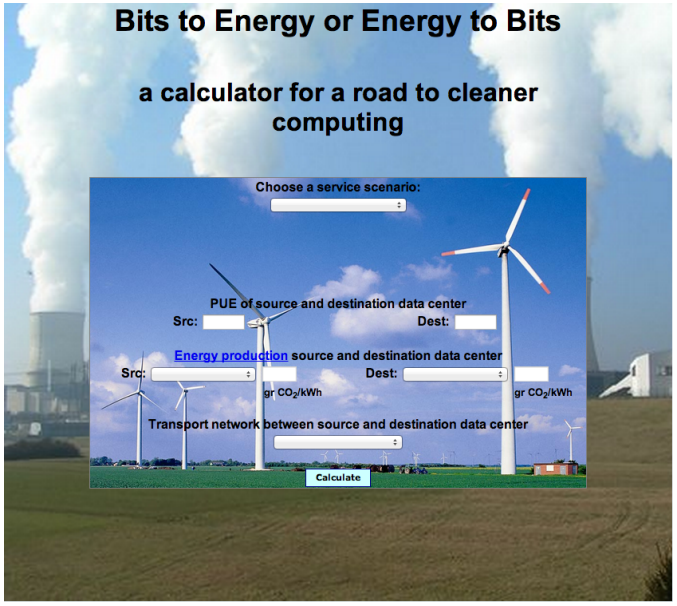
Power Usage Effectiveness: PUE

PUE = Total data center power/IT equipment power



Data from a
survey of the Uptime Institute

Our calculator choose for a default value of 1.9 (if unknown).



Efficiency vs. sustainability

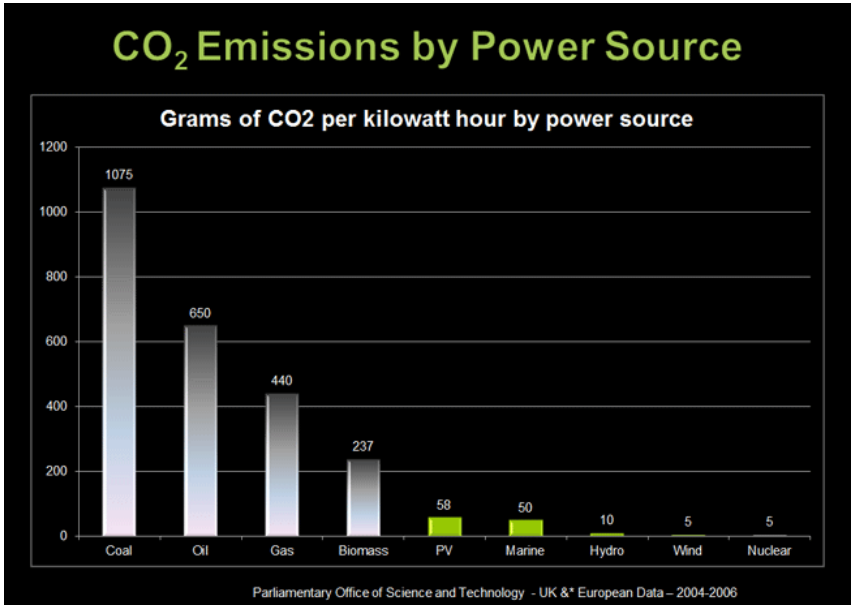
- Energy efficiency:

Reduce the amount of energy used to provide services, power devices

- Sustainability:

Use of renewables energy sources and reduction of carbon footprint.

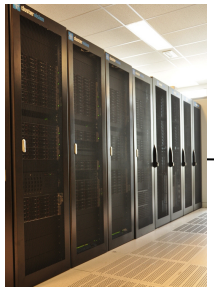
Jevon's paradox!

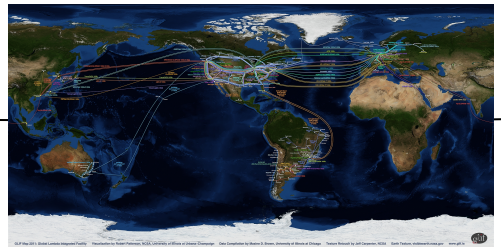


Bits-to-nets cost

Three components:

- Cost of local network at source data center
- Cost of local network at destination data center
- Cost of transport network





Local data center

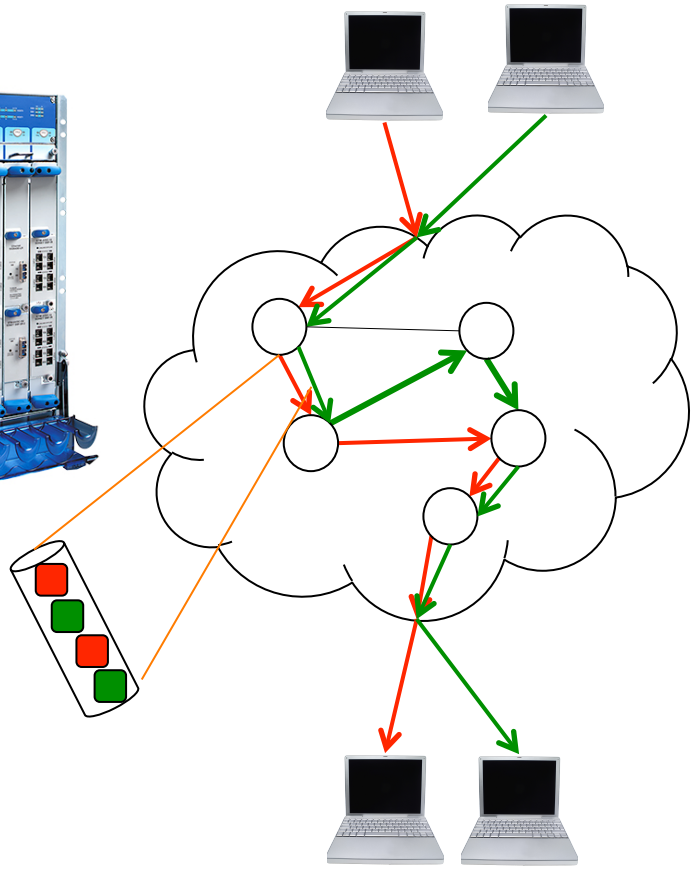
Remote data center

$$Cost_{bits-to-nets} = Cost_{LAN-source-data-center} + Cost_{transport-network} + Cost_{LAN-destination-data-center}$$

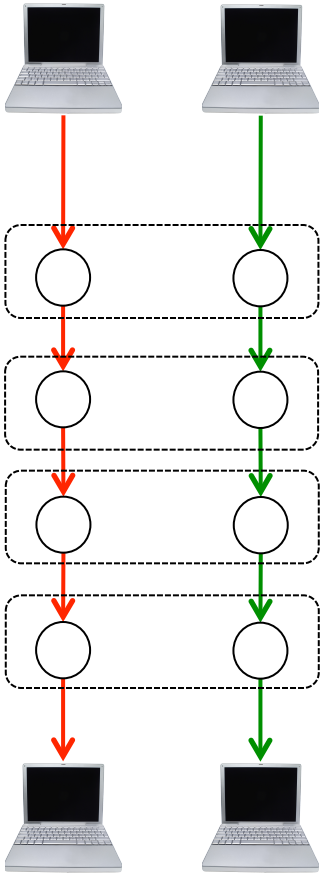
$$Cost_{bits-to-nets} = Cost_{LAN-source-data-center} + Cost_{transport-network} + Cost_{LAN-destination-data-center}$$

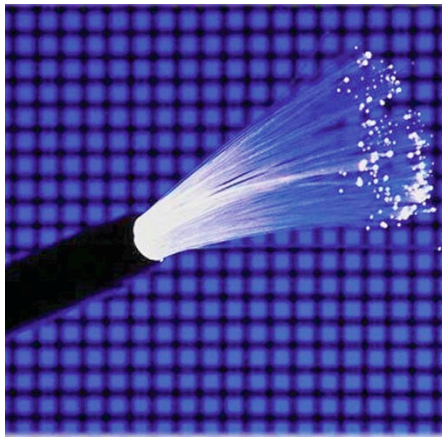
Hybrid networks

- Internet



- Circuits/lightpaths





$$Cost_{bits-to-nets} = Cost_{LAN-source-data-center} + Cost_{transport-network} + Cost_{LAN-destination-data-center}$$

Internet

Oversubscription factor: 1/5

Short distances: 1 or 2 hops
Long distance: 3 or 4 hops

Lightpaths

Oversubscription: none

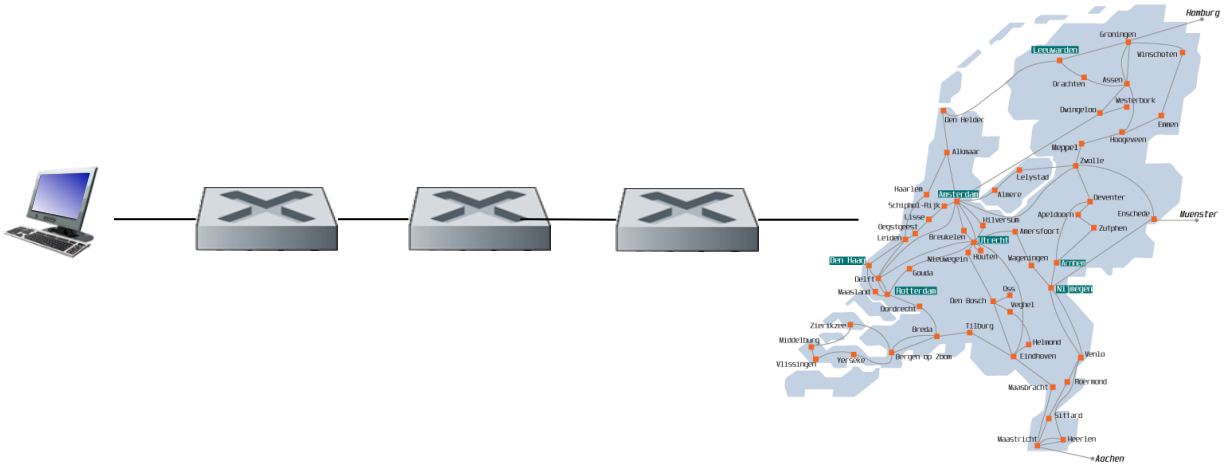
Short distance: direct connection
Long distances: 1 or 2 devices in between

Internet Short distance	Lightpaths Short distance	Internet Long distance	Lightpaths Long distance
Transport network:	Transport network:	Transport network:	Transport network:
Switch 2x20%x 10 Gbps	Switch 2x 10 Gbps	Switch 2x20%x 10 Gbps	Switch 2x 10 Gbps
DWDM 20%x 10 Gbps	DWDM 1x 10 Gbps	DWDM 20%x 10 Gbps	DWDM 1x 10 Gbps
DWDM 4x20%x 1 Wavelength	DWDM 4x 1 Wavelength	DWDM 4x20%x 1 Wavelength	DWDM 4x 1 Wavelength
DWDM 20%x 10 Gbps	DWDM 4x 1 Wavelength	DWDM 20%x 10 Gbps	DWDM 4x 1 Wavelength
Switch 2x20%x 10 Gbps	DWDM 1x 10 Gbps	Switch 2x20%x 10 Gbps	Switch 2x 10 Gbps
Router 2x20%x 10 Gbps	Switch 2x 10 Gbps	Router 2x20%x 10 Gbps	DWDM 4x 1 Wavelength
Switch 20%x 10 Gbps		Switch 20%x 10 Gbps	DWDM 4x 1 Wavelength
DWDM 20%x 10 Gbps		DWDM 20%x 10 Gbps	Switch 2x 10 Gbps
DWDM 4x20%x 1 Wavelength		DWDM 4x20%x 1 Wavelength	DWDM 4x 1 Wavelength
DWDM 20%x 10 Gbps		DWDM 20%x 10 Gbps	DWDM 4x 1 Wavelength
Switch 2x20%x 10 Gbps		Switch 2x20%x 10 Gbps	DWDM 1x 10 Gbps
		Router 2x20%x 10 Gbps	Switch 2x 10 Gbps
		Switch 20%x 10 Gbps	
		DWDM 20%x 10 Gbps	
		DWDM 4x20%x 1 Wavelength	
		DWDM 20%x 10 Gbps	
		Switch 2x20%x 10 Gbps	
		Router 2x20%x 10 Gbps	
		Switch 20%x 10 Gbps	
		DWDM 20%x 10 Gbps	
		DWDM 4x20%x 1 Wavelength	
		DWDM 20%x 10 Gbps	
		Switch 2x20%x 10 Gbps	

$$Cost_{bits-to-nets} = Cost_{LAN-source-data-center} + Cost_{transport-network} + Cost_{LAN-destination-data-center}$$

Data center cost

- Given a typical data center network:



And known power (P) and capacity (C) of the devices in the topology:

$$Cost_{LAN-source-data-center} = \frac{P_{host}}{C_{host}} + \frac{P_{switch}}{C_{switch}} + \frac{P_{firewall}}{C_{firewall}} + \frac{P_{router}}{C_{router}}$$

Summary

Just started.

Still lots of open questions:

- What are typical networks?
- How do we collect power information from devices?
- What is the best way to calculate the energy-to-bits cost?

More information

- Email: p.grosso@uva.nl
- URL: http://staff.science.uva.nl/~grosso/

… And the final report on this research!