



# on Greening Content in the Internet



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**Tokyo, 19<sup>th</sup> January 2012**

**This talk is about**  
**“How we can do a more Energy Efficient**  
**Internet where *Content is King*”**

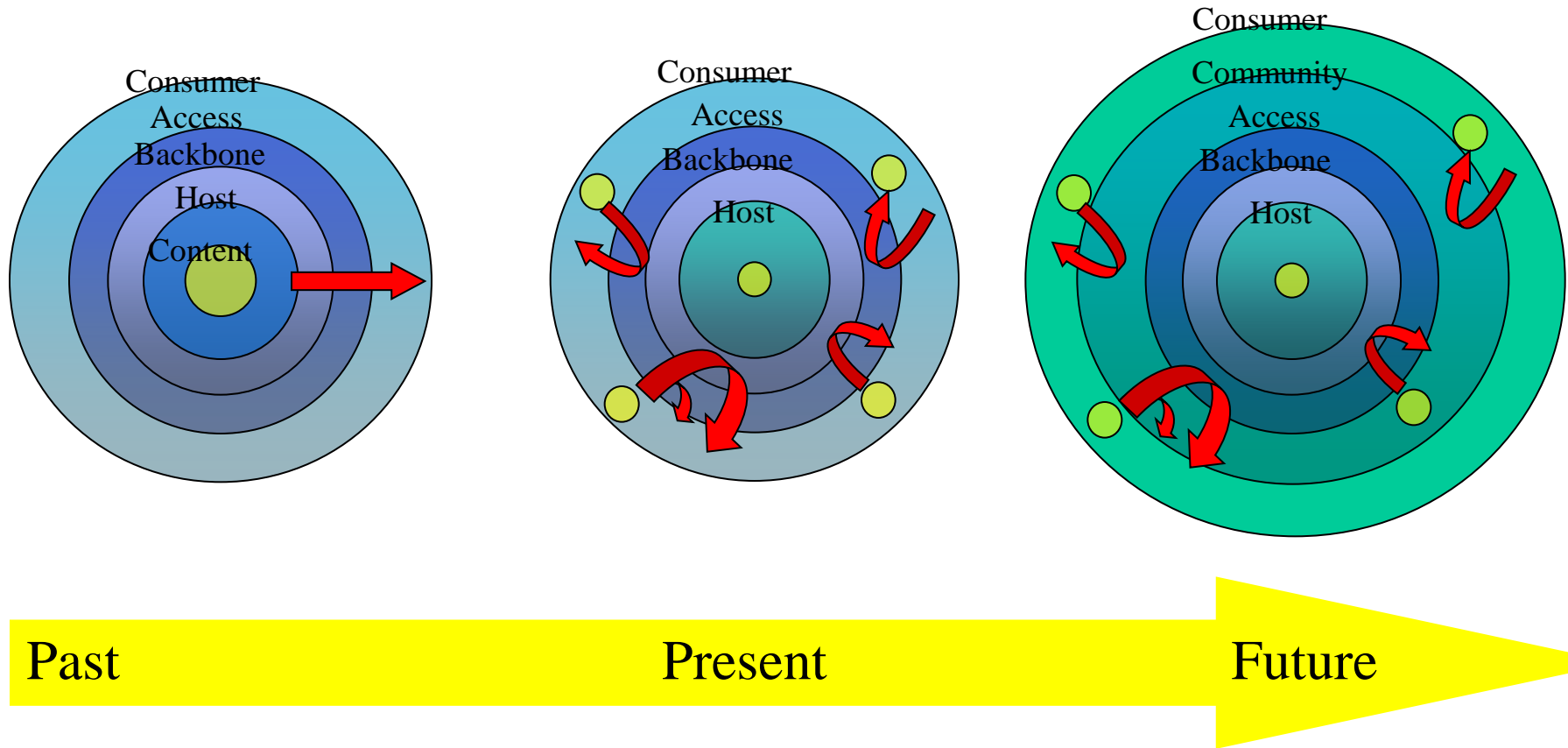
# Once upon a time....

## **Content Is King – Bill Gates (1/3/1996)**

Content is where I expect much of the real money will be made on the Internet, just as it was in broadcasting.

The television revolution that began half a century ago spawned a number of industries, including the manufacturing of TV sets, but the long-term winners were those who used the medium to deliver information and entertainment.

# Shifting Content and Infrastructures



# Today Media Internet

social networks

knowledge sharing

friendster



personalized browsers.

content sharing

search engines



the social web browser

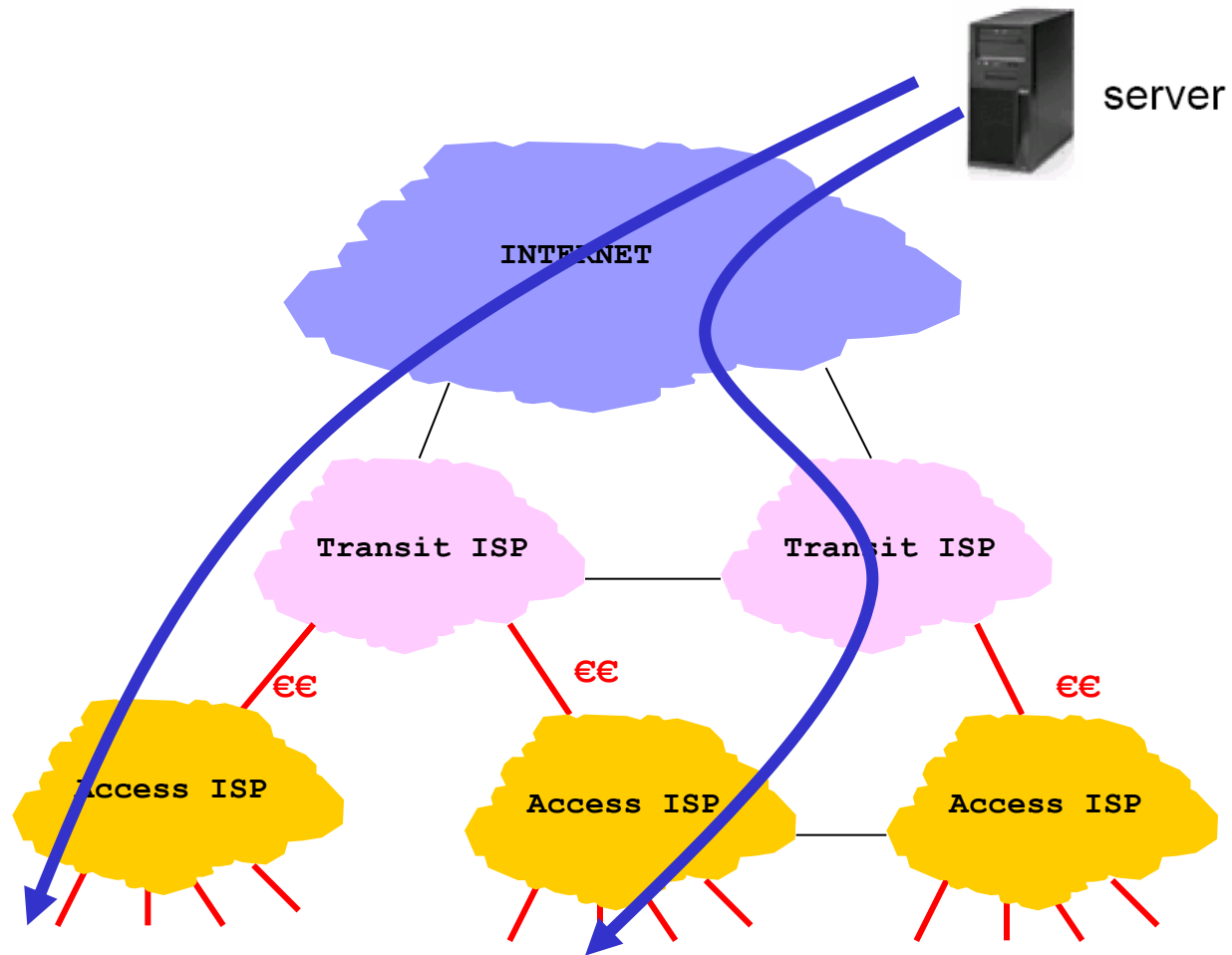


# Today Media Internet (ii)

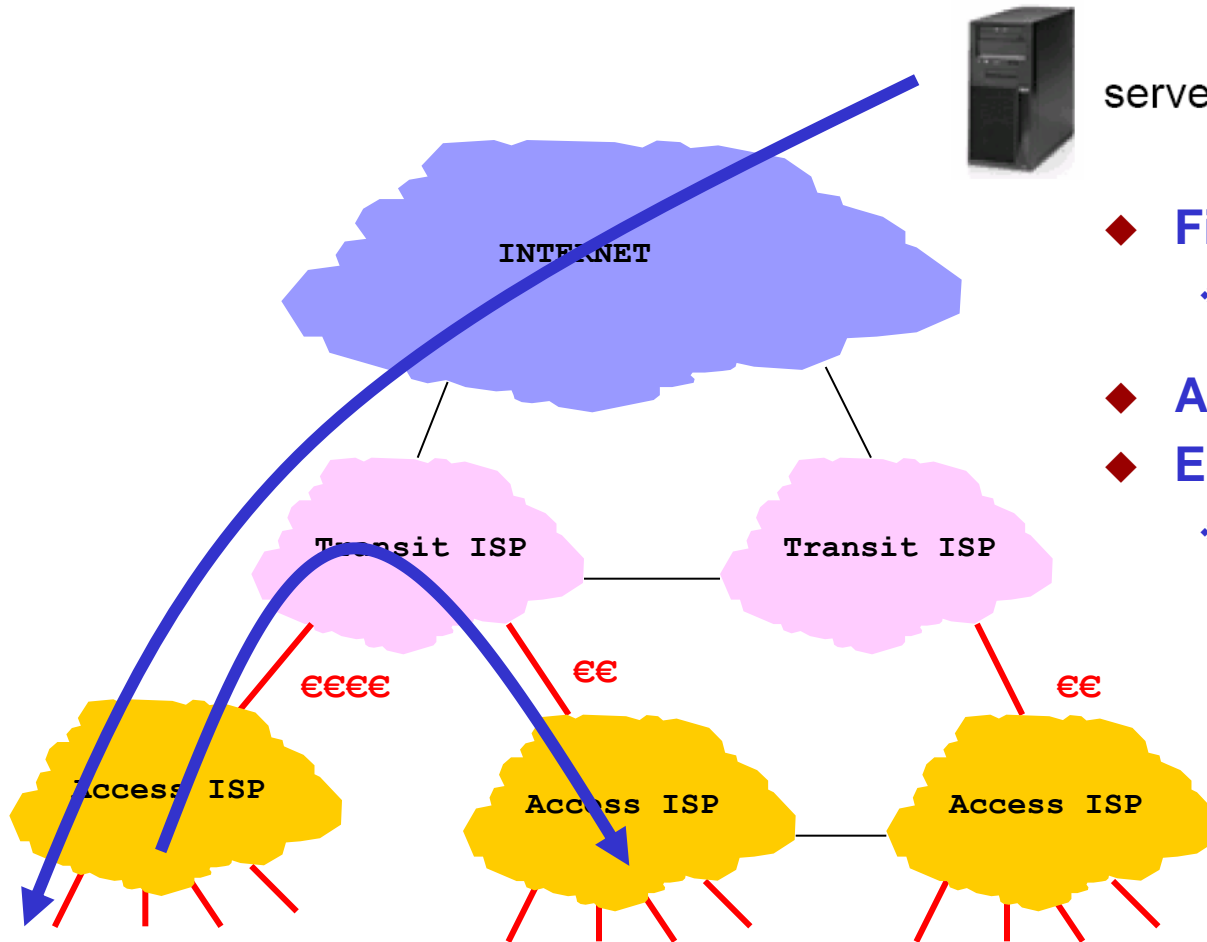
◆ And much more almost every day...



# Client-Server Economics



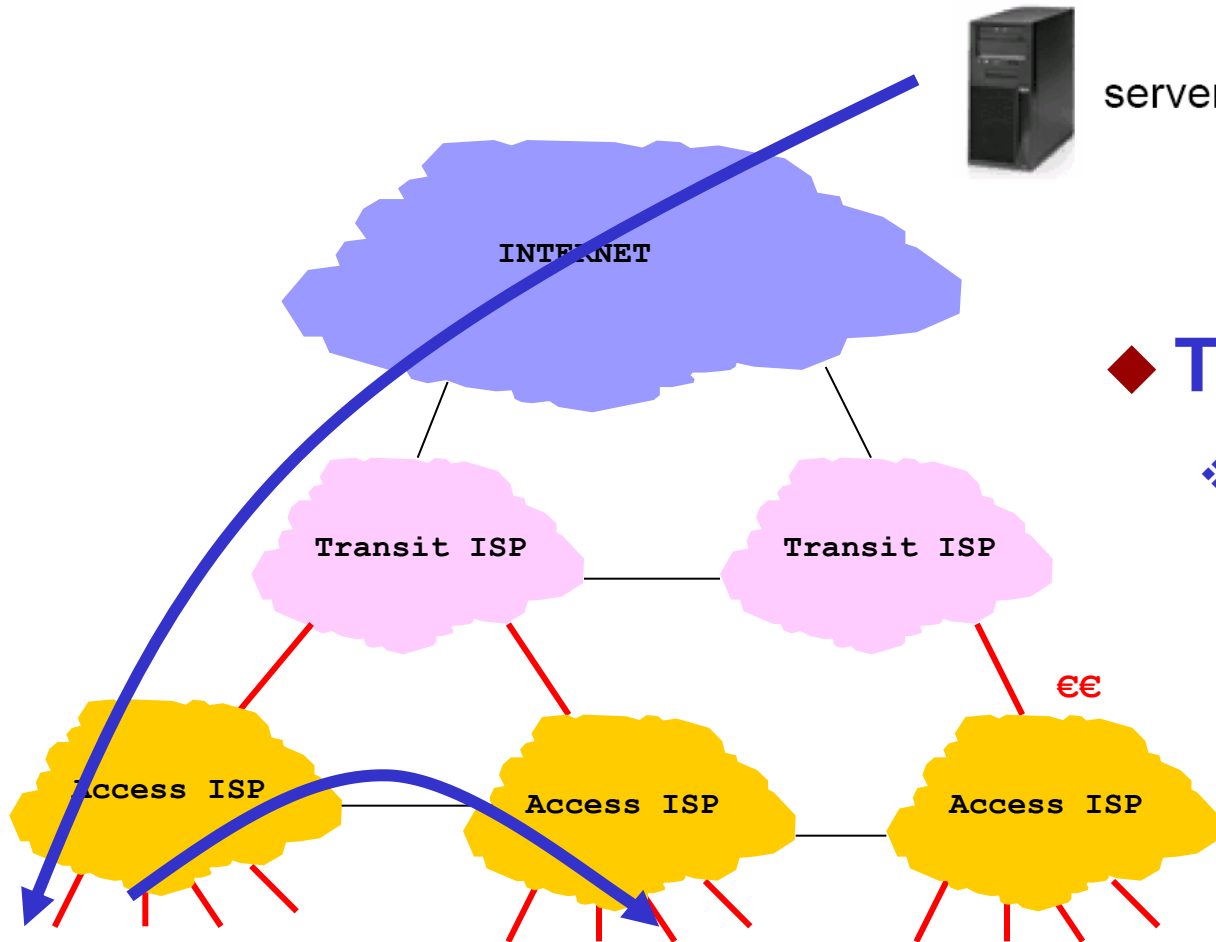
# P2P Economics



server

- ◆ Filtering out P2P traffic
  - ❖ But P2P increases access demands (€€)
- ◆ Add caches
- ◆ Enrich connectivity
  - ❖ Peering between access ISPs

# P2P Economics



◆ That means:

❖ **Flattening Internet**

# Flattening the Internet

**The world is Flat: A Brief History of the  
Twenty-First Century. Thomas Friedman**

# Flattening the Internet

**The world is Flat: A Brief History of the  
Twenty-First Century. Thomas Friedman**

**and**

***It's also increasingly in the palm of your  
hand...***

# Flattening the Internet

**The world is Flat: A Brief History of the  
Twenty-First Century. Thomas Friedman**

**and**

***It's also increasingly in the palm of your  
hand...***

***and***

***Increase the needs of battery/power***

***“Content is King  
or***

**How we can make the Content Green”**

# Content is not Green

- ◆ **Content distribution infrastructures consume substantial amounts of energy.**
- ◆ **Servers and data centers consumed around 100 billion kilowatt hours at a cost of 7.4 billion USD in 2011.**
- ◆ **To meet the growing demand for content:**
  - ❖ **Content providers are enlarging data centers**
  - ❖ **Network providers are increasing network capacity**

# Content is not Green

**Providers invest in more content distribution infrastructures, which consume a substantial amount of energy.**

# Research today

- ◆ Most research focused on energy consumption/optimization at data centers
- ◆ Dynamic resource provisioning (e.g., DVFS, sleeping)
- ◆ Request routing to a data center with lower energy costs
- ◆ Energy-proportional computing: power consumption  $\sim$  utilization
- ◆ Researchers are seeking energy-proportional (EP) networking

# But...

**...user demands increase, so EP  
computing/networking is not the solution**

# Maybe CDN can helps....

Shifting content to the users...

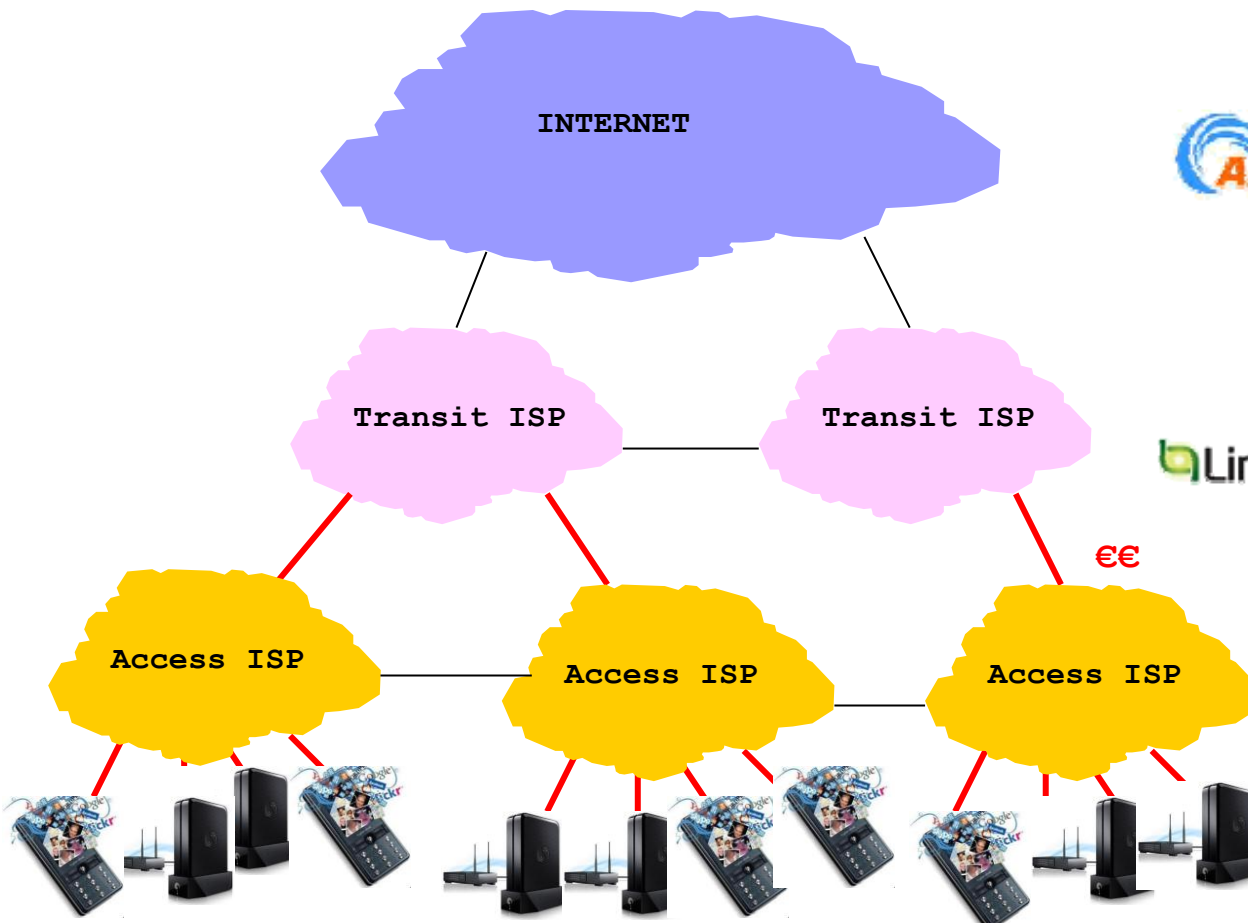
...means

hop count reduction and overall network  
traffic reduction

and

energy savings

# CDNs today



- ◆ Akamai
  - ❖ 40,000 servers
  - ❖ 900 PoPs, 71 countries
  - ❖ 300 Gbps



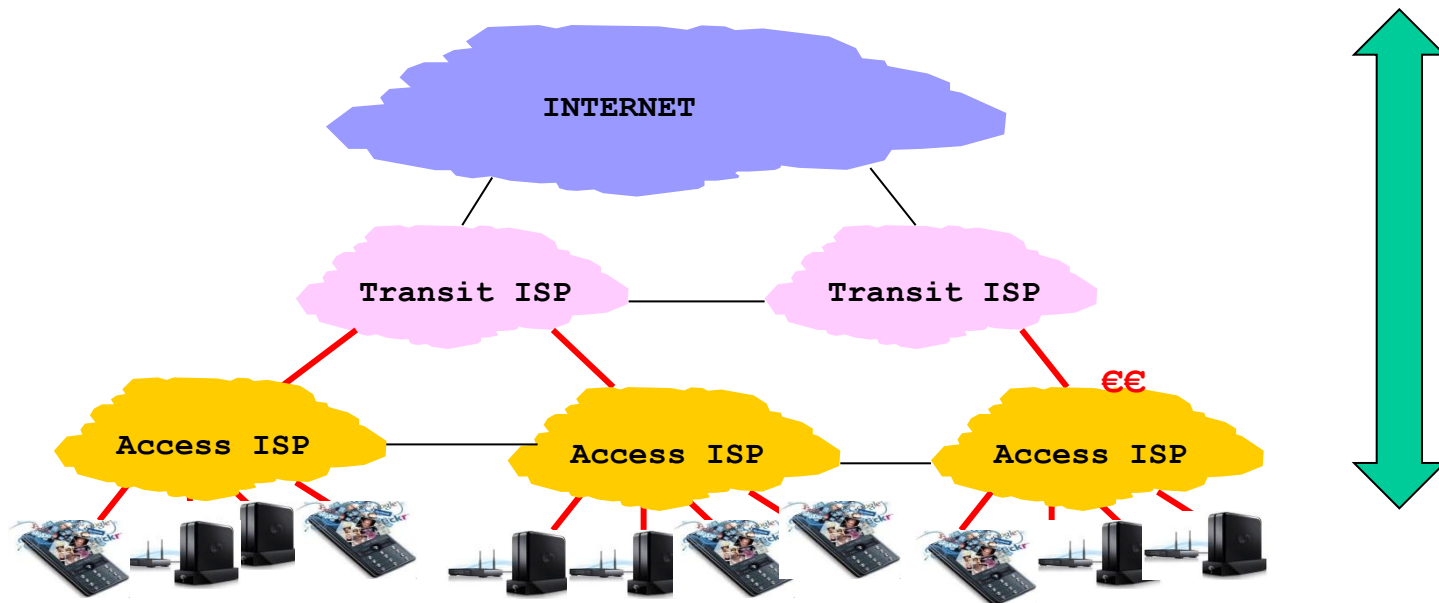
- ◆ Limelight
  - ❖ 25,000 servers
  - ❖ 25 PoPs
  - ❖ 1,000 Gbps

- ◆ CDN servers at home (PC, STB)



- ❖ NADA, BitTorrent

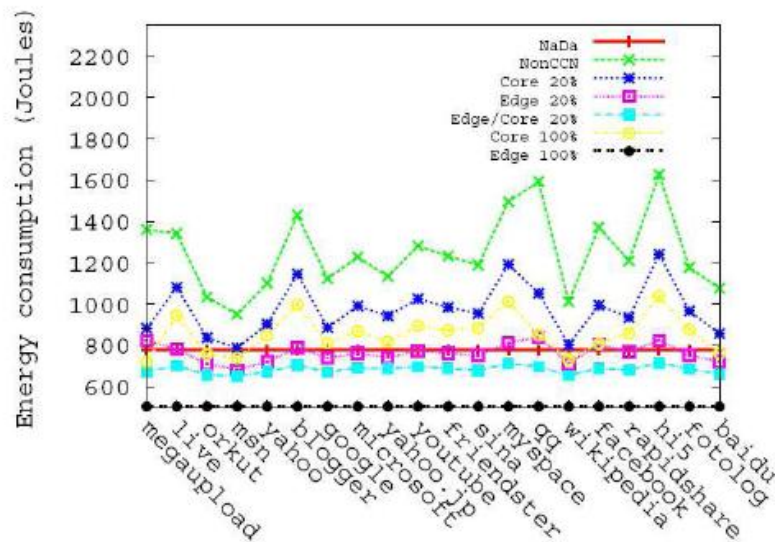
# CCN on stage



- ◆ Routers support content caching throughout the network.
- ◆ No need for dedicated infrastructure components.
- ◆ A simple model for CCN router energy consumption
- ◆ Memory hierarchy to support content caching in routers
- ◆ Example: Memory 4G ~ 10W, SSD 32G ~ 1W, Disk ~ 12W (if needed)

# Current research on Green CCN

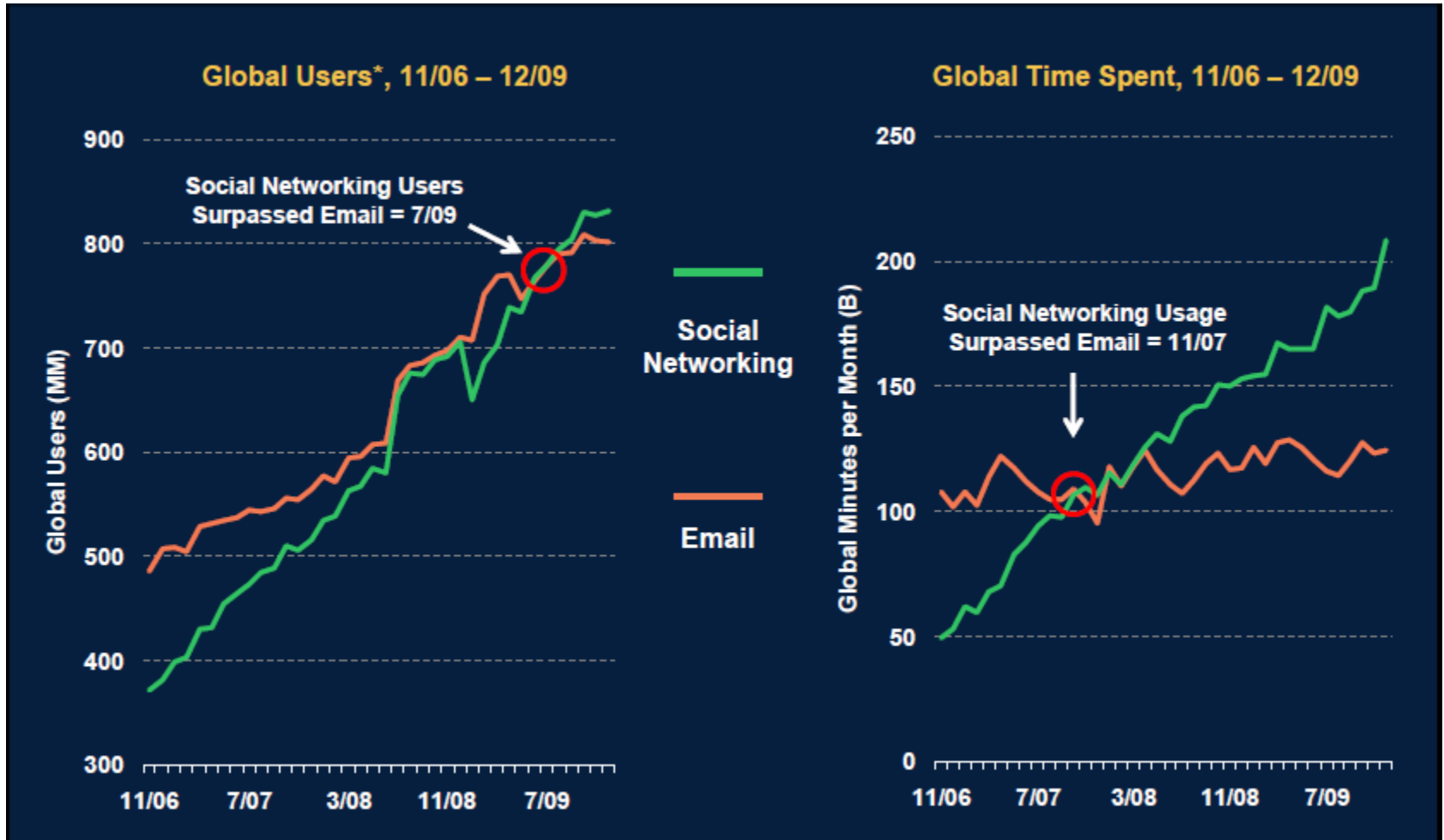
- ◆ **Comparision of EE of p2p, cdn, nada and ccn**
  - ❖ **Experiments by Volker Hilt et al, Alcatel-Lucent Bell Labs**
  - ❖ **Path energy model: content server, core/edge router, DSLAM/OLT, home gw**
  - ❖ **Metric: energy consumption per dowloading 1Gb**
  - ❖ **Scenarios with different levels of CCN deployment**



# The particular case of the OSN

# Evolution of Internet Traffic

## socialnets > email



Source: comScore global, Morgan Stanley Research

# TREND NoE and Green OSNs

- ◆ **How green is the networking infrastructure of the OSNs?**
  - ❖ **Intensive crawling of Twitter, Facebook and G+**
  - ❖ **Research based on Internet scale measurements**
  - ❖ **Important collection of datasets**

# TREND NoE and Green Content

- ◆ **Not only green aspect, but also a more global characterization of the OSNs**
- ◆ **Understanding the locality effect**
  - ❖ **improve/optimize distributed architectures (e.g. where to place a cache server)**
- ◆ **Understanding the information flow**
  - ❖ **does the distance between two users influence the probability that these two users interact in Twitter?)**
- ◆ **Facebook graph analysis > 280M relations**
- ◆ **Google Plus graph analysis > 215M relations**
- ◆ **Compare Twitter, Facebook and G+**

Micro  
Twee  
Frien  
Some  
20  
+  
S  
T  
m

The screenshot shows the Twitter website interface. At the top, there is a navigation bar with the Twitter logo, a search bar labeled "Buscar", and links for "Inicio", "Perfil", "Mensajes", and "A quién seguir". The user's profile "robegs" is visible in the top right corner.

The main content area is titled "What's happening?" and features a text input field. Below this, there are tabs for "Cronología", "@Menciones", "Retweets", "Búsquedas", and "Listas".

The tweet feed includes:

- A tweet from **SergioRamos** (Sergio Ramos) posted 1 minute ago, mentioning "3 puesto finalmente para SR4,2 puesto para Benzema y el mítico Pirata primer puesto." with a link to [pic.twitter.com/EuX9c716](http://pic.twitter.com/EuX9c716).
- A tweet from **SamFirmware** (SamFirmware) posted 5 minutes ago, sharing firmware information for Samsung S5570 (Android 2.3.4).
- A tweet from **SamFirmware** (SamFirmware) posted 5 minutes ago, sharing firmware information for Samsung I9103 (Android 2.3.5).
- A tweet from **realmadrid** (Real Madrid) posted 5 minutes ago, mentioning a photo of Marcelo during an Audi event with a link to [on.fb.me/mYjOlt](http://on.fb.me/mYjOlt) and the hashtag #realmadrid.
- A tweet from **realmadrid** (Real Madrid) posted 9 minutes ago, mentioning a photo of Iker Casillas at an Audi event with a link to [on.fb.me/nui7Z9](http://on.fb.me/nui7Z9) and the hashtag #realmadrid.
- A tweet from **realmadrid** (Real Madrid) posted 10 minutes ago, mentioning a photo of Iker Casillas during a car handover with a link to [on.fb.me/qHf8Dp](http://on.fb.me/qHf8Dp).
- A tweet from **muyinteresante** (MUY Interesante) posted 12 minutes ago, mentioning a song composed in the UK with a link to [bit.ly/oOFVfG](http://bit.ly/oOFVfG).

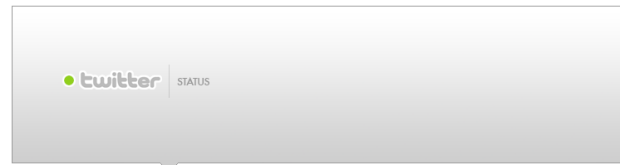
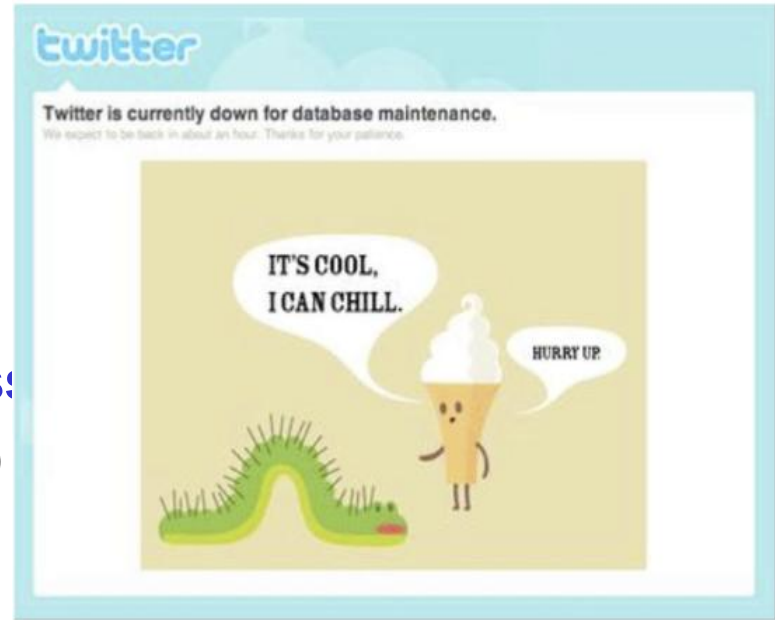
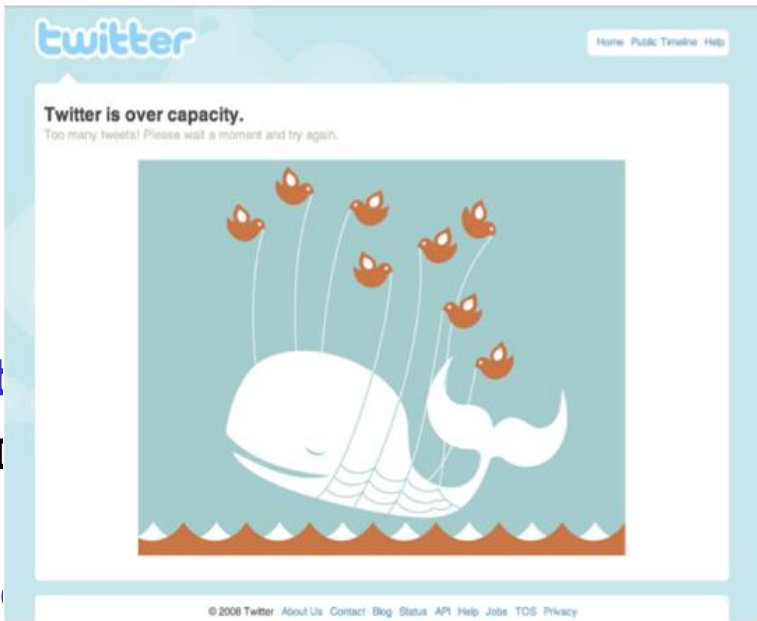
On the right side, there is a sidebar with "Tus Tweets 1.271" (hace 19 horas), "Siguiendo 69", and "Seguidores 45". Below this, there are "Temas del momento" (Global topics) such as #gadhañ, #CoisasGays, Spirit Day, Saddam Hussein, Osama Bin Laden, Lego House, Misrata, Libyans, and Col. There is also a section for "Twitter para iPhone" and a footer with links for "Sobre nosotros", "Ayuda", "Blog", "Móvil", "Estado", "Empleos", "Términos", "Privacidad", "Atajos", "Publicidad", "Negocios", "Media", "Desarrolladores", and "Recursos".

System  
Under

Marketing (e.g. advertise

Greening the Network

Challenge



**MON JUN 27TH** **Misleading error message** 20 hours ago

If you try to follow a user who was recently suspended, you may see an error message that your account is suspended. Really, the account you're trying to follow was suspended; your account is okay. We are working to fix this wording now and apologize for the confusion.

17

Tweet

**SUN JUN 26TH** **Tweet delivery delays for streaming clients** 1 day ago

We experienced temporary delays but the issue has now been resolved.

13

Tweet

**FRI JUN 24TH** **Intermittent errors** 3 days ago

We are experiencing intermittent errors on certain user actions. Some users may see the error message "Your account may not be allowed to perform this action. Try logging out and in again." We are working to fix this.

**UPDATE:** Issue has been resolved. If you are still seeing the error message, refresh the page.

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Updates on the status of the [Twitter](#) service.

**Related Links**  
[Official Company Blog](#)

[Official Help Documents](#)

[Developer Community](#)

[Archive](#)

[RSS](#)

Powered by [Tumblr](#)

# Towards Real Energy-efficient Network Design

Grant agreement n. 257740

THEME [ICT-2009.1.1]

[The Network of the Future]

Coordinator: Marco Ajmone Marsan – Politecnico di Torino

[www.fp7-trend.eu](http://www.fp7-trend.eu)

Politecnico di Torino

Universidad Carlos III de Madrid

Interdisciplinary Institute for Broadband Technology

Technische Universität Berlin

Ecole Polytechnique Fédérale de Lausanne

Consorzio Interuniversitario per le Telecomunicazioni

Panepistimio Thessalias

Alcatel- Lucent Bell Labs France

Huawei Technologies Duesseldorf GmbH

Telefonica Investigacion Y Desarrollo SA

France Telecom SA

FASTWEB SPA

**Academic**

**Manufacturers**

**Operators**

# What is our objective?

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...

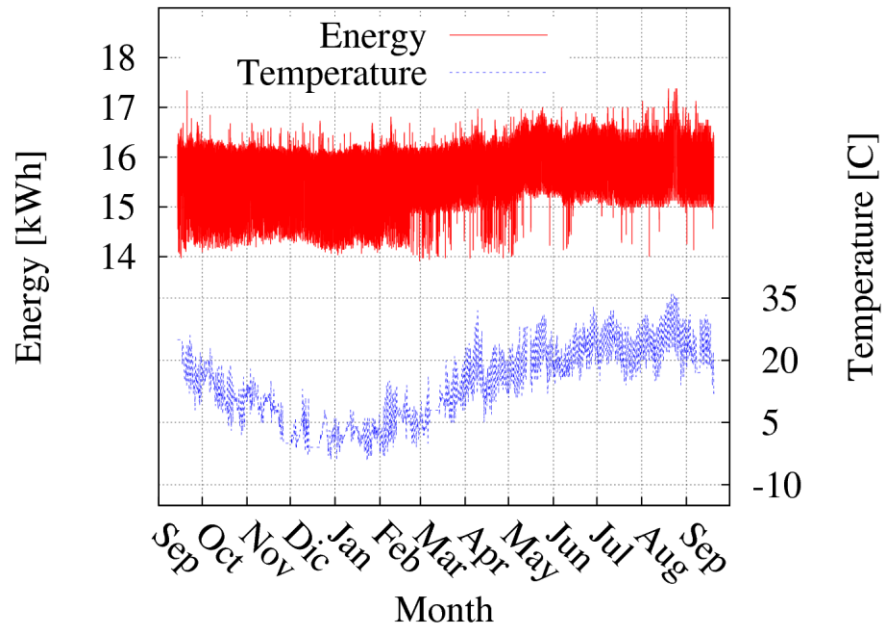
- ◆ **Derive reliable, updated data and models about consumption and traffic**

# Start from data...

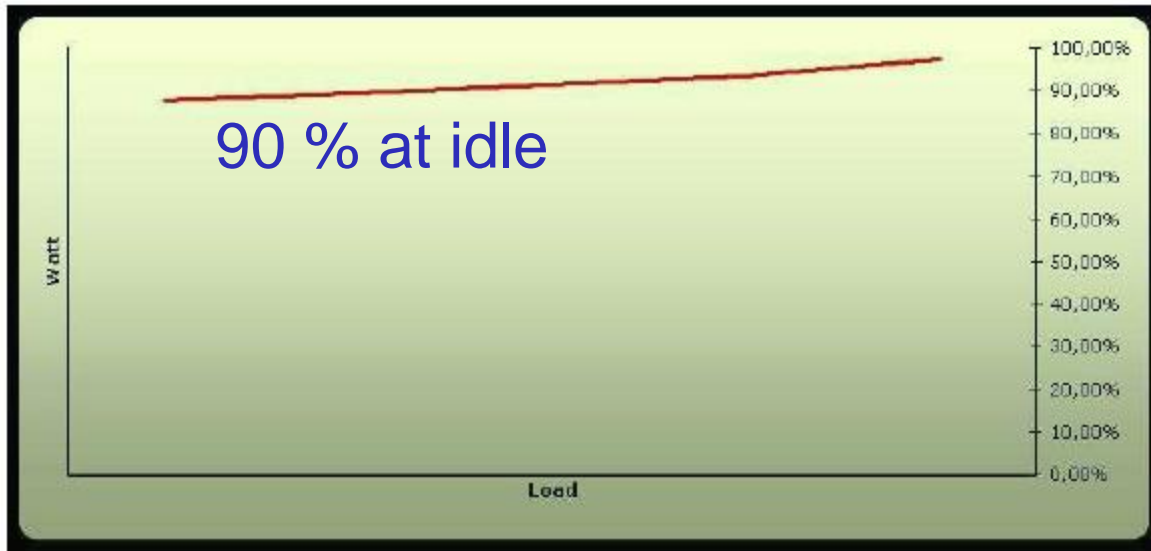
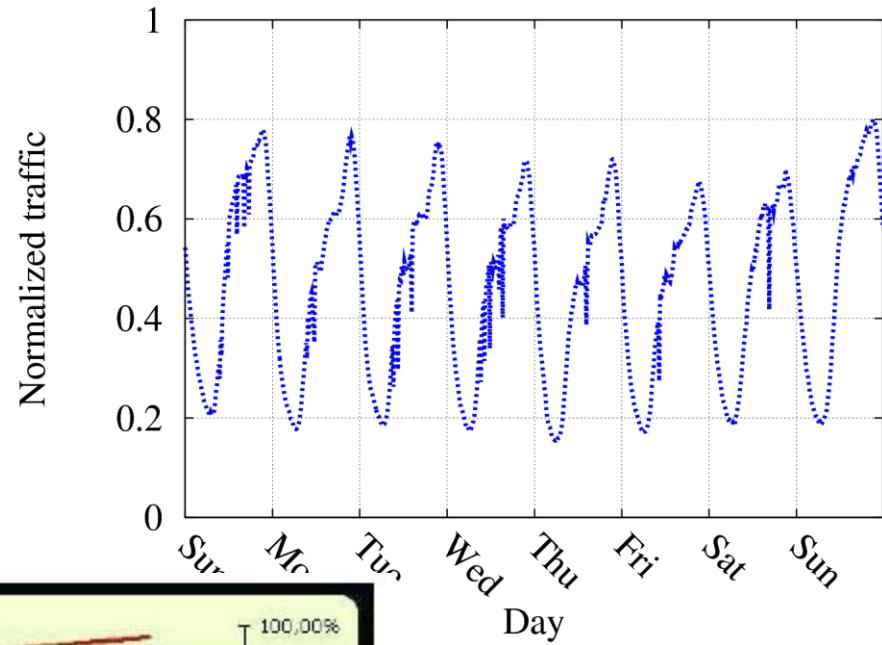
*Operator with monitoring facilities in network in oper.*



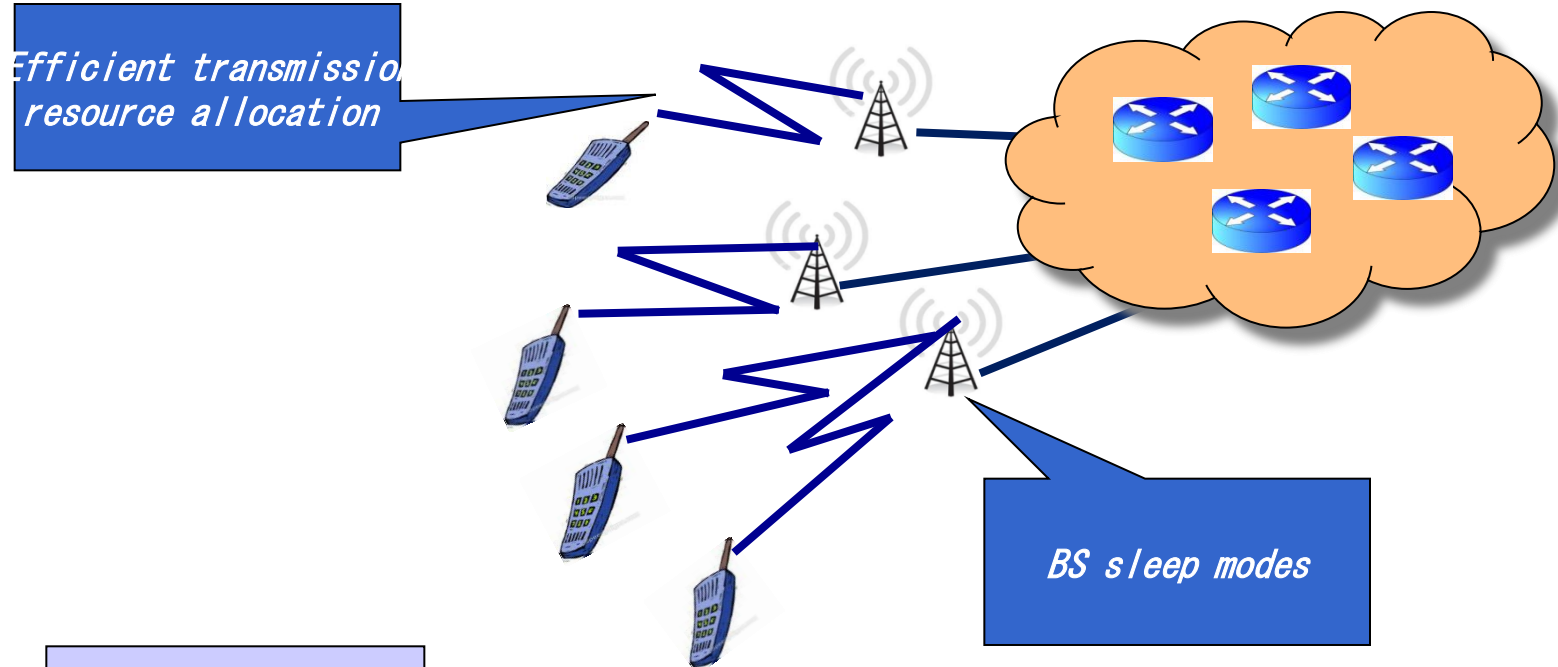
*Academic partner with measurement & analysis skills*



# Start from data...

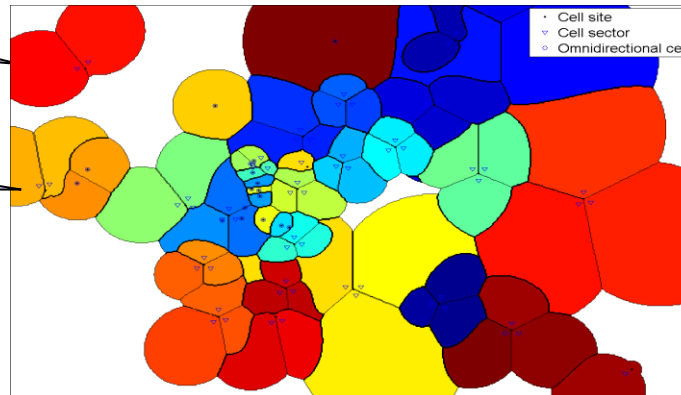


# ... to solutions at the access

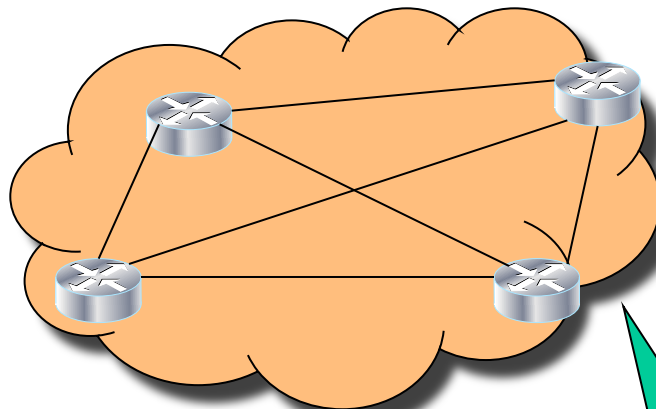
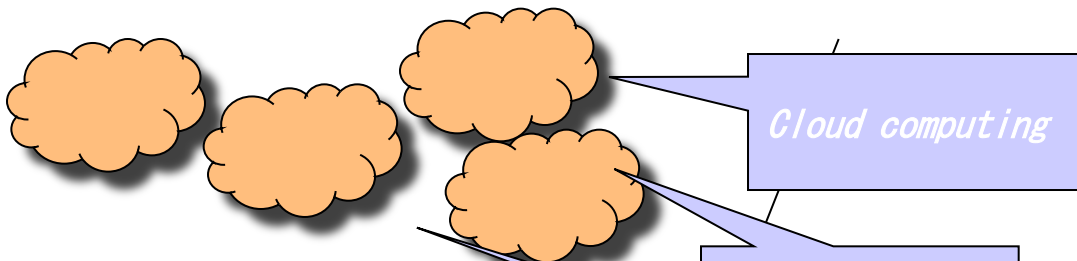


Energy efficient planning

Planning with sleep modes



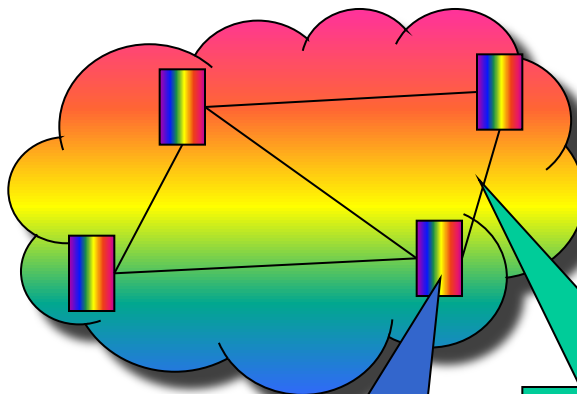
# and the core



Evaluation of heuristics

Generic evaluation of architectures

Multilayer optimization tool for core scenarios



Use of sleep mode

Transmission techniques

# 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**



**e-Energy 2012 Third International Conference  
on Future Energy Systems: Where Energy,  
Computing and Communication Meet**

**May 9-11, 2012 -- Madrid, Spain**

**<http://e-energy2012.networks.imdea.org/>**

**in cooperation with ACM SIGCOMM**

**Deadline 27 January**