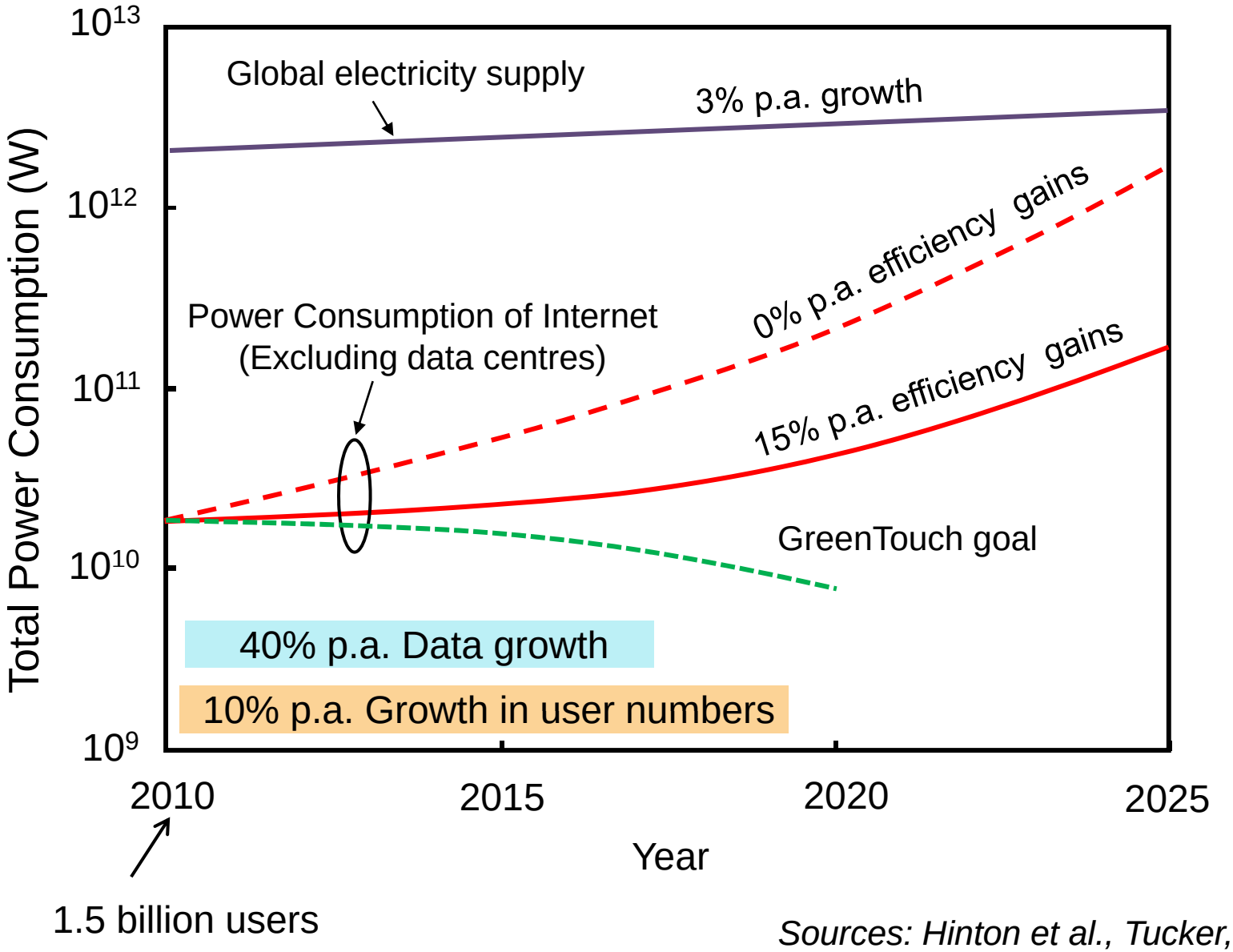
Research in GreenTouch™

Rod Tucker

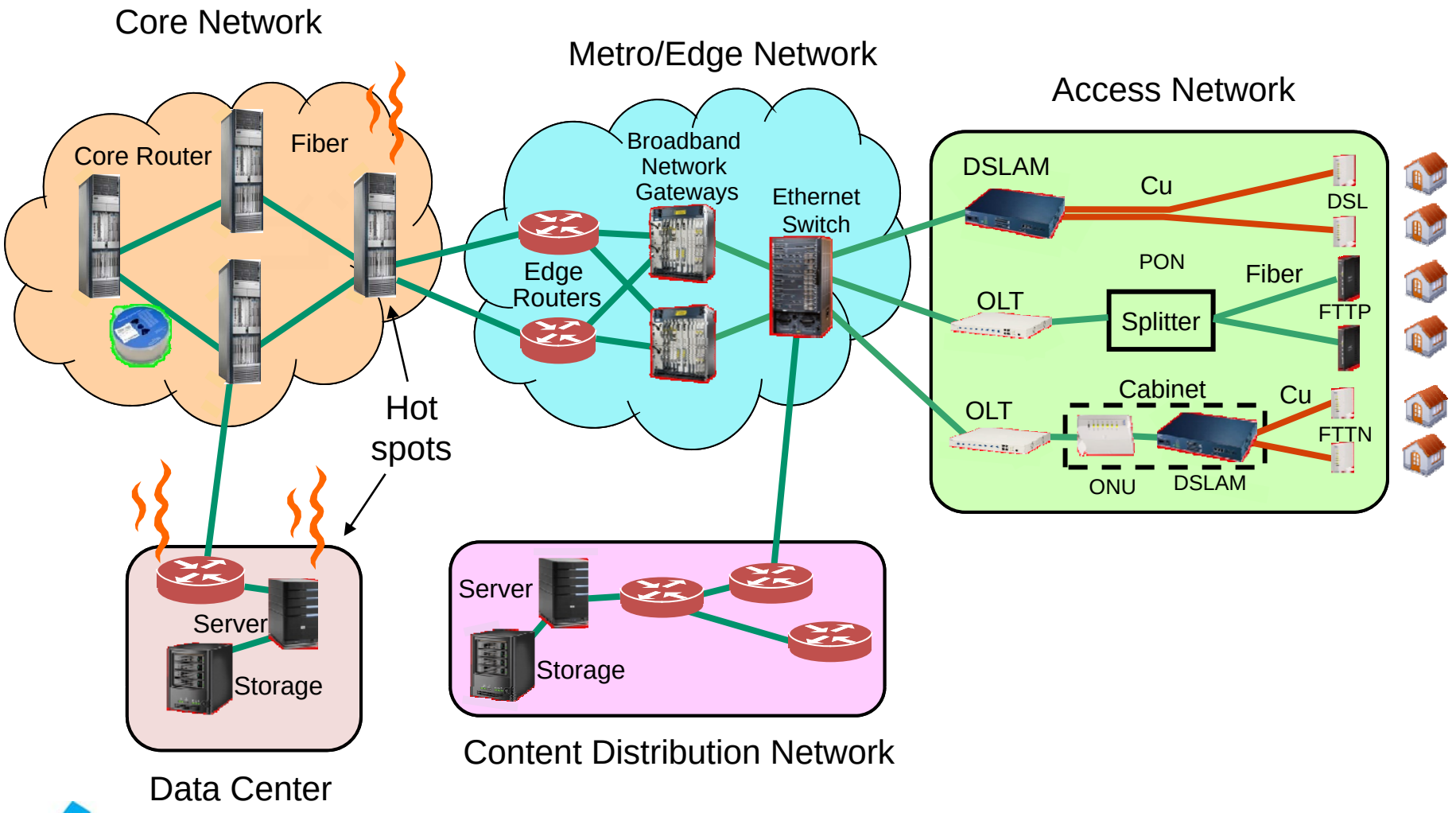
Centre for Energy-Efficient Telecommunications
University of Melbourne

Power Consumption of the Global Internet



Sources: Hinton et al., Tucker, IEEE

Inside the Network



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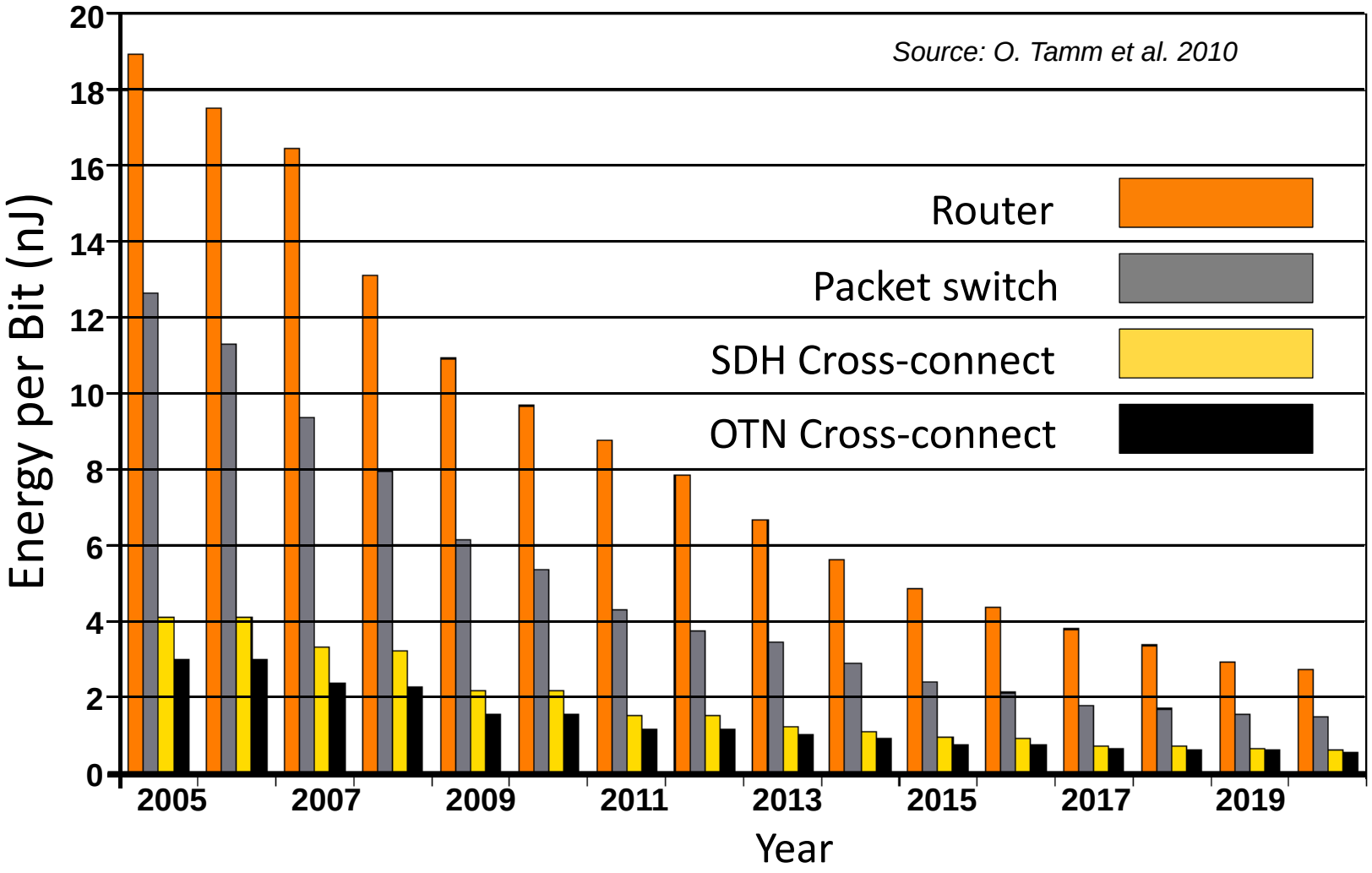
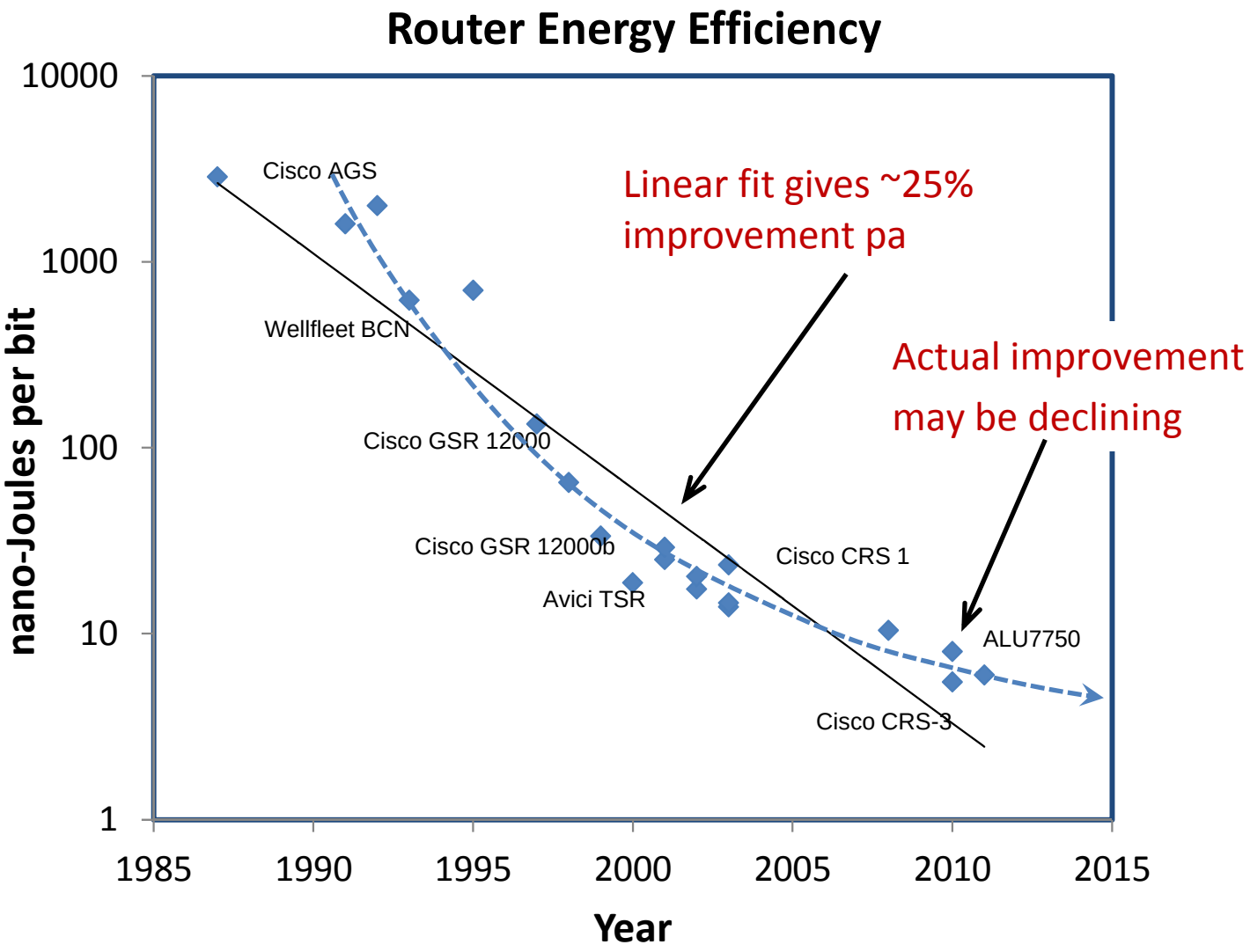
Energy per Bit in Key Equipment

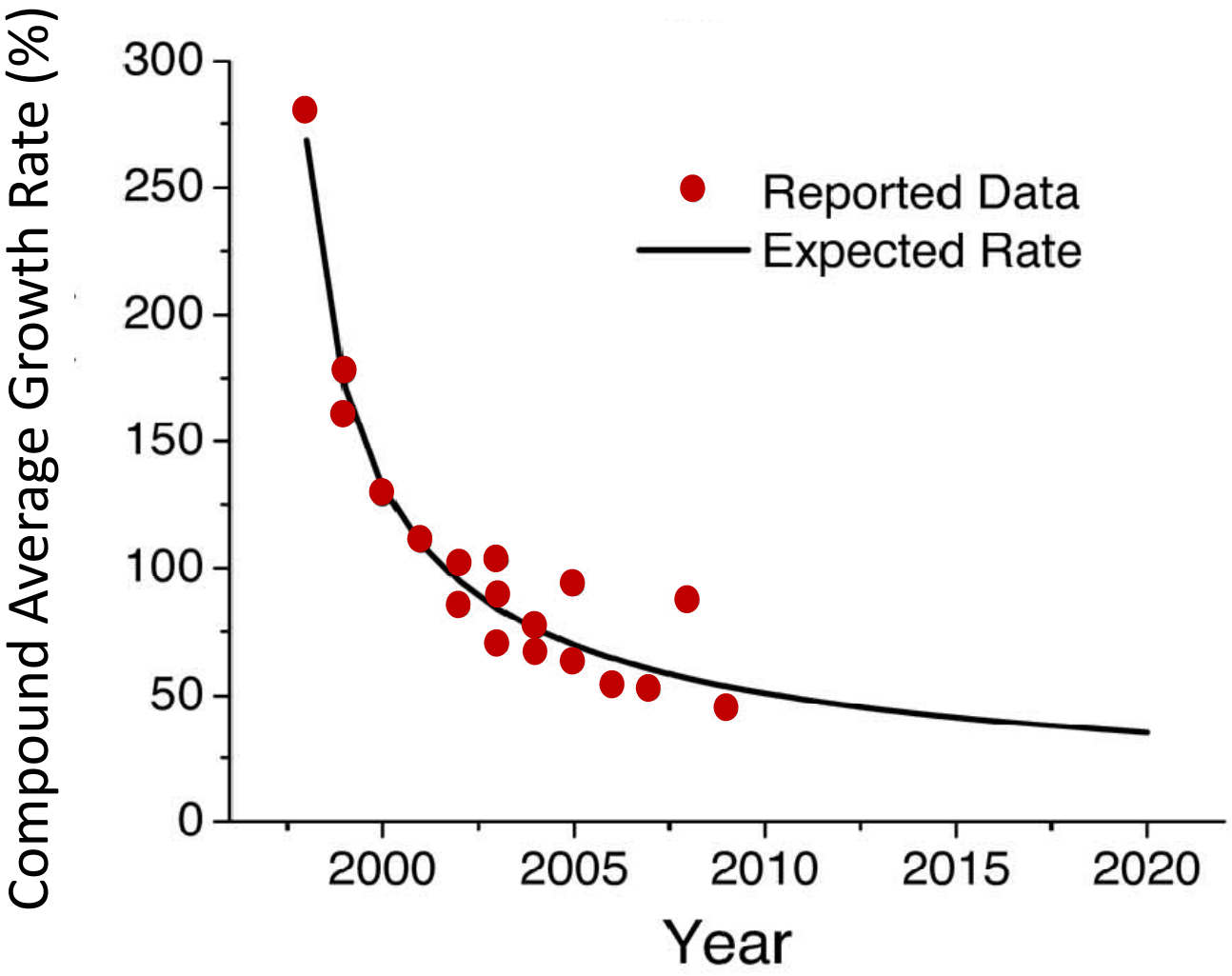


Router Energy Consumption Trends



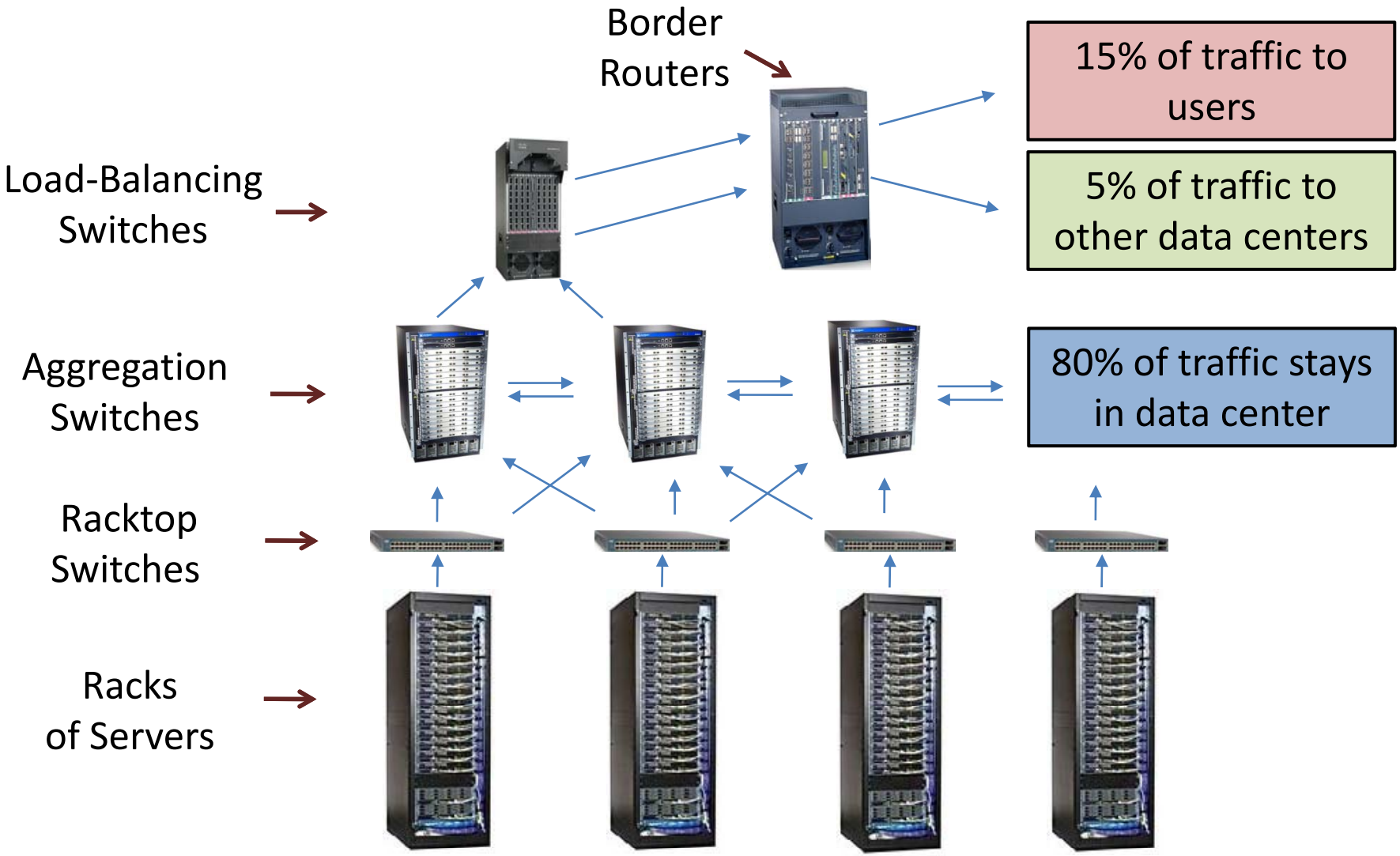
Source: Nielsen, ECOC 2011

Internet Traffic Growth Trends

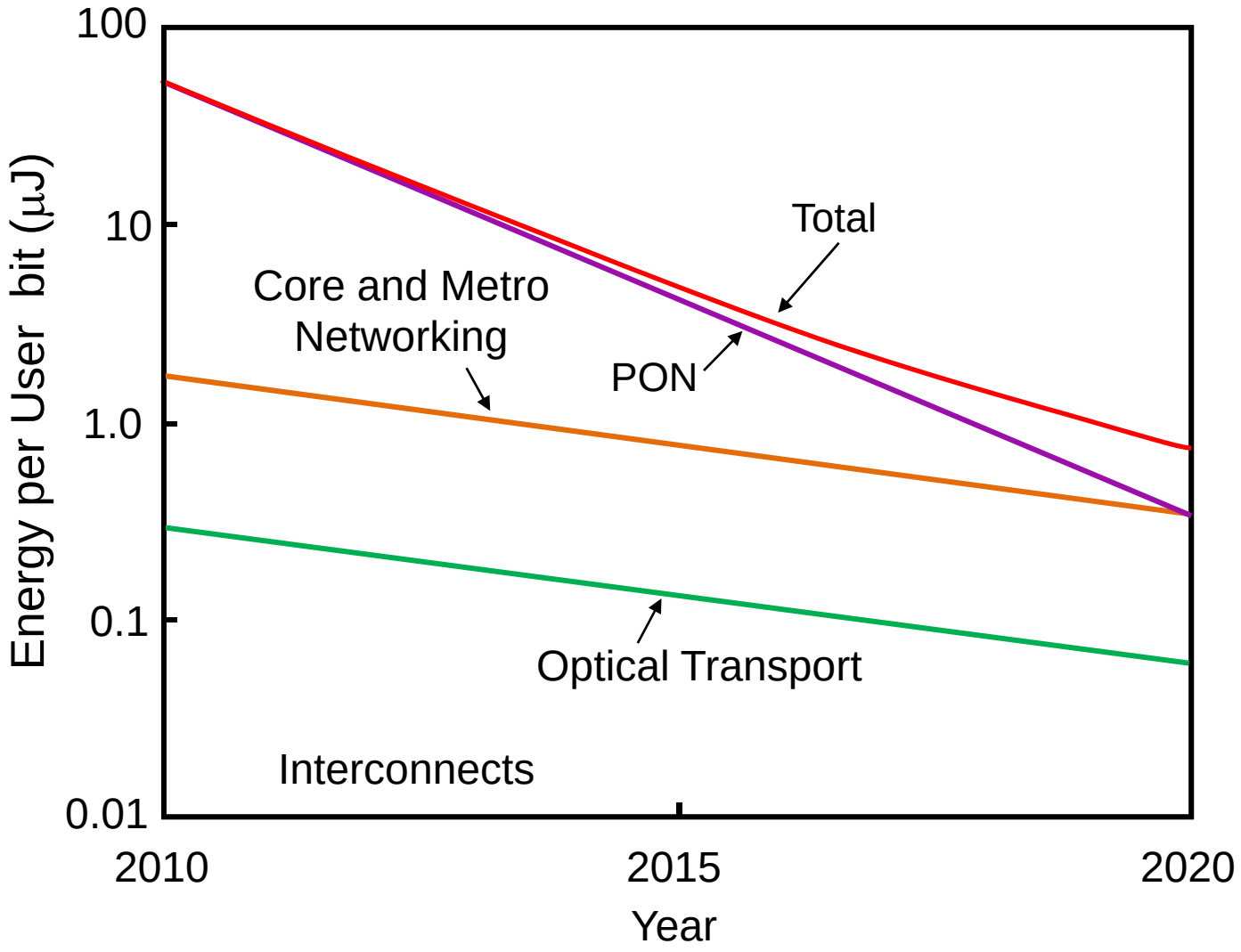


Source: Kilper et al., JSTQE 2011

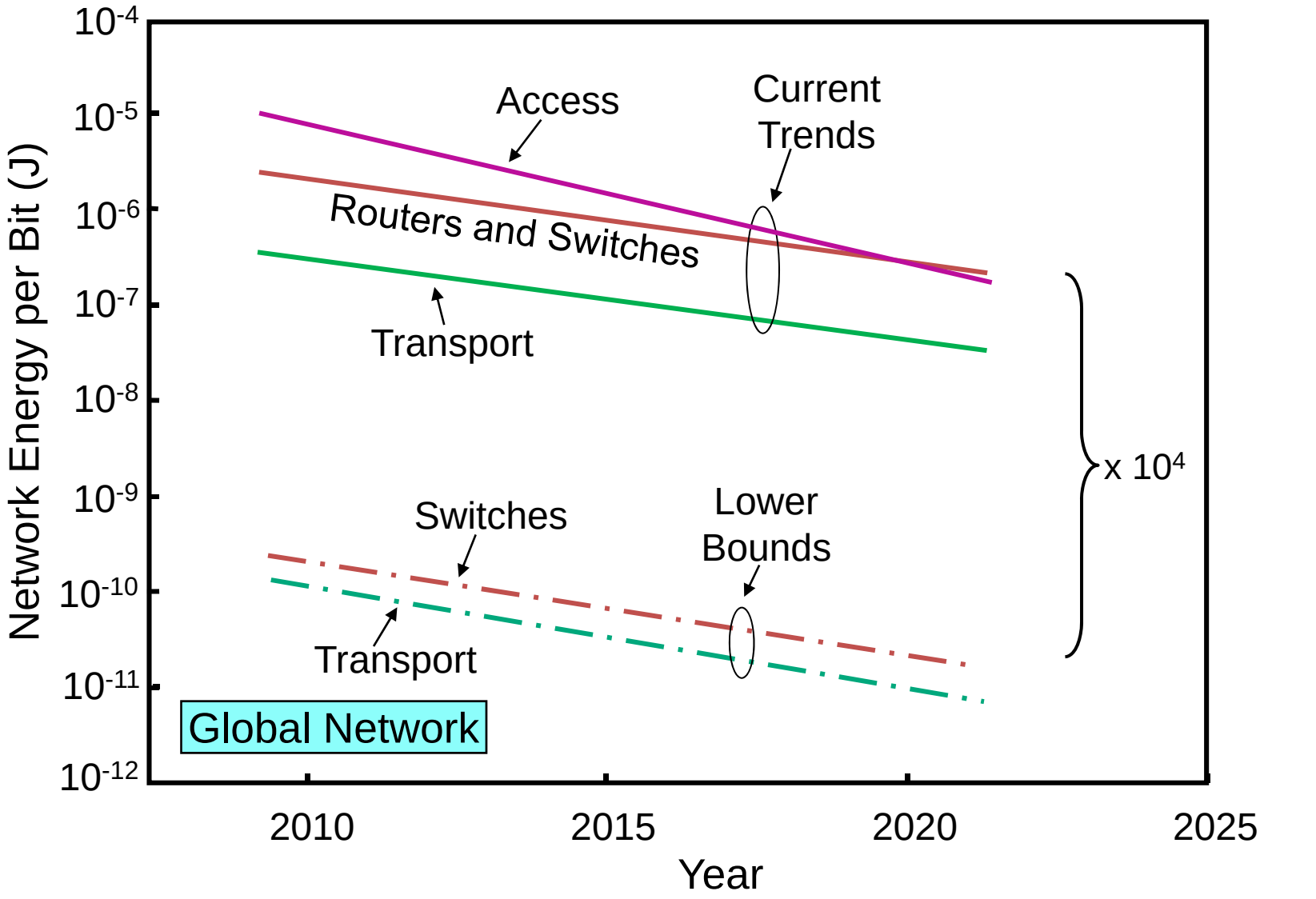
Data Centers and Content Servers



Network Energy per User Bit



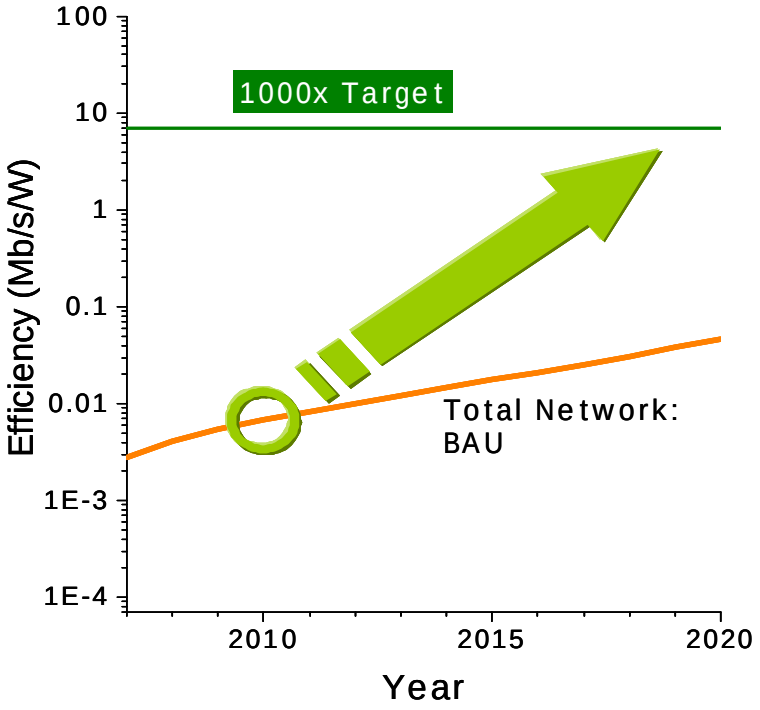
Gap Between Theory and Practice



Source: Tucker, JSTQE 2011

GreenTouch Mission

By 2015, our goal is to deliver the architecture, specifications and roadmap — and demonstrate key components and technologies —needed to increase network energy efficiency by a factor of 1000 from current levels.



- Global research consortium representing industry, government and academic organizations
- Launched in May 2010
- 52 member organizations
- 300 individual participants from 19 countries
- 25+ projects across wireless, wireline, routing, networking and optical transmission

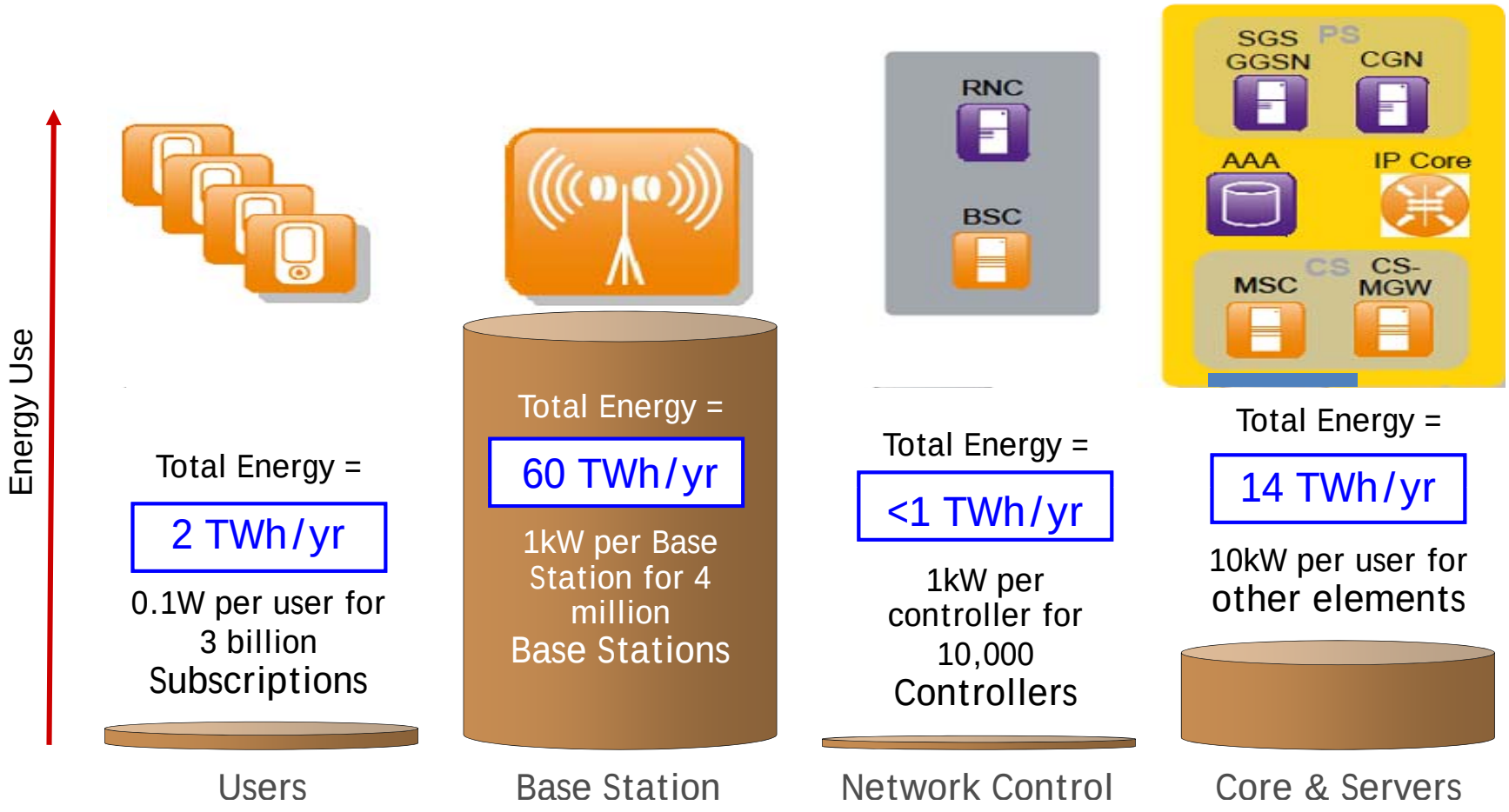
Some Research Projects

GreenTouch™

Beyond Cellular – Green Mobile Networks	Fondazione Politecnico di Milano
Virtual Home Gateway	swisscom
Optimal End-to-End Resource Allocation	University of Leeds
Service Energy Aware Optical Networks	Columbia University in the City of New York
Green Transmission Technologies	Huawei
Minimum Energy Access Architectures	ceet
Single-Chip Linecards	Bell Labs
Large-Scale Antenna Systems	imec
Highly-Adaptive Layer Mesh Networks	Bell Labs
Massive MIMO	Samsung Advanced Institute of Technology

25+ Projects

Power Consumption of Wireless Access



The greatest opportunity to reduce energy consumption is to improve base stations

Based on: ETSI RRS05_024, NSN

Green Wireless Opportunities (1)

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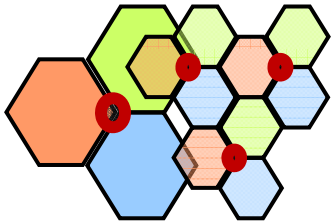
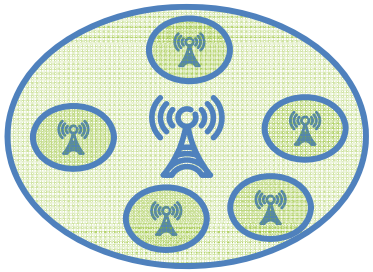
Deployment:

Relays Nodes

Multi RAT

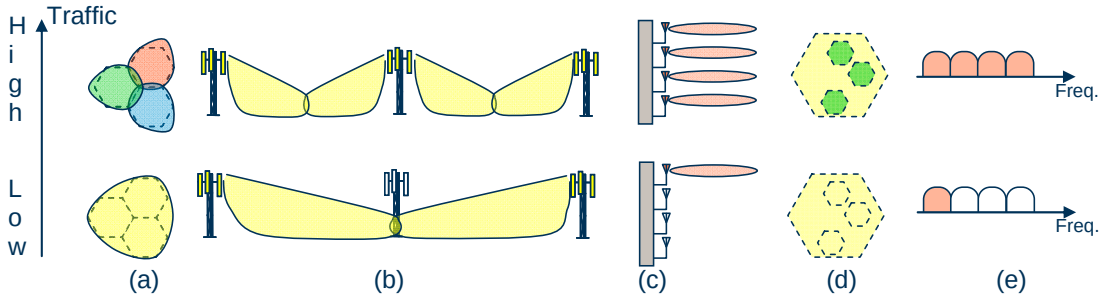


Heterogeneous Networks



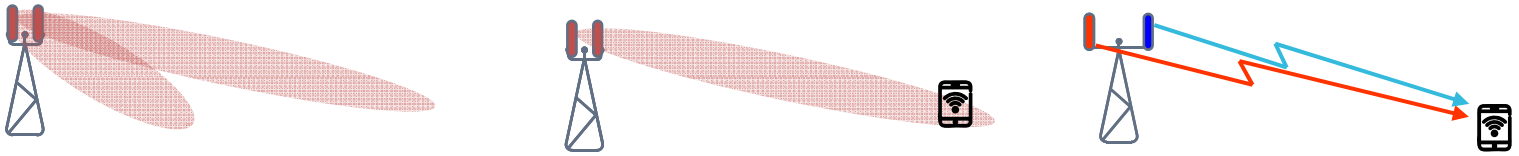
Network Management:

BS cooperation, Adaptive NW configuration



Multi-Antenna Techniques:

Reconfigurable antennas, Beam forming, Spatial multiplexing



Green Wireless Opportunities (2)

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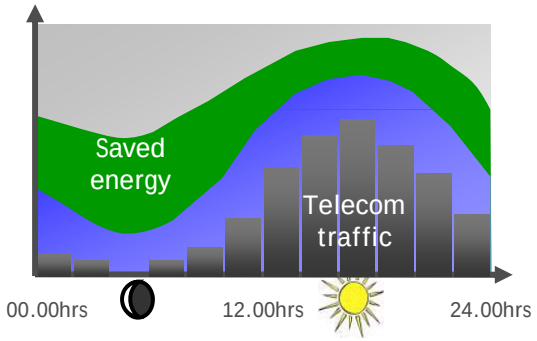
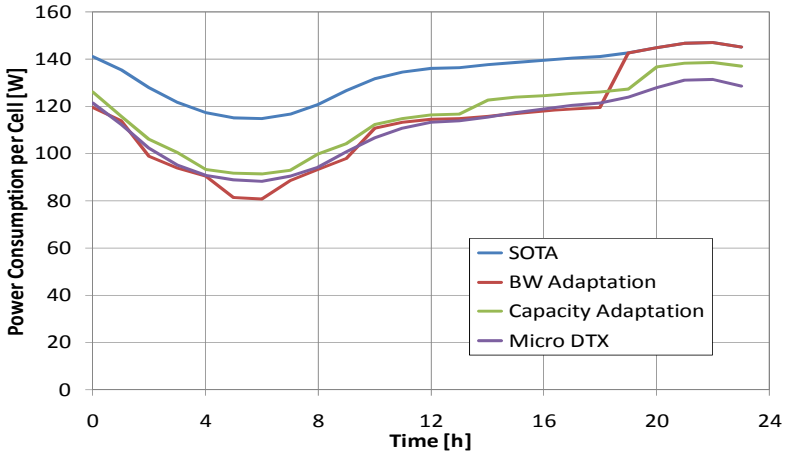
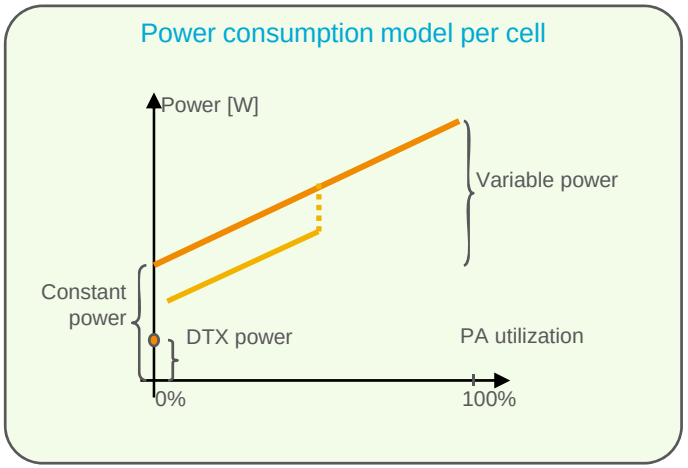
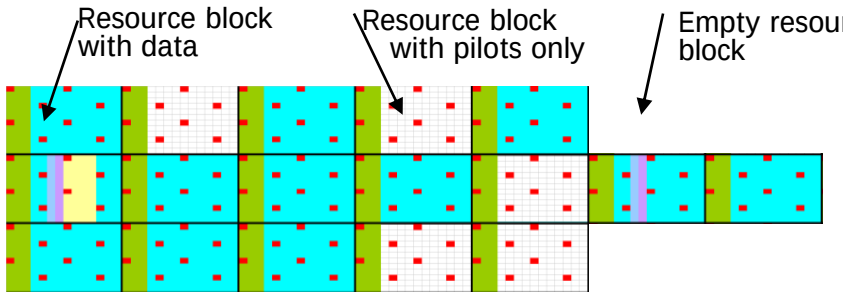
Radio Resource Management:

Energy efficient scheduling, Sleep modes, Bandwidth Adaptation









High load:
Most resources used

Low load:
Capacity adaptation

BW adaptation:
Pilots suppressed

Some Specific Router Limitations

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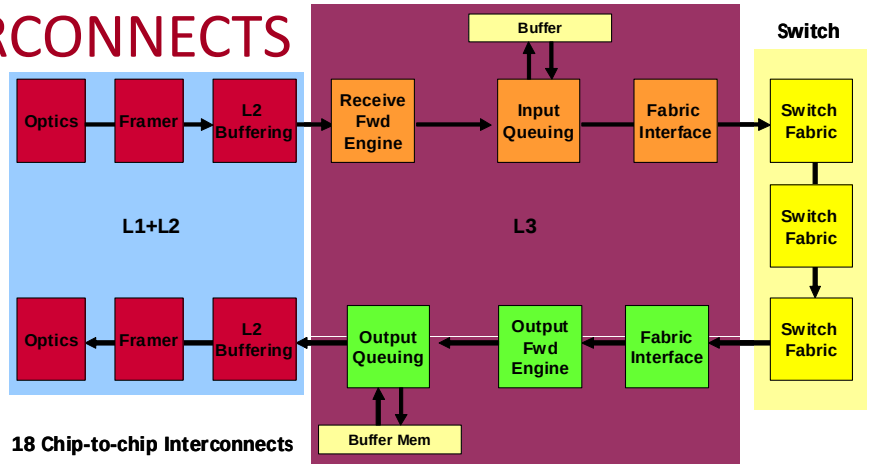
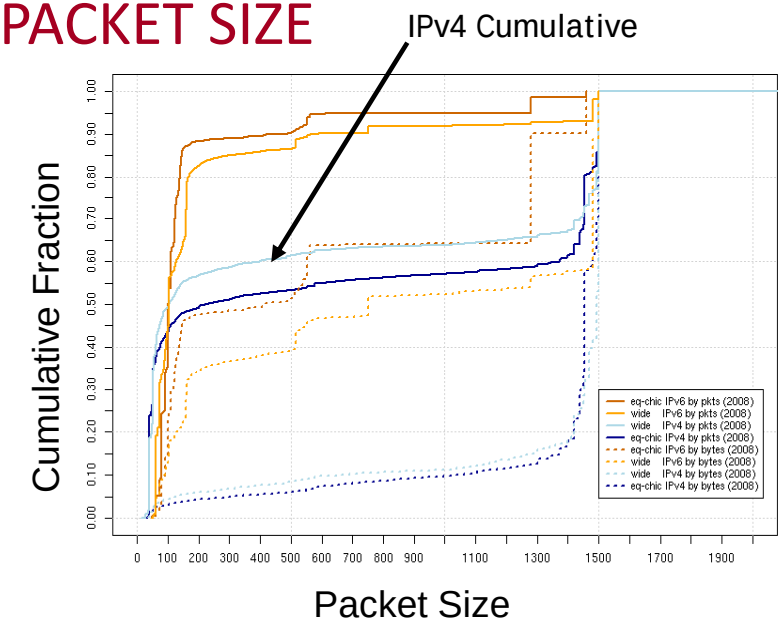
INTERCONNECTS

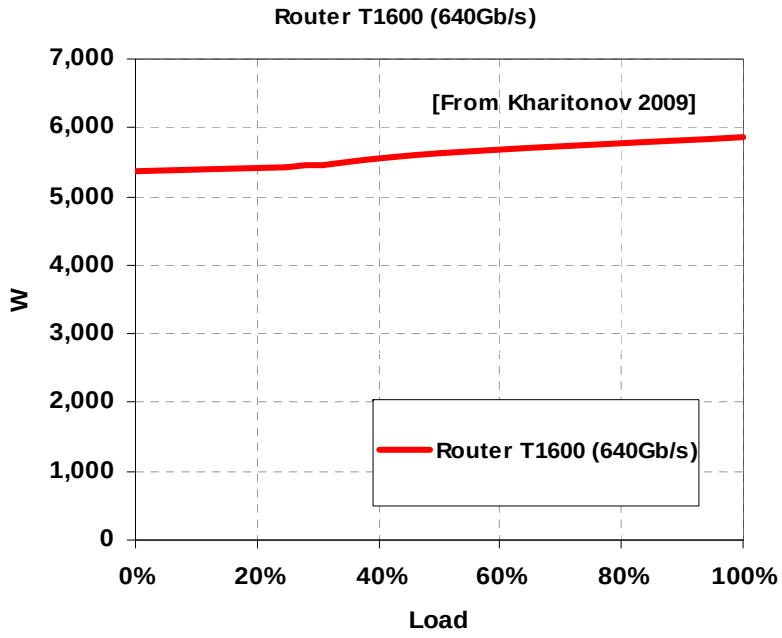


PACKET SIZE



http://www.caida.org/research/traffic-analysis/pkt_size_distribution/graphs.xml

ENERGY DOES NOT FOLLOW LOAD



D.Kharitonov, "2009 IEEE GLOBECOM Workshops

Efficient Switching and Routing

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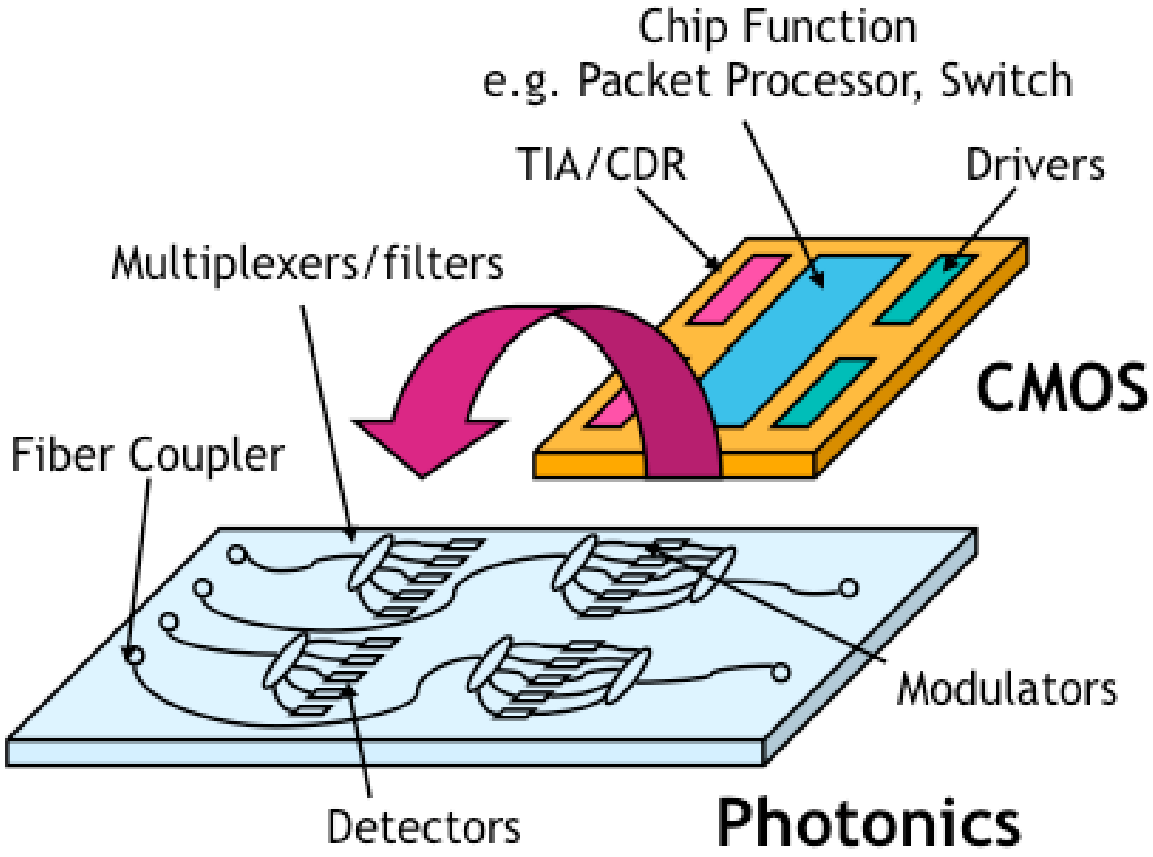
SCORPION: SILICON PHOTONIC INTERCONNECT AND SINGLE CHIP LINECARD



Contributing Members

Bell Labs

GreenTouch™

SEASON:
SERVICE ENERGY AWARE SUSTAINABLE OPTICAL NETWORKS

Contributing Members

Bell Labs

UNIVERSITY OF TORONTO

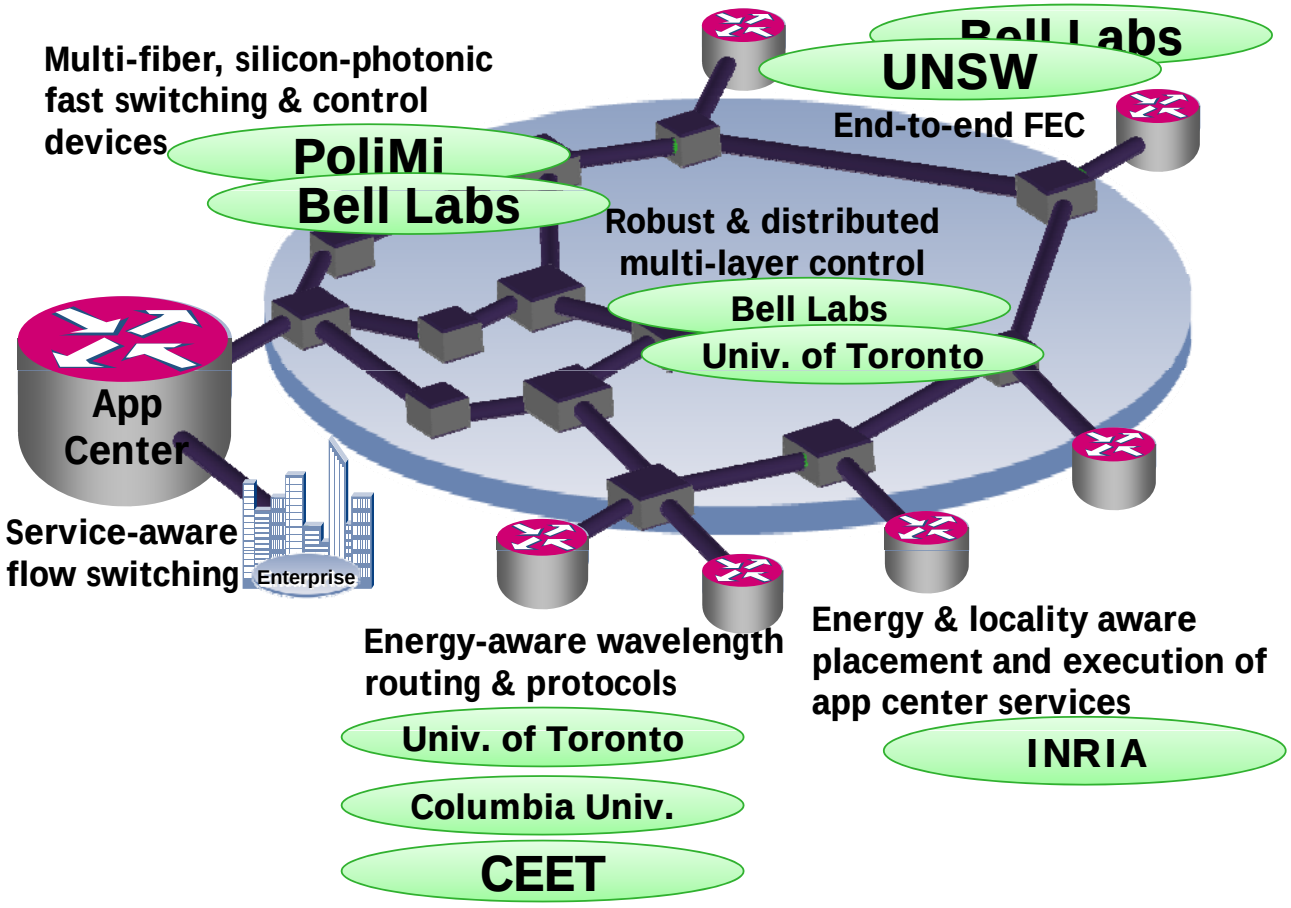
UNSW
THE UNIVERSITY OF NEW SOUTH WALES
SYDNEY • CANBERRA • AUSTRALIA

ceet centre for energy-efficient telecommunications
BELL LABS AND UNIVERSITY OF MELBOURNE

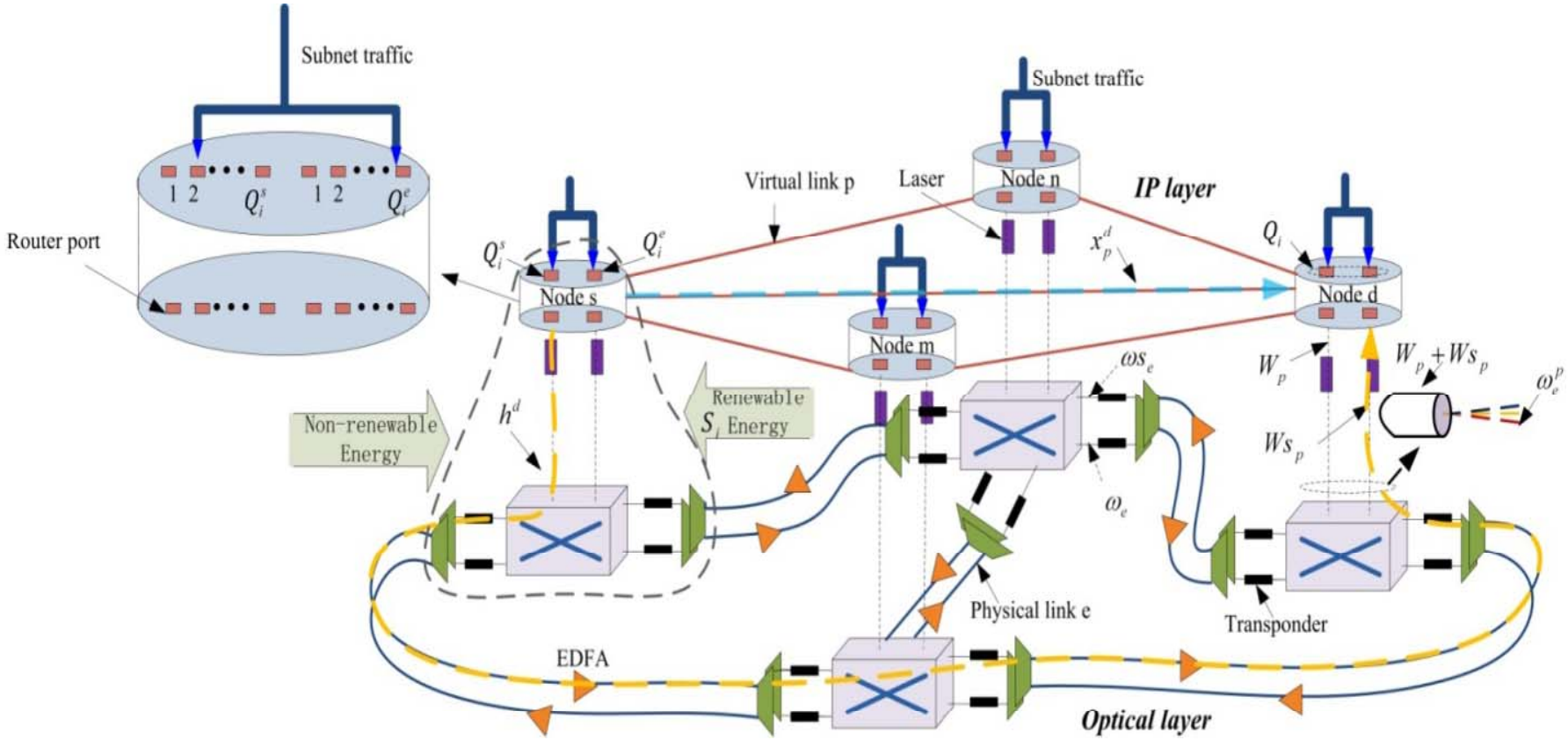
Fondazione Politecnico di Milano

FRENCH NATIONAL INSTITUTE FOR RESEARCH IN COMPUTER SCIENCE AND CONTROL | INRIA

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK



OPERA:
OPTIMAL END TO END RESOURCE ALLOCATION



Contributing Members

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UNIVERSITY OF CAMBRIDGE

UNSW THE UNIVERSITY OF NEW SOUTH WALES SYDNEY • CANBERRA • AUSTRALIA

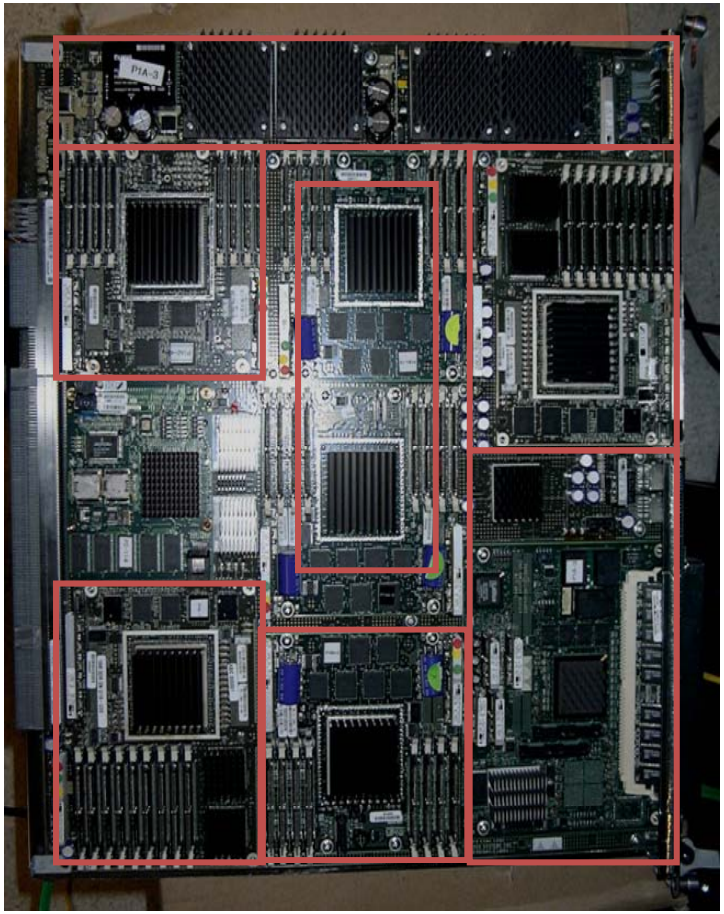
Fondazione Politecnico di Milano

AIT CENTER OF EXCELLENCE FOR RESEARCH AND EDUCATION

Perceptum ex Optimus

REPTILE:
ROUTER POWER MEASUREMENTS

GreenTouch™



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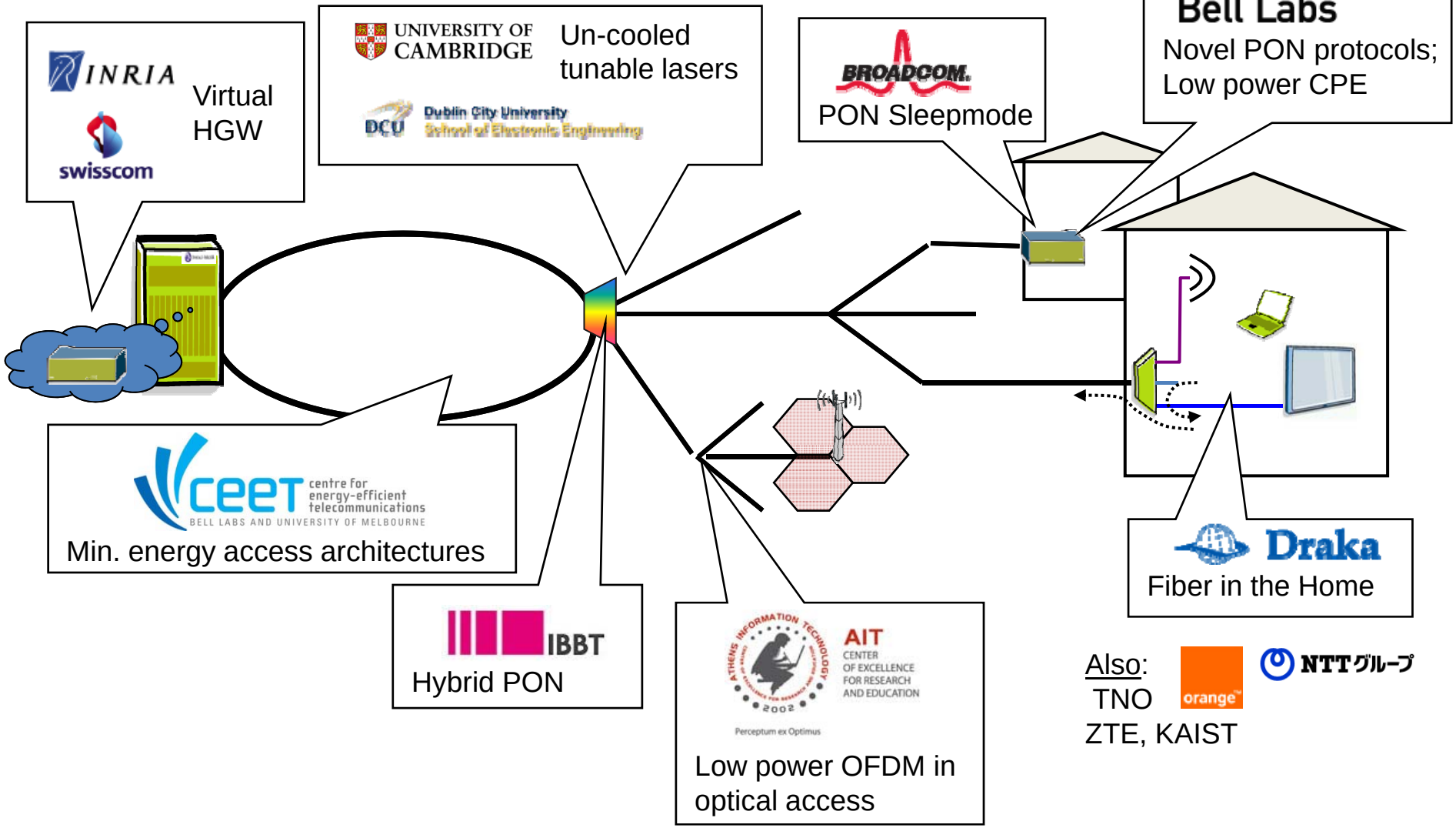
Wireline Access Networks



Wireline Access Networks

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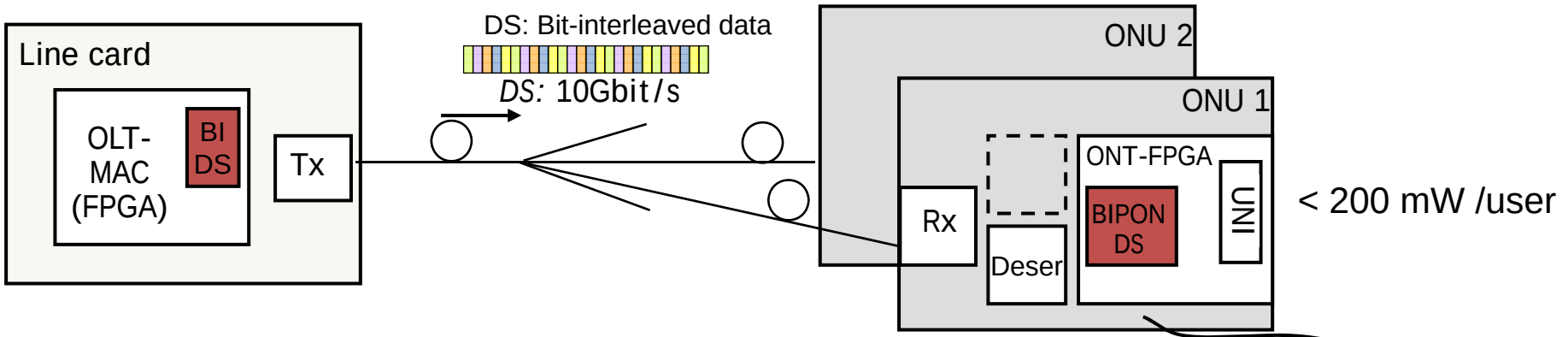
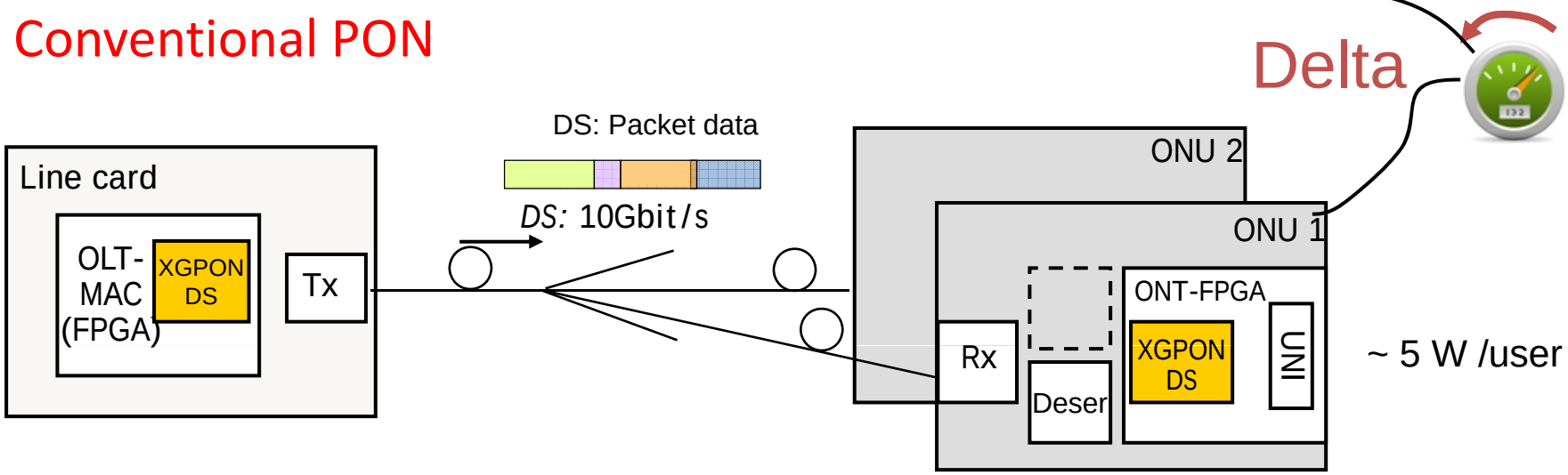
Bit-Interleaved PON



Conventional PON



Bell Labs

INTEC design

orange™

Status of GreenTouch

- Over 15 research programs and 25 research projects
  - Wireless and mobile communications
  - Wireline access
  - Core networks and optical transmission
  - Services, applications and trends
- New approaches being taken:
  - Devices and low power electronics / photonics
  - Architectures, algorithms and protocols
  - “Power-follows-load” intelligent management
  - Service and energy optimized networks
- Two major public demonstrations in wireless and fiber-to-the-home technologies
- Establishing and defining common reference architecture and roadmap with strategic research directions
- New members are welcome!