Energy-efficient Networking: The views of leaders of international research projects

Organizer: **Marco Ajmone Marsan**

Politecnico di Torino

CCW 2011

Hyannis, October 11th, 2011

SEVENTH FRAMEWORK PROGRAMME

Four **OUTSTANDING** sxpeakers

- **Suresh Goyal,** *Alcatel-Lucent Bell Labs*
  GreenTouch
- **Ayman Radwan,** Instituto de Telecomunicações
  C2POWER
- **Idelfonso Tafur Monroy,** *DTU Photonik*
  CHRON
- **Franco Davoli,** *University of Genoa*
  ECONET

Towards Real Energy-efficient Network Design

Grant agreement n. 257740
THEME [ICT-2009.1.1]
[The Network of the Future]

Coordinator: **Marco Ajmone Marsan**
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In memory

TREND was conceived by my friend and colleague **Fabio Neri**, who tragically and unexpectedly passed away on April 16th, 2011.

Fabio brought the TREND partners together, led the proposal submission, was the leader and the core of the TREND project until his passing.

The Problem

- Energy is becoming *the issue* of our future
  - Energy consumption is causing dramatic climate changes
  - We depend on energy which is becoming *scarce* and *expensive*
- We must cope with this and reduce energy consumption in all sectors,

ICT and networking included

What about ICT?

- Information and Communication Technologies play a positive role for energy saving:
  - *moving bits instead of atoms*
    - teleworking and telecommuting
    - e-commerce
    - intelligent transport systems
    - electronic billing
  - sensors to monitor and manage environment

ICT positive role

Estimated energy saving through ICT, in % consumed energy per sector and in total

- Manufacturing: 25-30% (total 7-8%)
- Transport: 26% (total 8%)
- Buildings: 5-15% (total 2-6%)

Source: Ad-hoc Advisory Group „ICT for Energy Efficiency“ of the European Commission DG INFSO, 2008.

… but

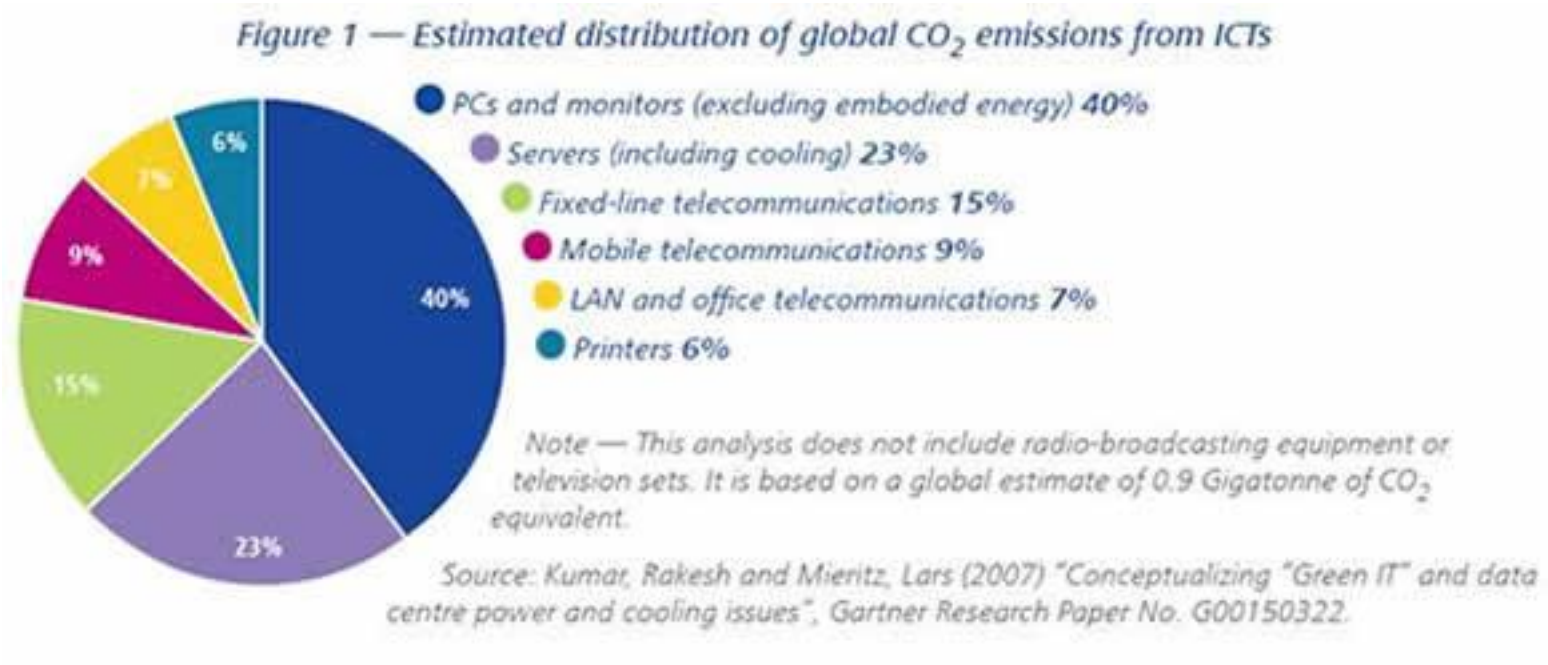
ICT is also a greedy consumer!

"ICT alone is responsible of a percentage which varies from 2% to 10% of the world power consumption."

"Electricity demand of ICT is almost 11% of the overall final electricity consumption in Germany."

"ICT sector produces some 2 to 3%of total emissions of greenhouse gases."

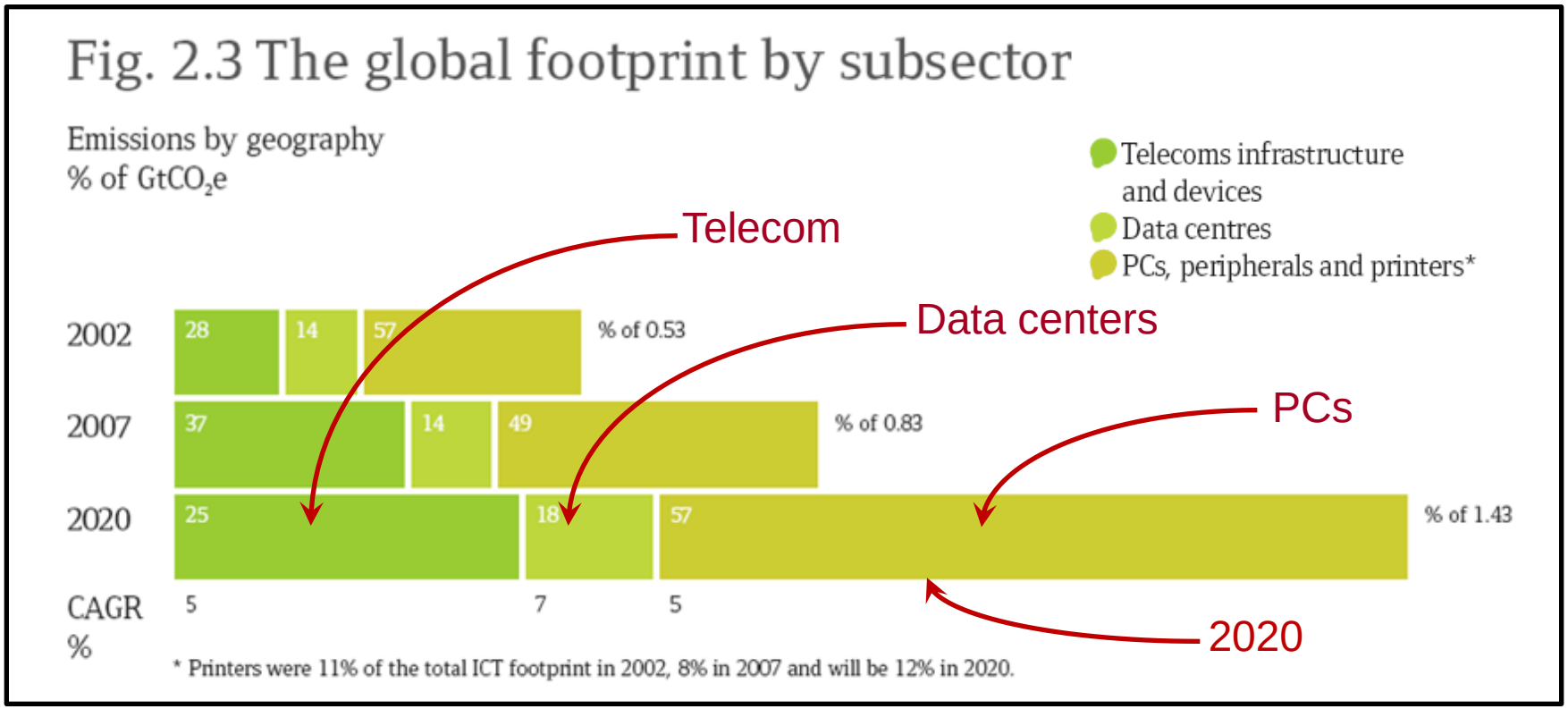
Which ICT?



Source: GreenTouch initiative: http://www.greentouch.org/

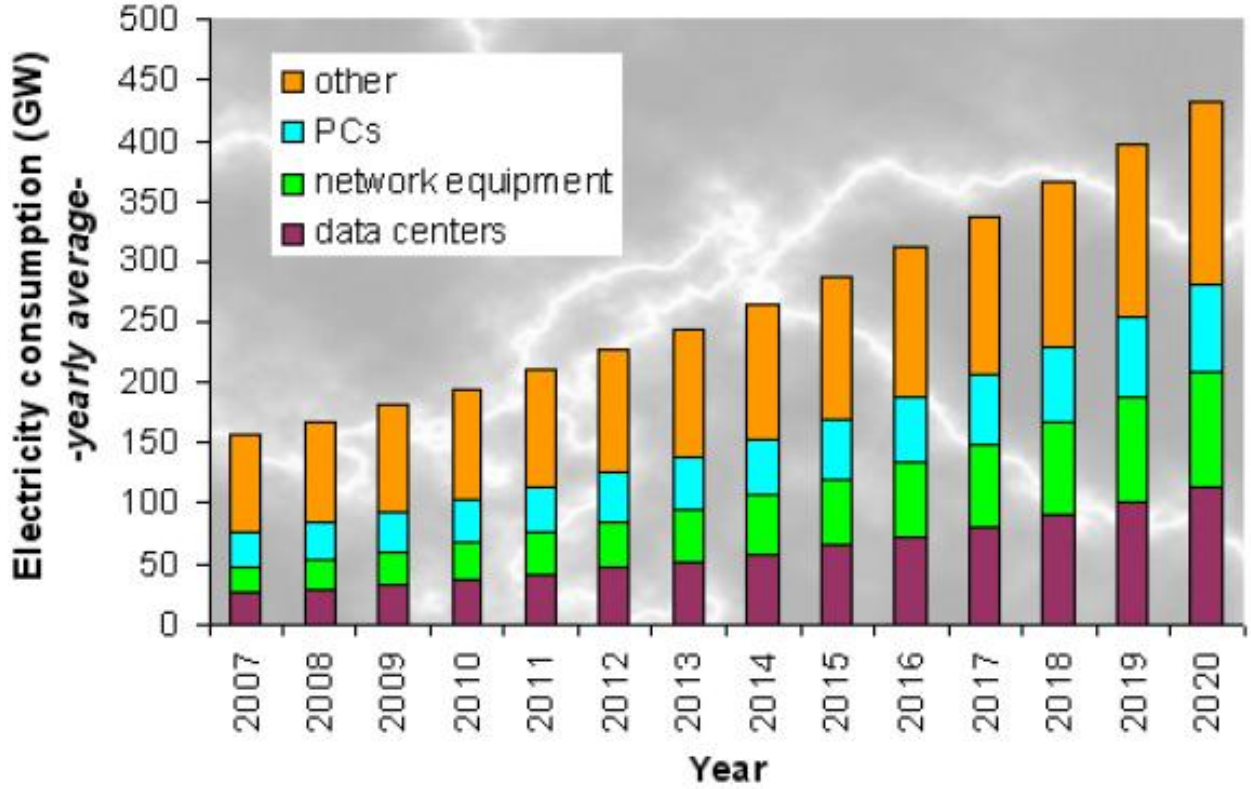
ICT footprint

PCs (not data centers) are major CO_2 contributor



Source: SMART 2020 report

Consumption might double in the next decade



Source: M. Pickavet et al, "Worldwide Energy Needs for ICT: the Rise of Power-Aware Networking," in IEEE ANTS Conference, Bombay, India, Dec. 2008.

TREND:
a NoE on green networking

Politecnico di Torino
Universidad Carlos III de Madrid
Interdisciplinary Institute for Broadband Technology
Technische Universitat Berlin
Ecole Polytechnique Federale de Lausanne
Consorzio Interuniversitario per le Telecomunicazioni
Panepistimio Thessalias

Academic

Alcatel- Lucent Bell Labs France
Huawei Technologies Duesseldorf GmbH

Manufacturers

Telefonica Investigacion Y Desarrollo SA
France Telecom SA
FASTWEB SPA

Operators

TREND actions

- Coordination and creation of an **identity for the European research** on energy-efficient networking through integration and collaboration
- Specific **Integrated Research Actions** (IRAs), and **Joint Experimental Activities** (JEAs) internal to the NoE
- Establishing **contacts and links** primarily among FP7 projects, but also with national programmes and with projects outside the FP7-framework
- Organization of **workshops** targeting the dissemination of the TREND know-how and view on green networking

What is the objective of TREND?

Propose approaches to improve energy efficiency of existing networks by at least **20%**

Integration of the EU research community in green networking; in the **long term** consolidate the European leadership in the field

Start from data…

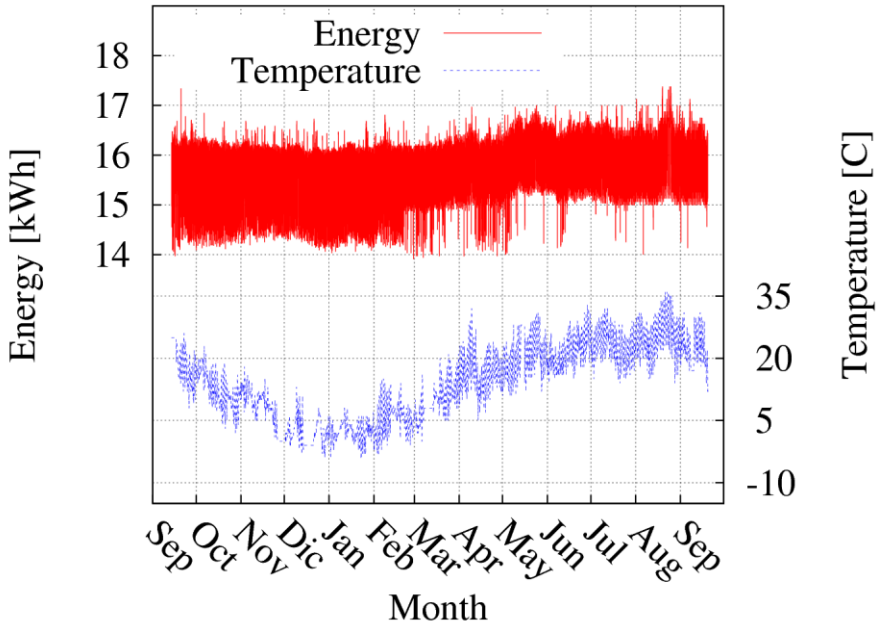
- Derive reliable, updated data and models about consumption and traffic

Start from data…

Operator with monitoring facilities in network in oper.

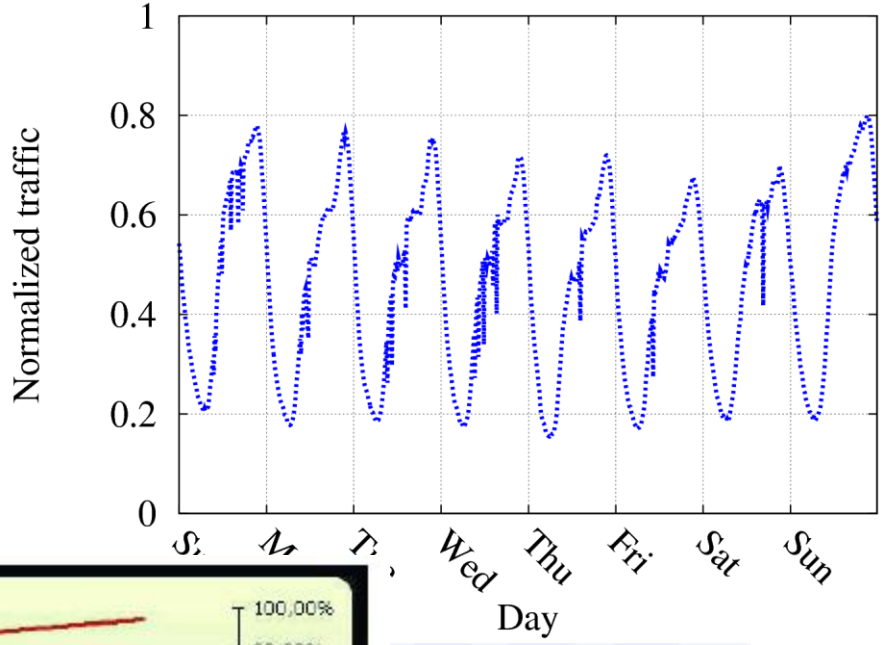
+

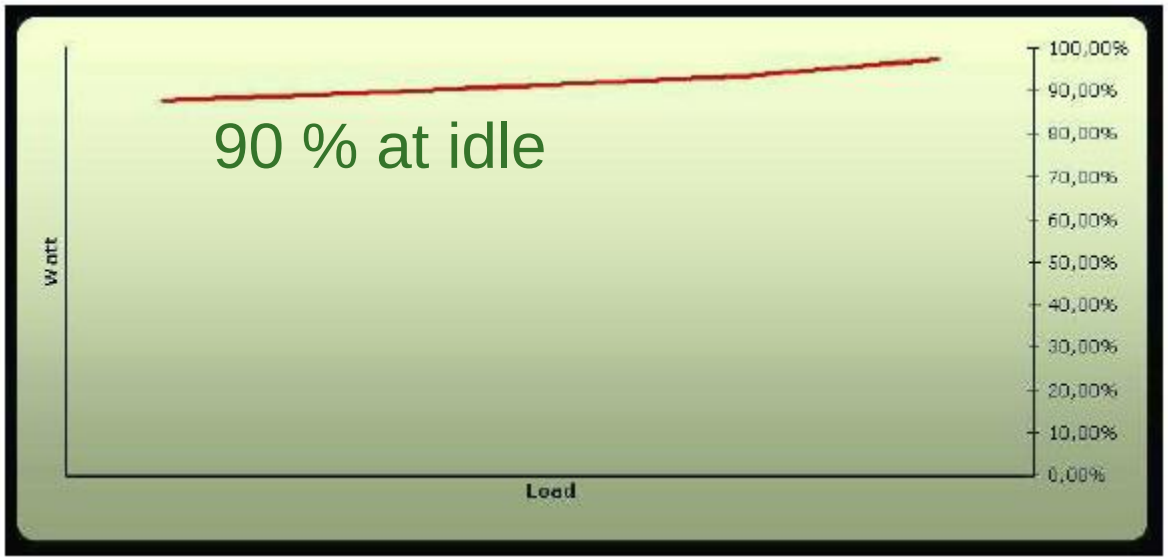
Academic partner with measurement & analysis skills



Start from data…

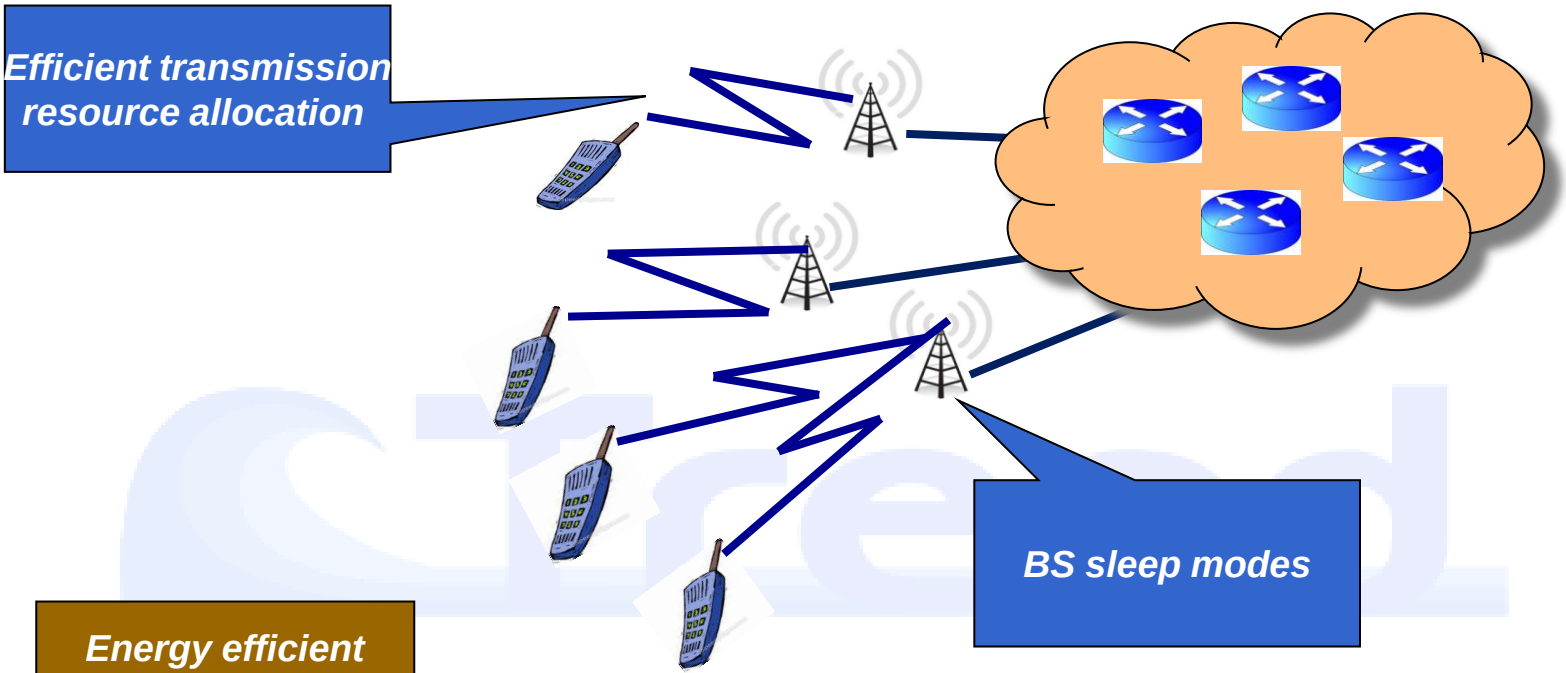
Traffic measurement





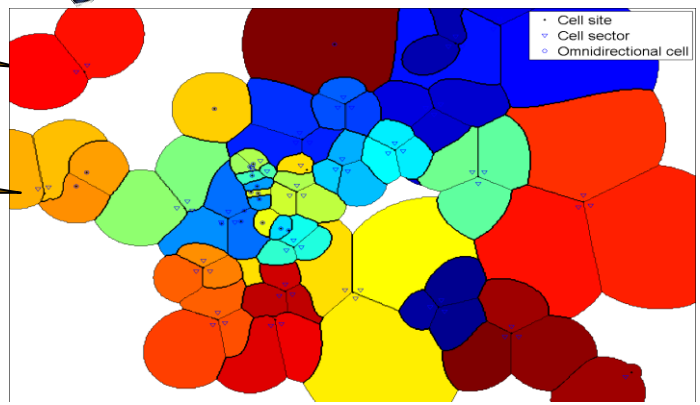
Device consumption

… to solutions at the access



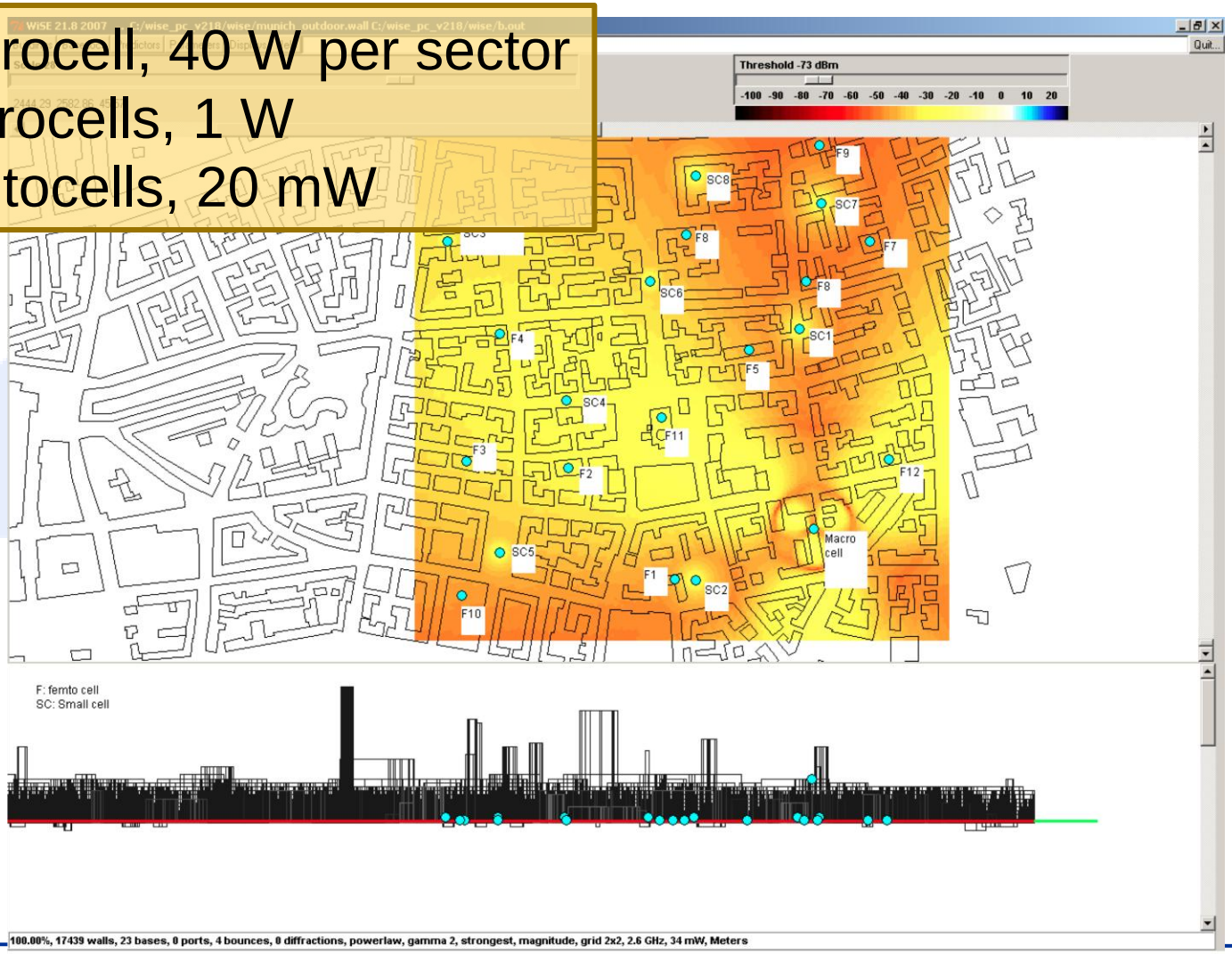
Energy efficient planning

Planning with sleep modes

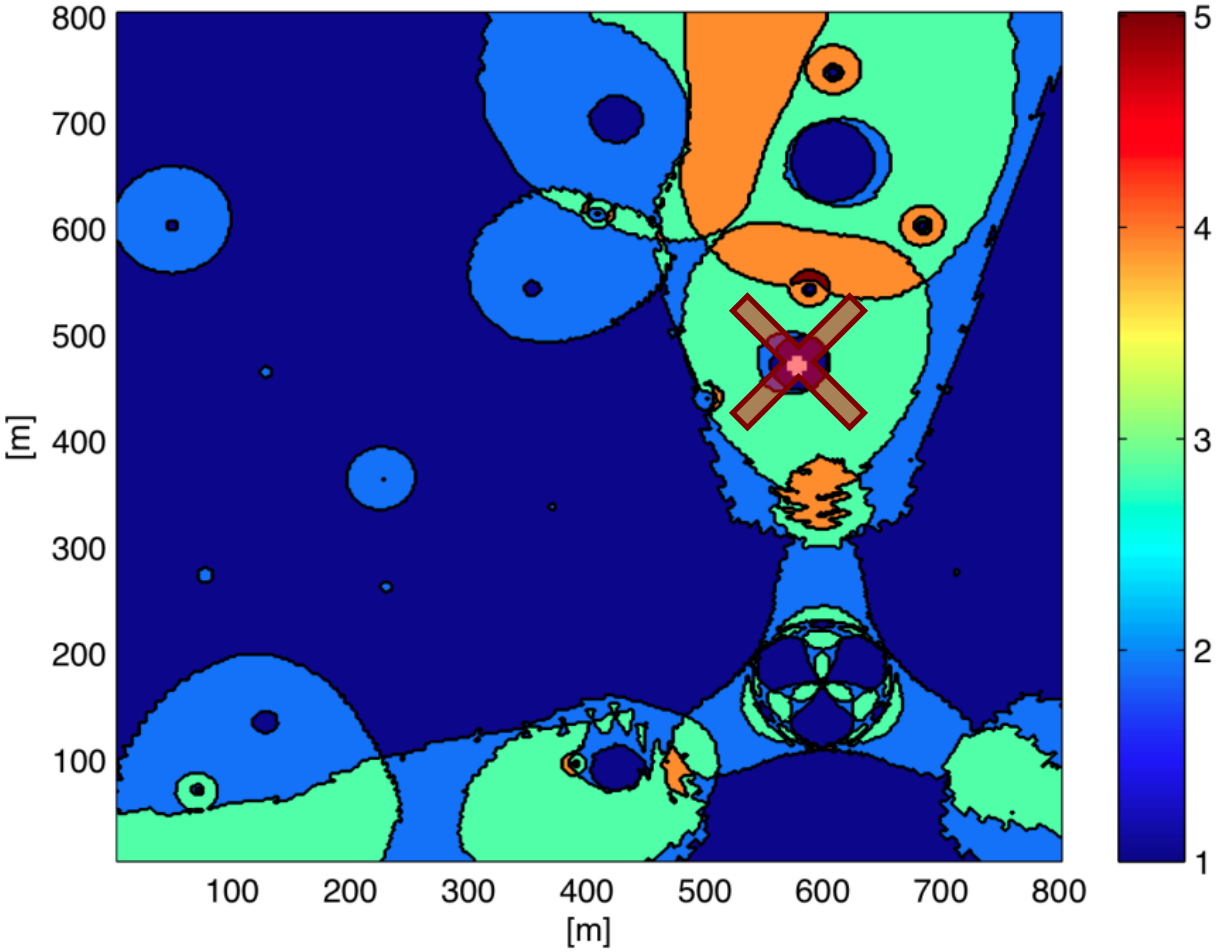


Sleep transients (PoliTO+ALBLF)

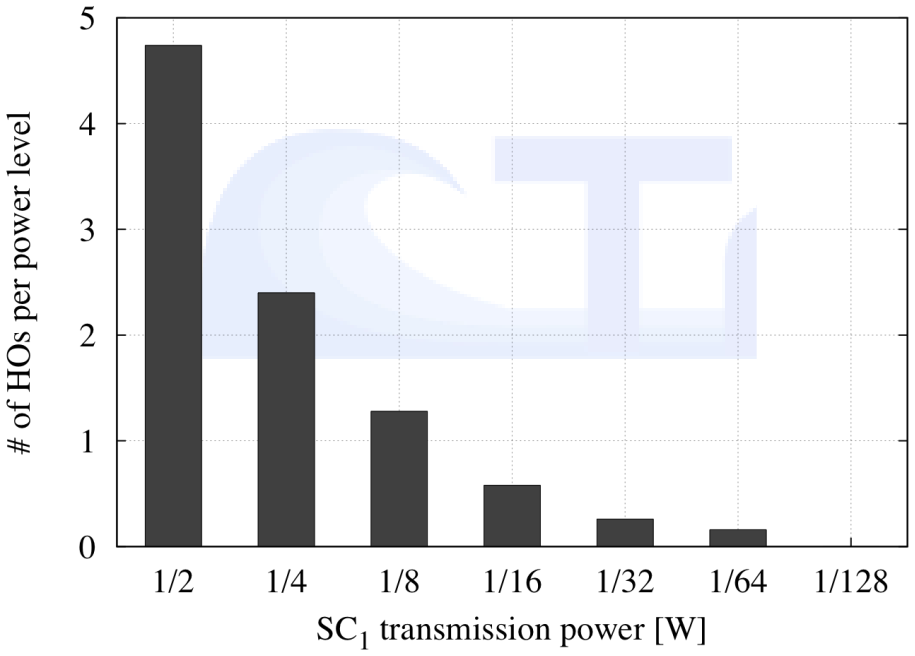
1 macrocell, 40 W per sector
8 microcells, 1 W
12 femtocells, 20 mW

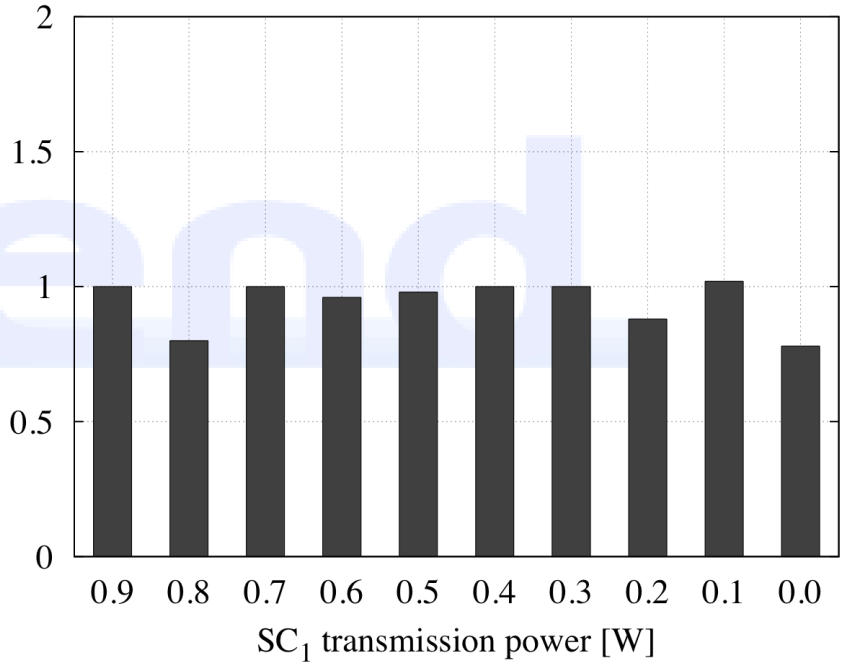


Sleep transients



Sleep transients : Multiplicative and additive profiles

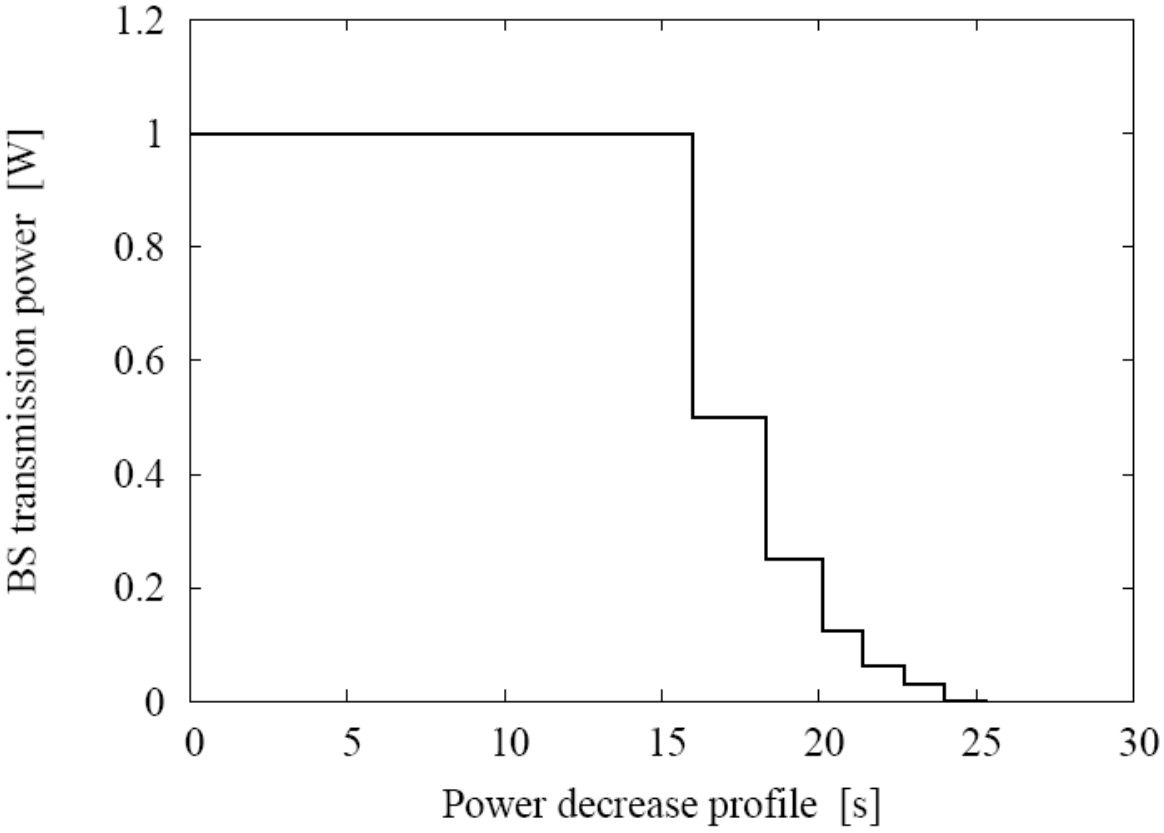




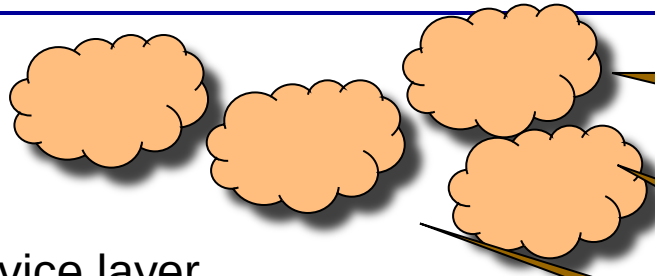
Geometric decrease

Linear decrease

Sleep transients : Geometric decrease profile



and the core



Cloud computing

Content Delivery

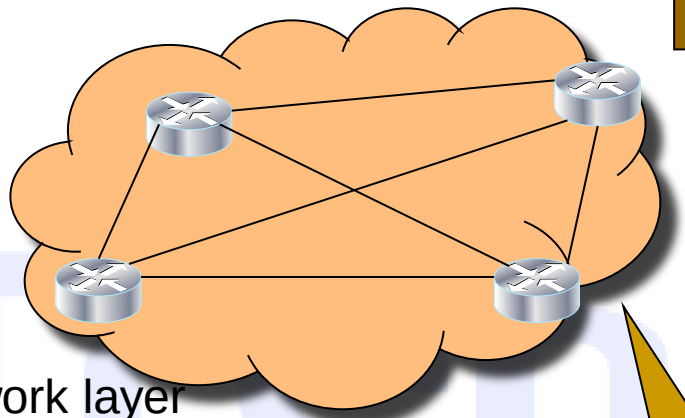
Social networks

Service layer

Planning

Control

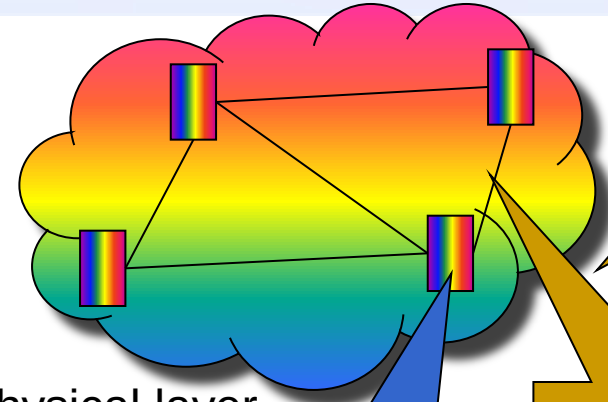
Evaluation of heuristics



Network layer

Generic evaluation of architectures

Energy-efficient architectures



Multilayer optimization tool for core scenarios

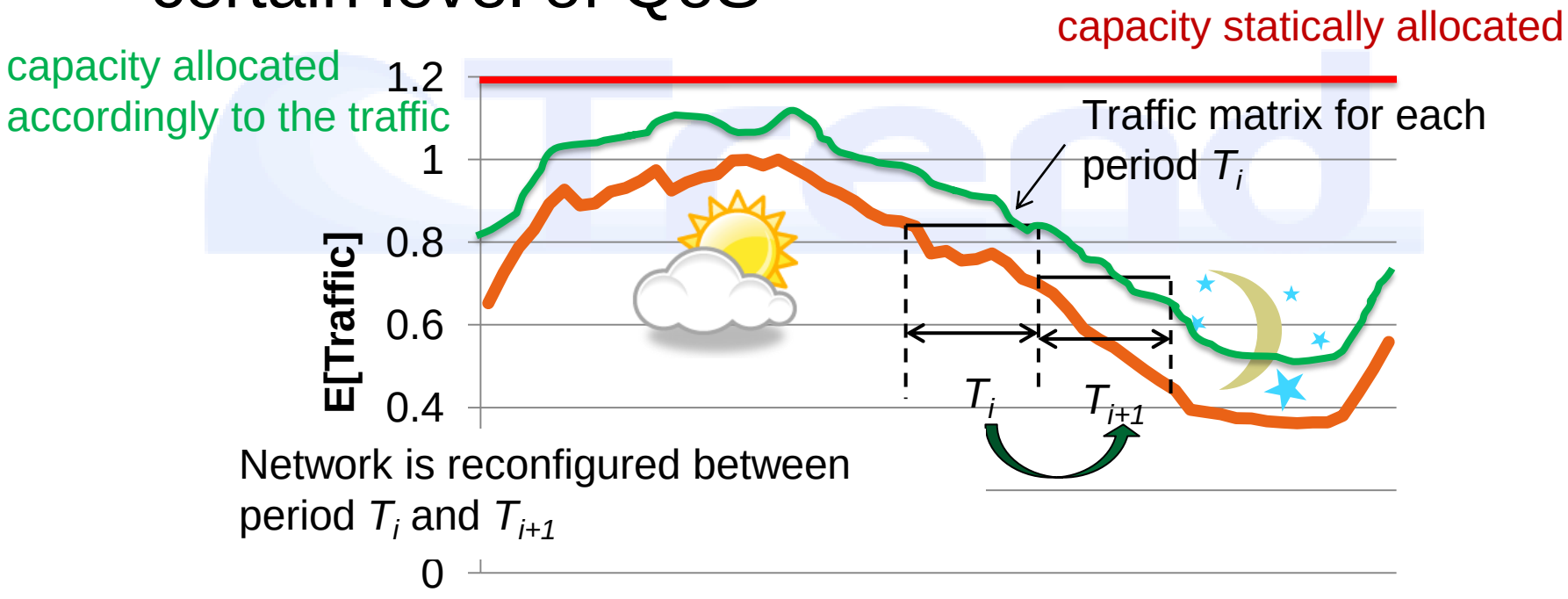
Physical layer

Use of sleep mode

Transmission techniques

Power-Aware Logical Topology Design (TUB+FT+PoliTO)

- Exploit the traffic dynamics to switch off unnecessary resources while ensuring a certain level of QoS

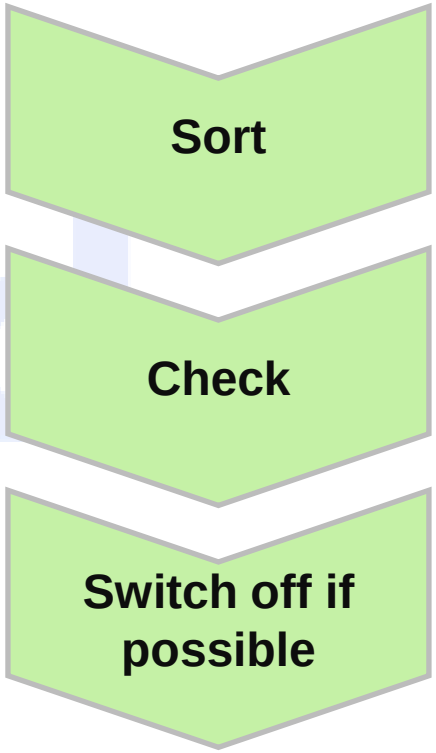


Least Flow Algorithm (LFA)[5]

- Inputs:
  - Static base network designed considering peak traffic
  - Traffic demand of period T_i

1. Sort logical links (increasing traffic volume)
2. For each logical link ***k*** :
   a. Recompute routing in the network without link ***k***
   b. If network without link ***k*** is
      - neither disconnected
      - nor overloaded

      reroute traffic and power link ***k*** off



[5] L. Chiaraviglio, M. Mellia, and F. Neri, “Reducing power consumption in backbone networks,” in ICC 2009.

Genetic Algorithm (GA)[6] (1)

- Input:
  - Current traffic matrix
  - Previous period Logical Topology (LT)
- Individual:
  - Represents a feasible LT (all the traffic requests can be routed over it)
- Fitness function: $\alpha \times P + (1-\alpha) \times C$

$a \hat{\mathrm{I}} \langle 0;1 \rangle$

Power consumption

Reconfiguration costs

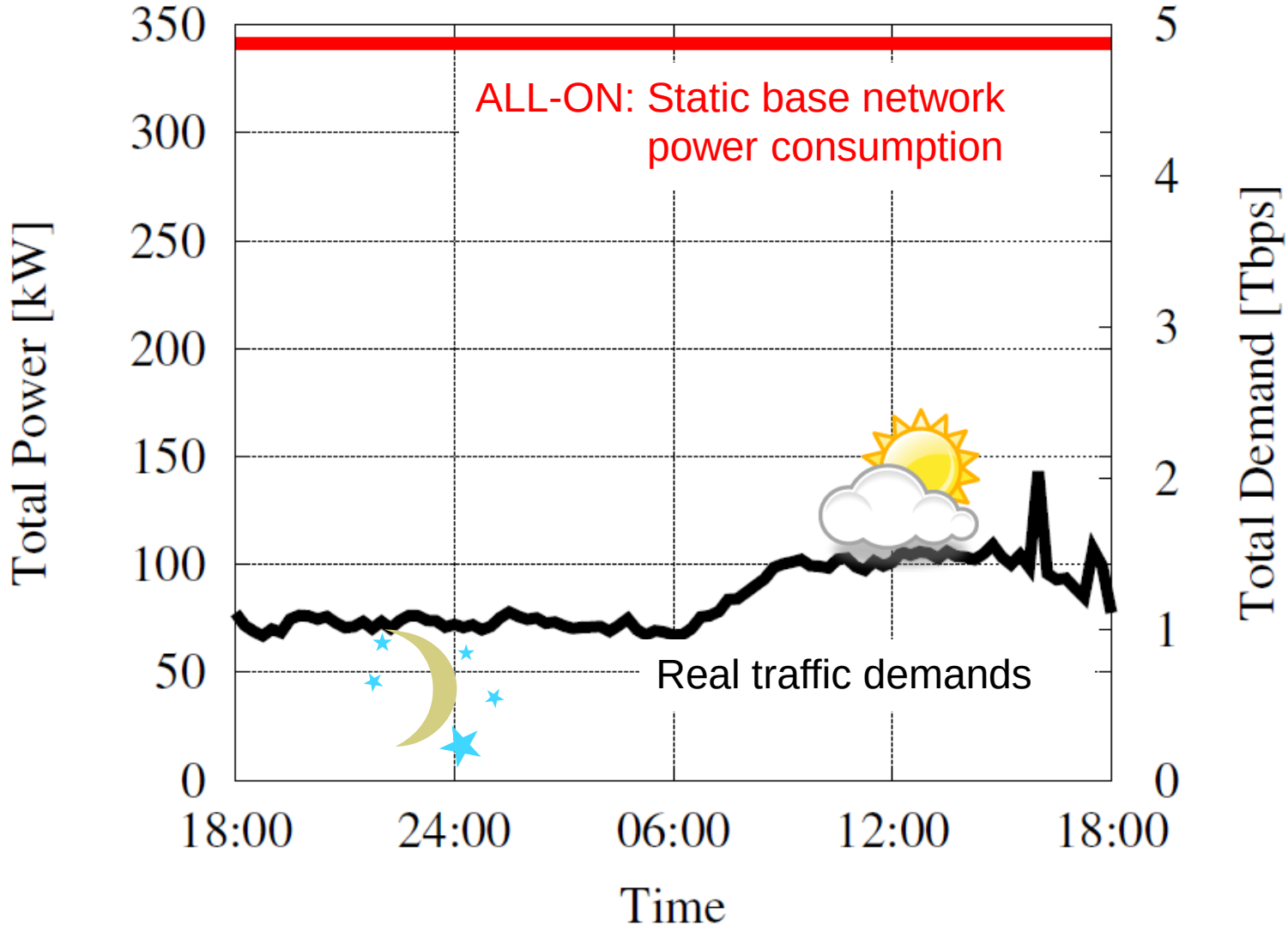
[6] E. Bonetto *et al.*, "Power-aware logical topology design heuristics in wavelength-routing networks," in ONDM 2011.

Scenario and settings

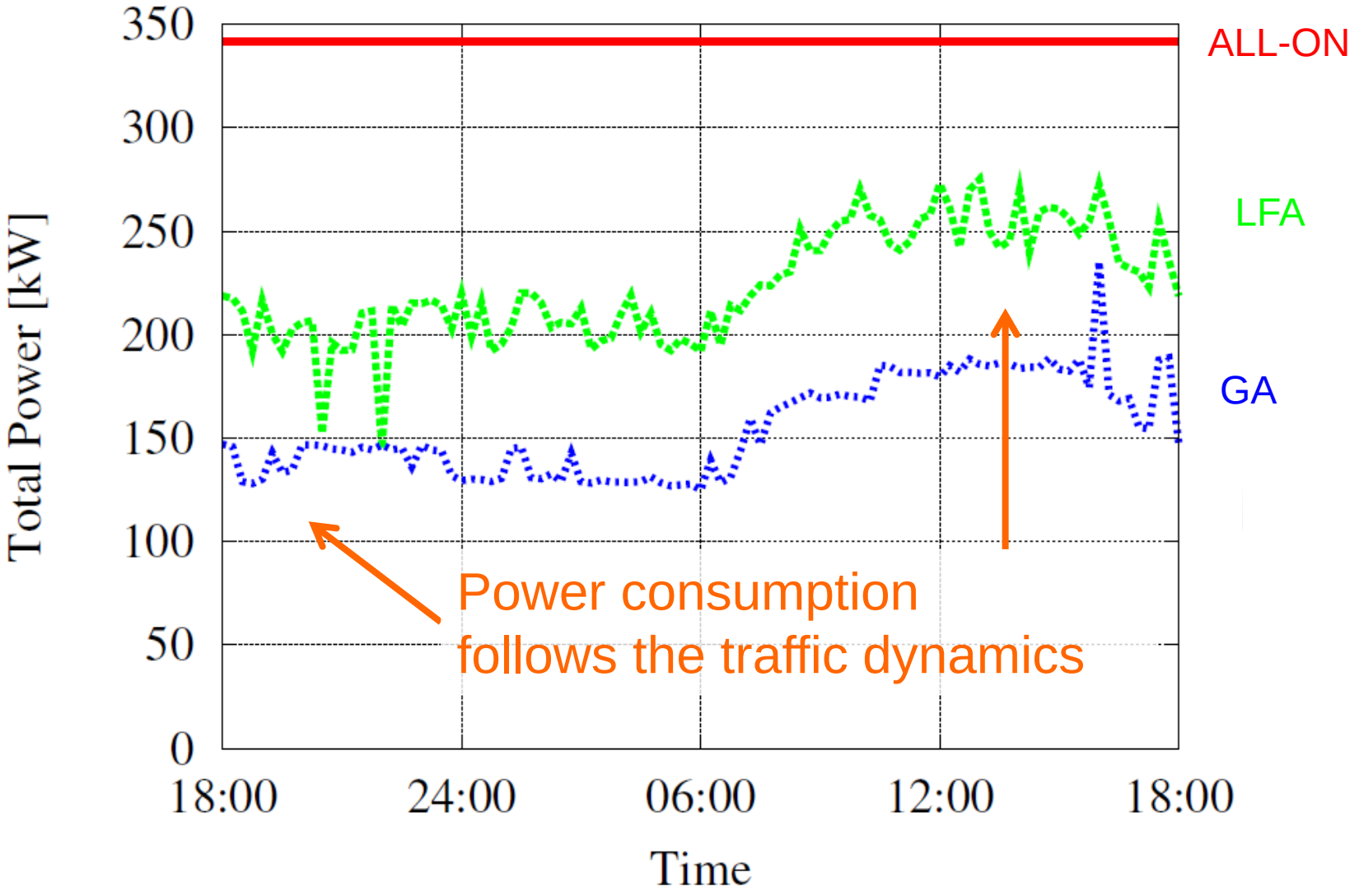
- Network settings:
  - 12 nodes Abilene network[7]
  - 96 real traffic matrices (measured every 15 min.)[7]
    - From 18:00 on 2004-05-31 to 17:59 on 2004-06-01 MDT
    - Maximum traffic matrix scaled up to 3 Tbps of total demand

[7] Y. Zhang, “6 months of Abilene traffic matrices,” http://www.cs.utexas.edu/~yzhang/research/AbileneTM/ (2004).

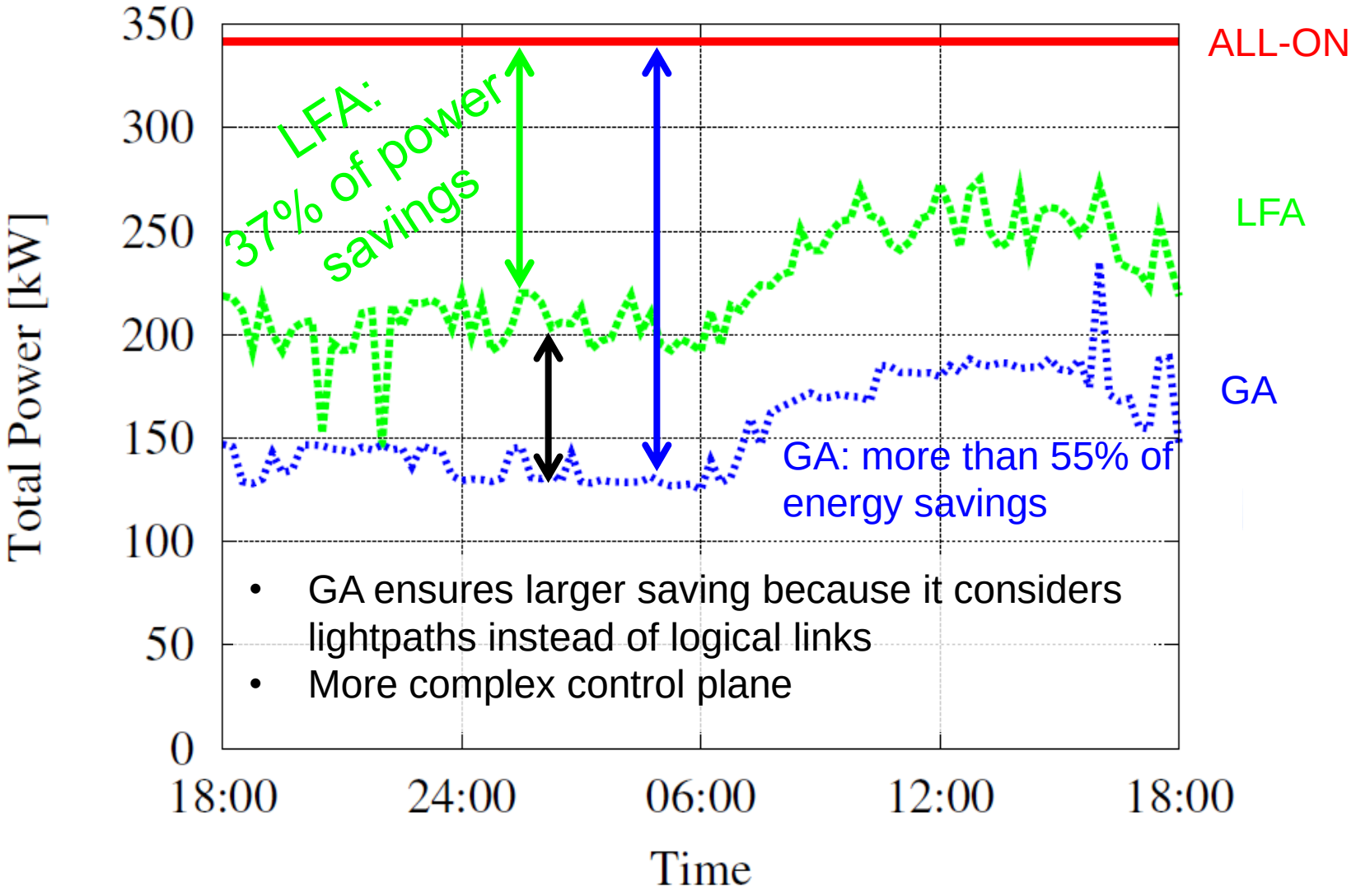
Traffic and static base network



Results: power consumption and traffic

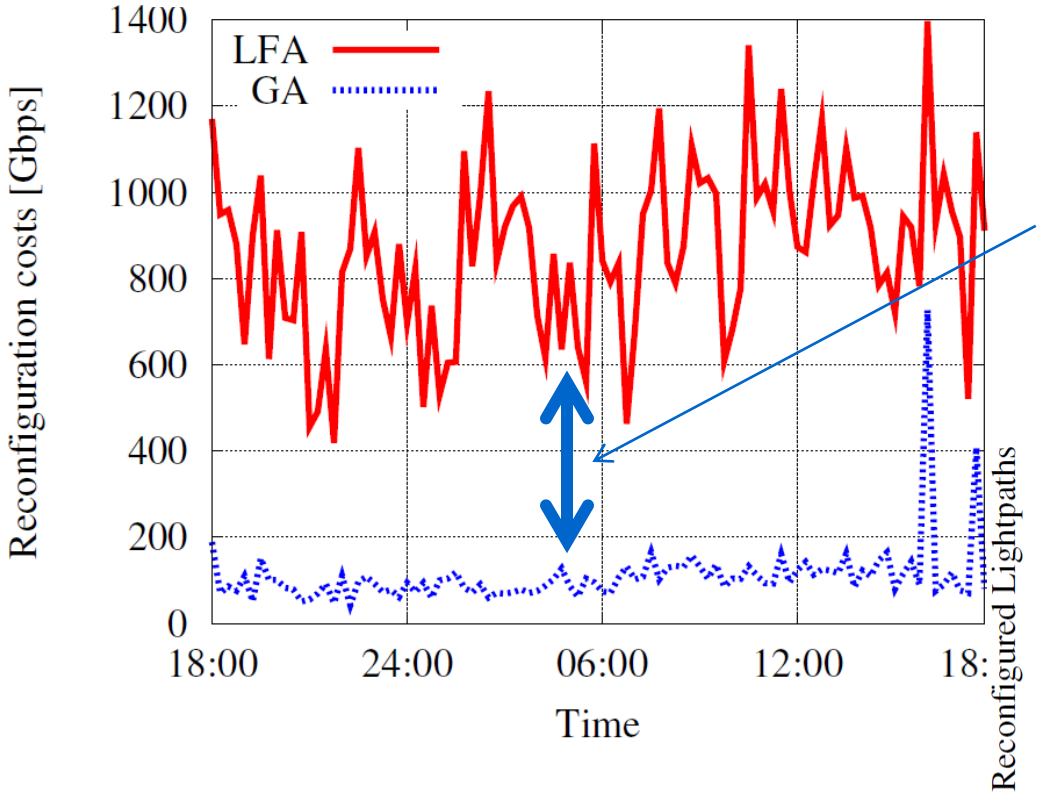


Results: power cons. (LFA, GA, SBN)

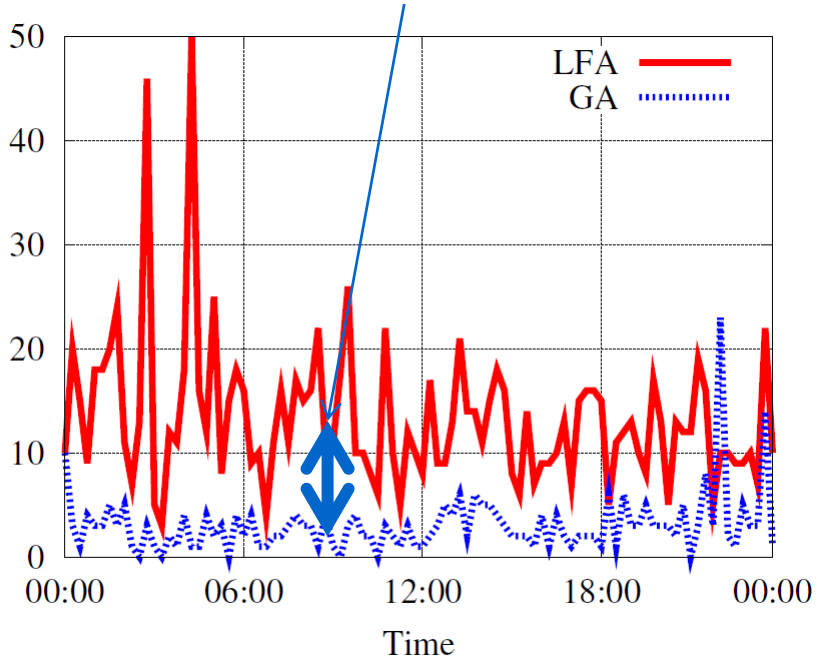


Results: reconfiguration costs

Traffic added to each lighpath



GA shows lower reconfiguration costs



Number of lighpaths changing between two consecutive intervals

Current Collaborating Institutions

Current CIs

- Politecnico di Milano (Italy)
- Università di Roma La Sapienza (Italy)
- Fondazione Ugo Bordoni (It
- Technische Universitat D
- Deutsche Telekom
- Institute IMDEA Netw
- Boston University (U

Please consider becoming a **TREND Collaborating Institution**!

Pending CIs:

- Zhejiang University (China)
- DTU Fotonik (Denmark)

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More information at:

http://www.fp7-trend.eu

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