



GREEN RESEARCH AND GREENTOUCH

Innovations for Long-term Sustainable Network Growth

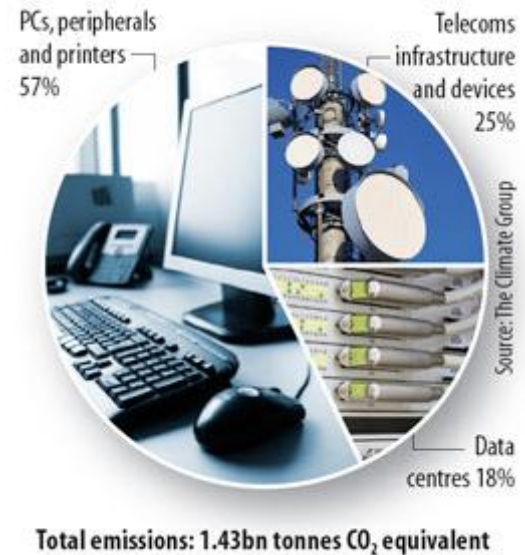
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SUSTAINABLE NETWORK GROWTH

Benefits & Opportunity

- **Society and industry crave connectivity & information**
 - Network traffic is doubling every 2-3 years
- **Green concerns include reducing GHG**
 - ICT contributes 2% to global GHG, growing to more than 3% by 2020
 - ICT can offset 5X its own carbon footprint by 2020
- **Sustainable network growth is essential to progress and low carbon economy**
 - Information generates wealth
- **Innovations that have kept network energy consumption in check are slowing**



Huge Opportunity

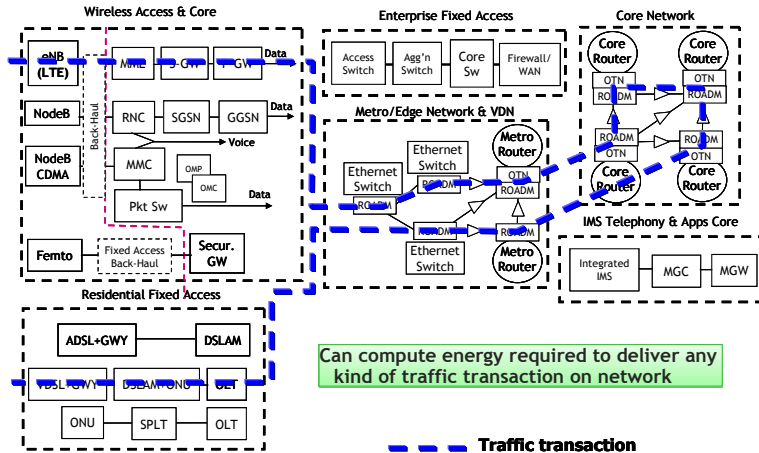
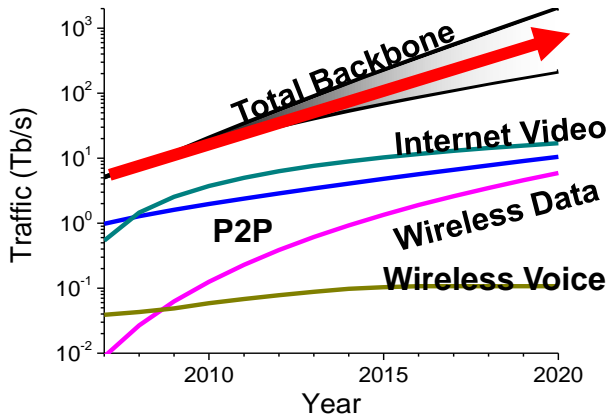
Reinvent scalable networks that

- Maximize energy-efficiency
- Reduce total-cost-of-ownership

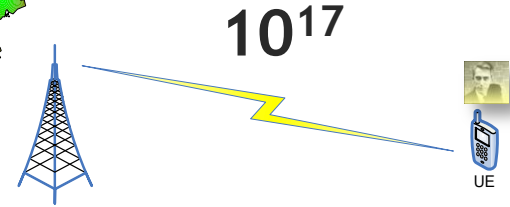
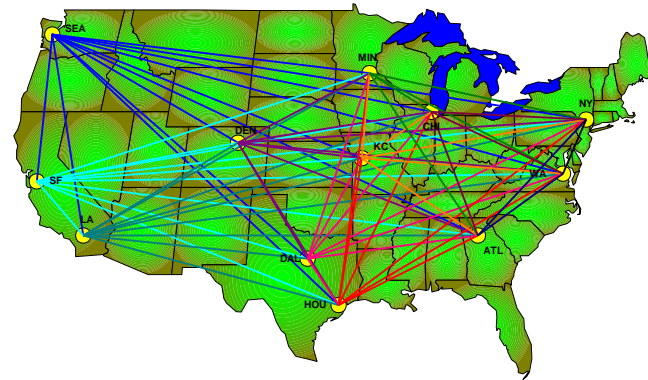
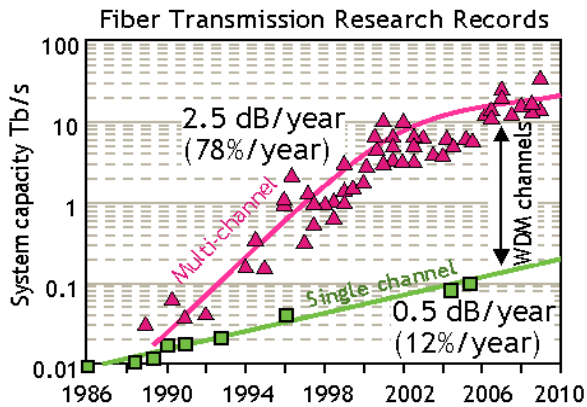
THE CASE FOR GREENTOUCH™

Bell Labs analysis...

Traffic is growing



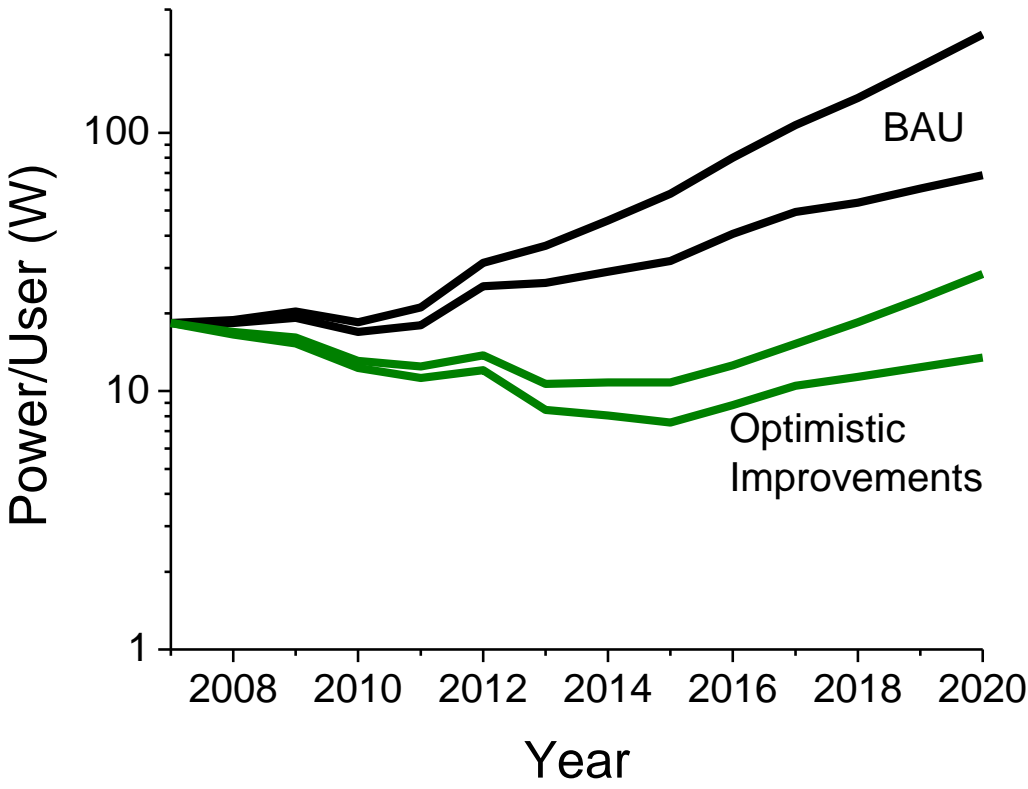
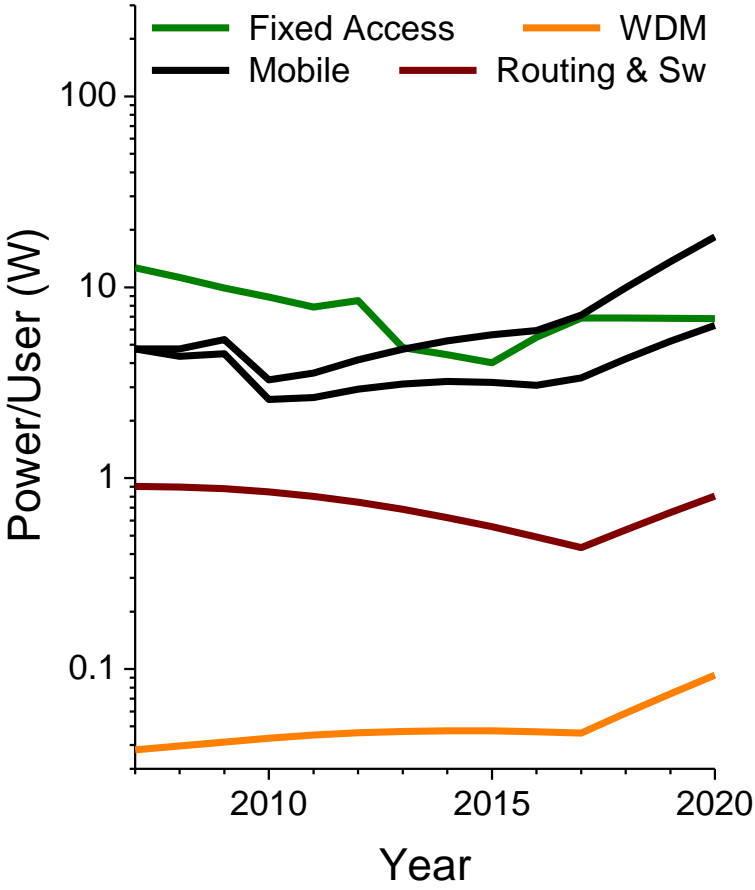
Innovation is slowing



Networks can be 10,000 times more efficient

Trending Shows That Despite Increasing Efficiency, Energy/User in Network is Rising

• Can we change this trend?
 • What is the best we can do?





GreenTouch™ TARGETS

By 2015, demonstrate architectures and technologies that yield a **1000-fold improvement in network efficiency (using 2020 traffic projections) over 2010 network efficiency**

- Global consortium with **experts** from across industry and world's top institutions working together in matrix of **open** innovation
- **Pre-competitive** research that emphasizes clean slate architectures and **out-of-the-box** thinking
- **Support and Funding** from members and Governments
- **Ambitious goal** in finite period of time



GreenTouch™ **GOAL**

Environmentally and Economically Sound

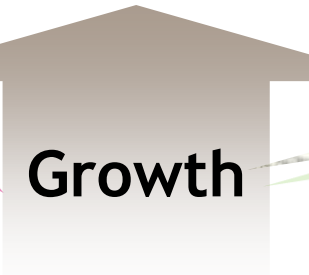
Green Services



Increased Revenue from Services



Increase



Growth

Bits per second

$$\text{Network Efficiency} = \frac{\text{Total Traffic Delivered to User}}{\text{Total Power per User}}$$

Reduced Carbon Footprint



Reduce

Watts



Reduced Costs



GreenTouch™ MEMBERS – GROWING LIST



..... Alcatel-Lucent





GreenTouch™ A Successful First Year

- **Launched January 11, 2010**
- **Technical goals & analysis vetted by founding partners**
- **Established operating framework**
- **Opened to all May 1, 2010, followed by solid membership growth**
- **All-member F2F, Amsterdam, Nov 15-18, 2010**
 - Refinement and expansion of research projects and demos
 - Integration of new members
 - Refinement of funding model
 - Identification of milestones and activities for 2011
 - Established key alliances: ITRS, ITU, TREND, CIAN



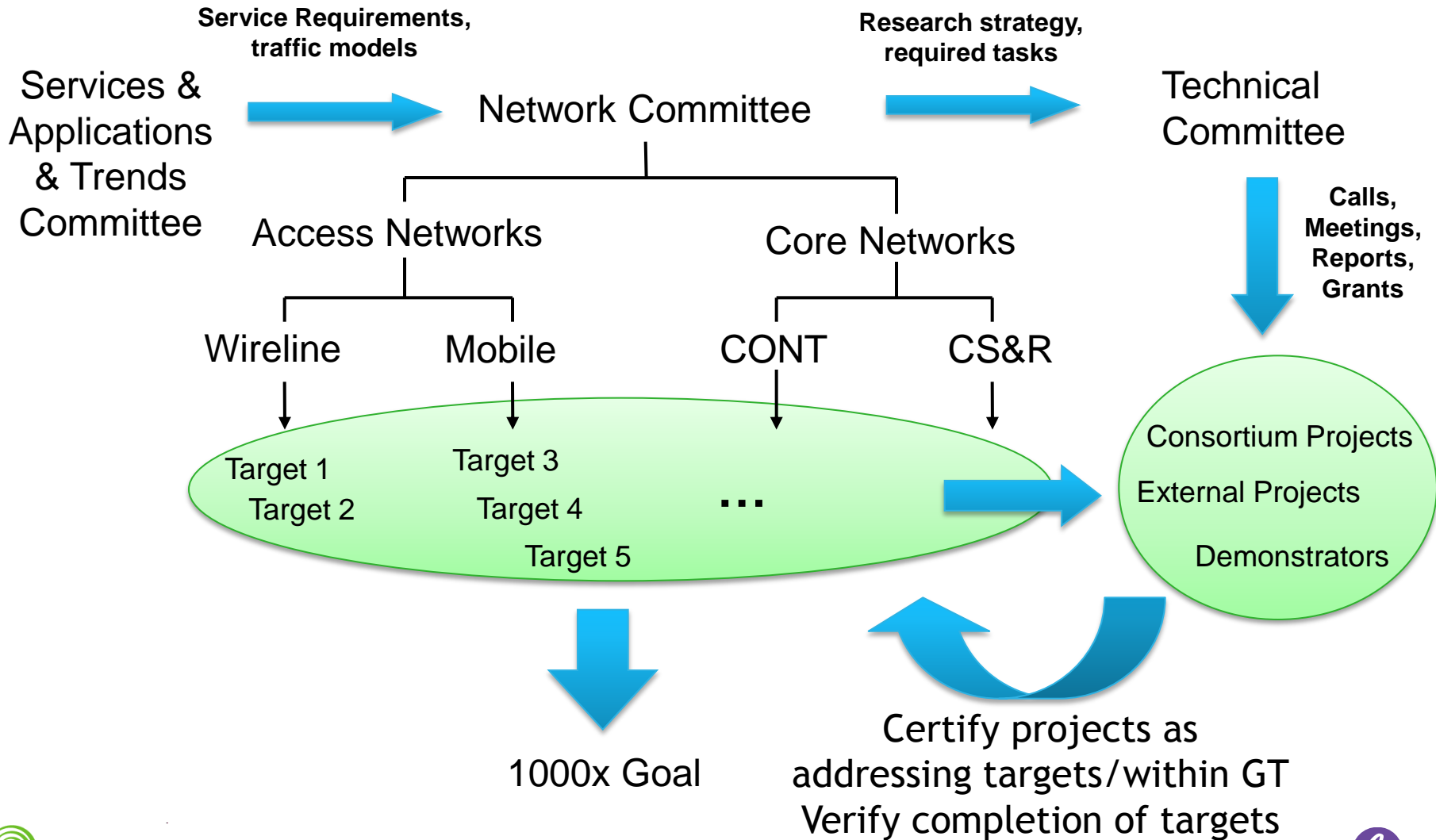
2011 Activities

- First technology demonstration – February 1, 2011 (London)
- Members Meeting - April 6, 2011 (Korea)
- Establishing common reference architecture
- Establishing research roadmap & key metrics to 2020
- Great research results!
- **Securing external funding**





GreenTouch™ Information Flow





GreenTouch™ Focusing on Biggest Wins

GreenTouch™ has established technical working groups to focus on the activities with the highest estimated potential of improving energy efficiency in communications networks

Technical Working Groups

Input to Working Groups comes from Services, Applications & Trends Committee

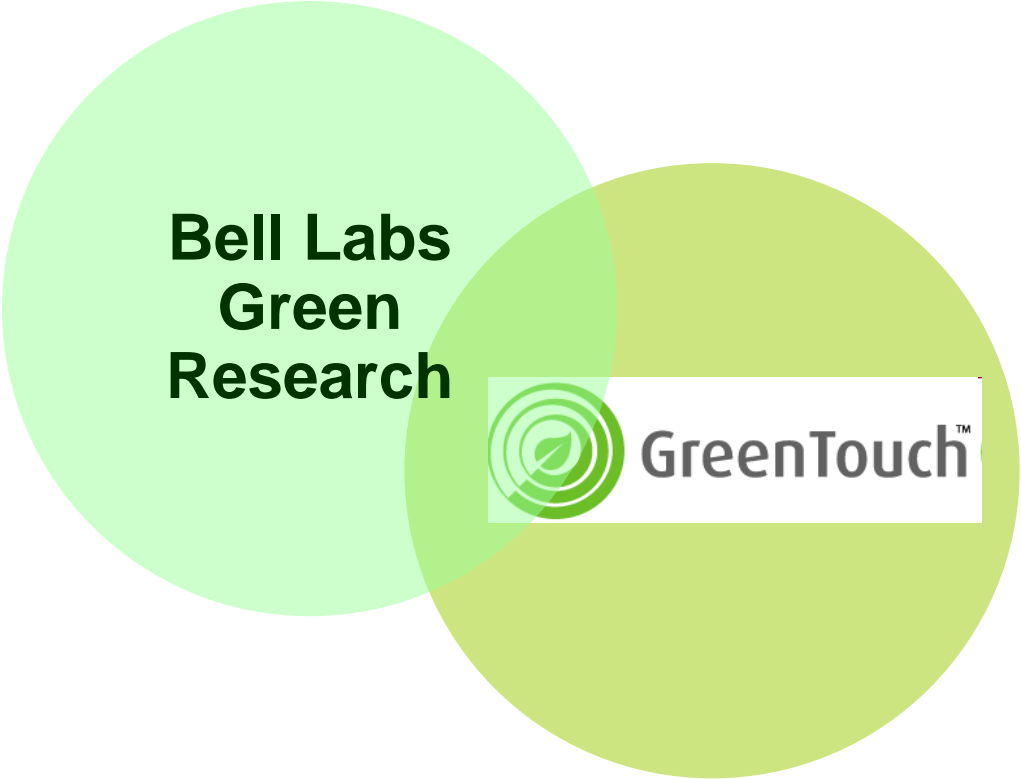
- Wireless (**1000X**)
- Wireline Access (**100X**)
- Core Routing & Switching (**100X**)
- Core Optical Networking and Transmission (**10X**)

Across the Working Groups there are More than 10 Collaborative Projects Underway

Infrastructure & Ideas in place to maximize success



Bell Labs Green Research & GreenTouch



Additional focus in Bell Labs Green Research on energy-efficiency enablement and market-leading products

GREEN RADIO NETWORK ARCHITECTURE APPROACHES

Green Air Interface

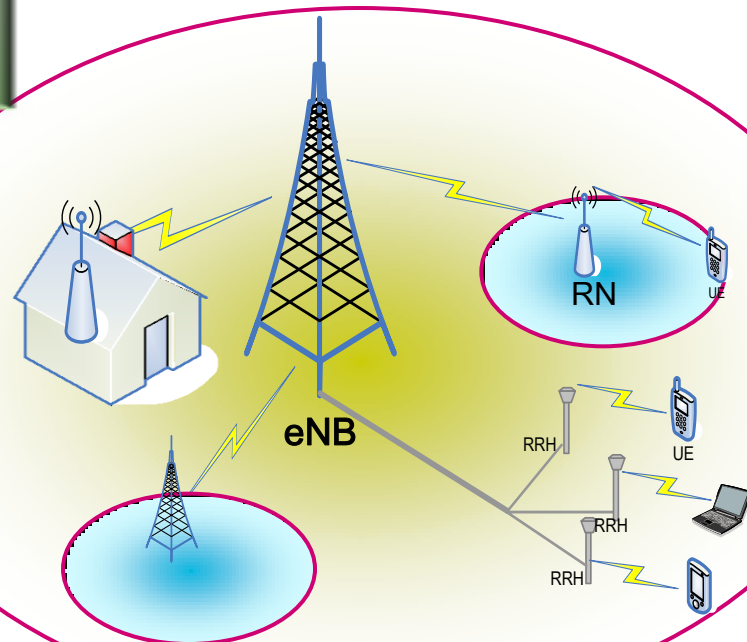
- Large Scale Antenna Systems
- Very High Bandwidth

Network Architecture & Mgmt

- Dynamic Management for Energy Efficiency
- Small Cells, Relays and Repeaters
- New BS Architecture - Cloud Computing for Signal Processing

Base Station Hardware

- Ultra Low-Power Base-Station on a Chip
- Photonic Enablers for RF Systems
- High Efficiency RF-Power Amplifiers
- Renewable Energy Powering
- New Architectures such as lightRadio™



Rethink entire wireless access for energy efficiency



- **Large Scale MIMO Demo (Feb. 1st 2011 in London)**
- **Large scale antenna systems (LSA)**
 - **Massive MIMO**
 - **Distributed Antenna Systems**
- **Green transmission technologies (GTT)**
 - **Very high bandwidth wireless systems**
 - **Tradeoff btw. energy efficiency and spectrum efficiency, bandwidth, service delay**
- **Beyond cellular green mobile networks / architectures (BCG)**
 - **Green Network Management / Intelligent Power Management**
 - **Independent network configuration for data and signaling**



LARGE SCALE MIMO

Base-station With Hundreds of Antenna



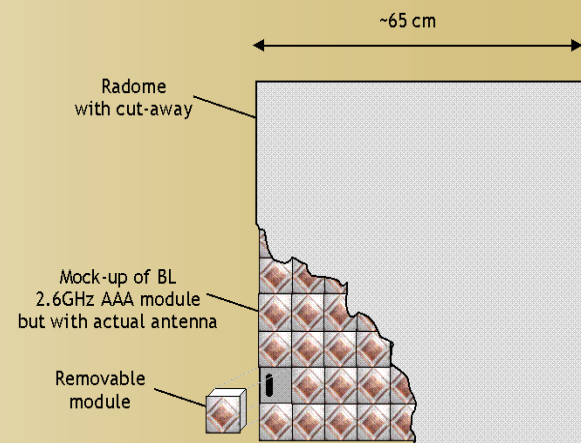
Concept: Ultra high energy-efficiency wireless through selective beam-forming, in highly cluttered environments, using base-stations with hundreds of antenna

Expectation: ~100x improvement in energy efficiency in highly mobile, multi-user systems

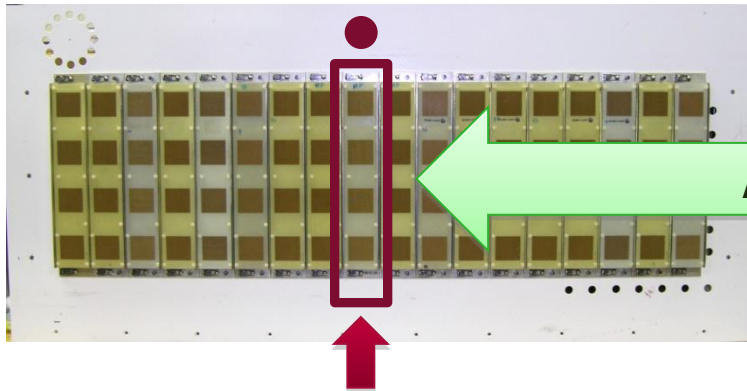
Challenges:

- Base-station design
- Acquiring CSI, calibration, ...
- Total power reduction
- New standards

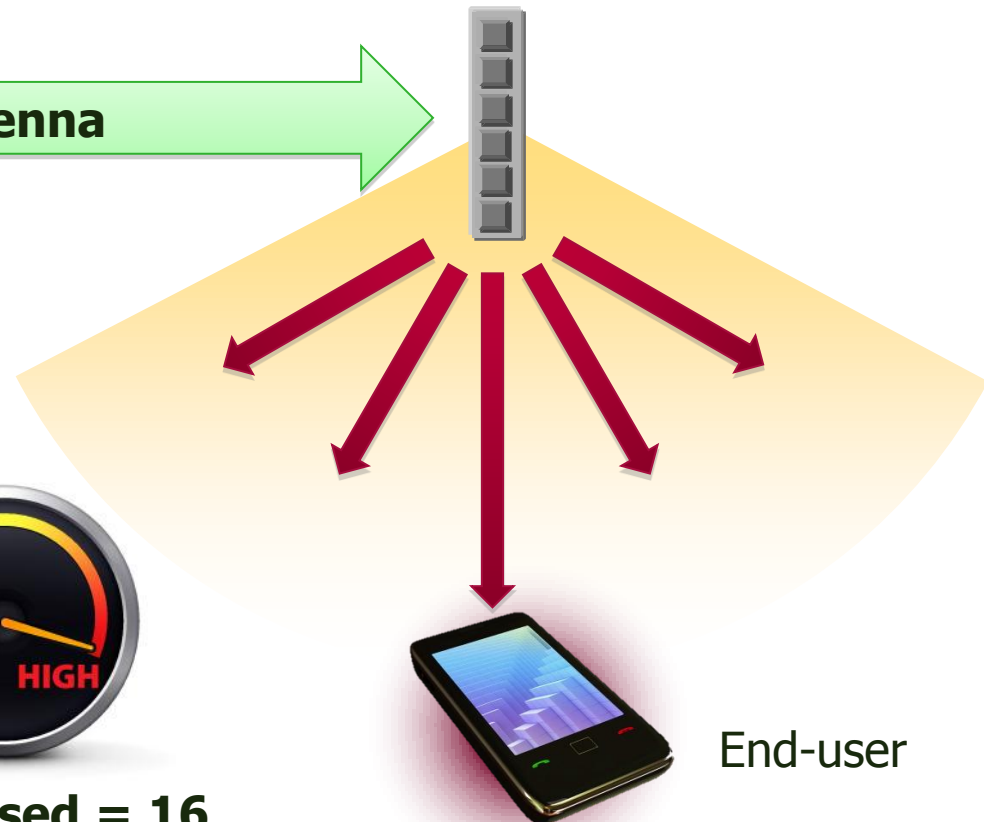
First Year Demo



SIMULATING CURRENT ANTENNA



Only **one antenna panel** is powered to simulate a call to an end-user.

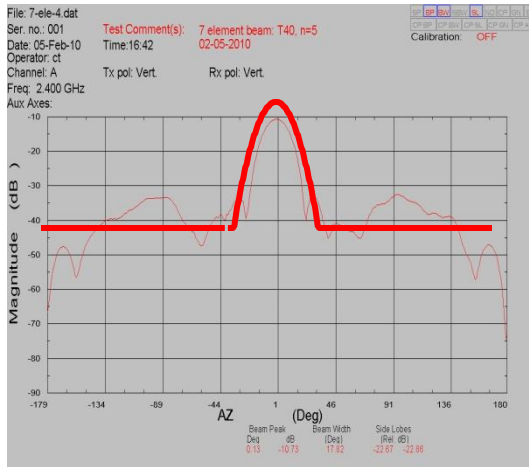
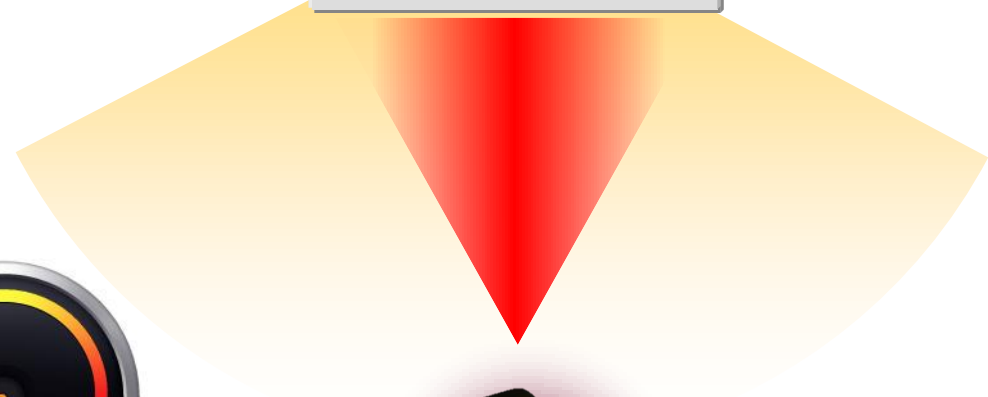
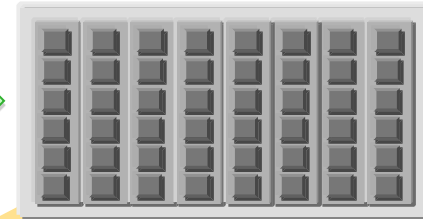
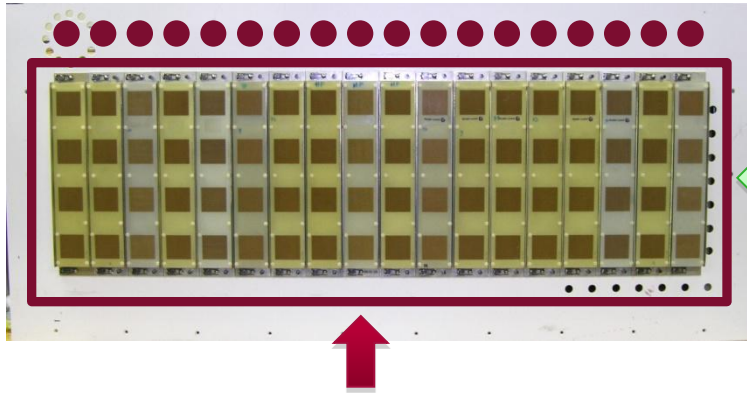


Power used = 16

End-user

LARGE SCALE ANTENNA SYSTEM

First Year Demo



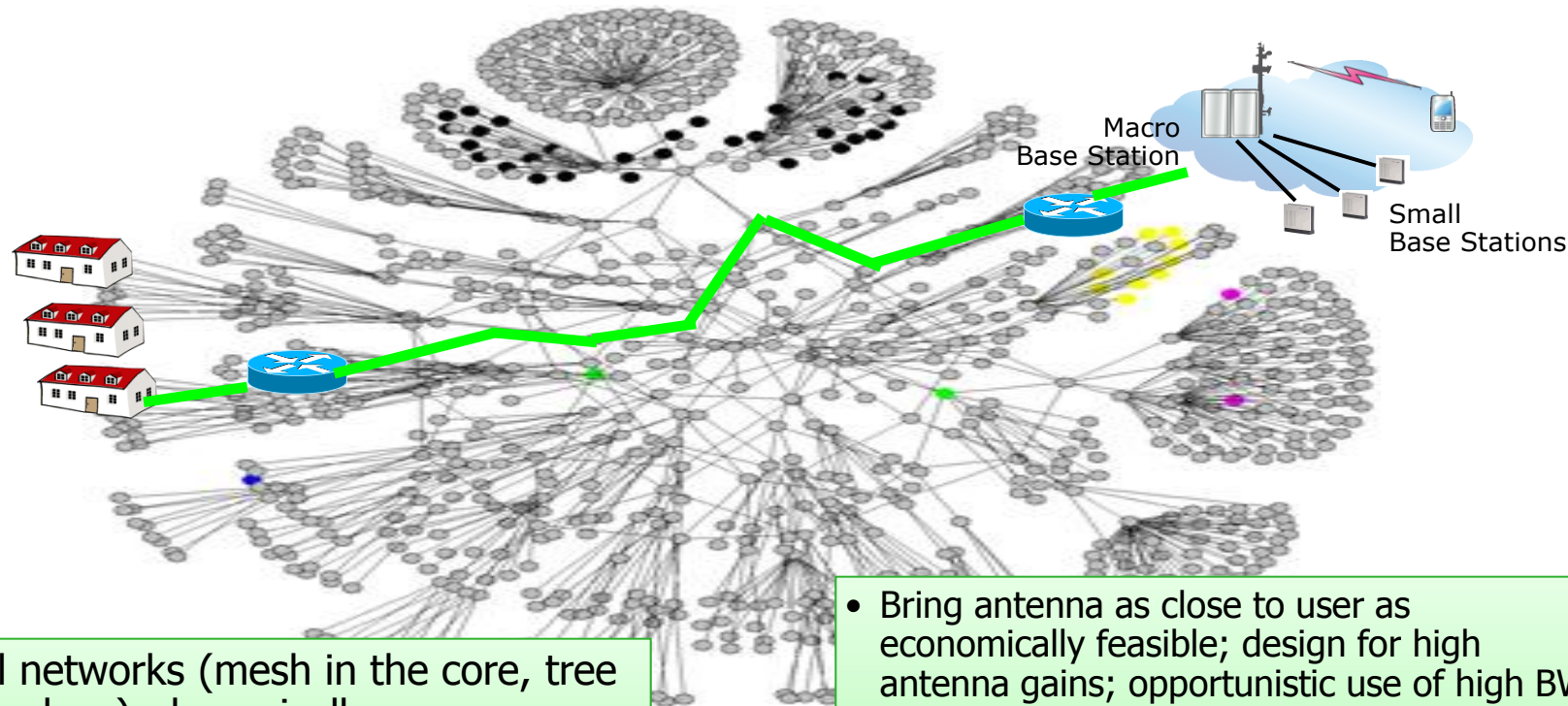
Power used = 1



End-user

Collaborators: **Bell Labs, Freescale, Huawei, imec, Samsung**

A Network That Behaves Like A Full Mesh



- In real networks (mesh in the core, tree at the edges), dynamically allocate/switch **a virtual fiber link** between the two end-points of a transaction, with minimum routing

- Bring antenna as close to user as economically feasible; design for high antenna gains; opportunistic use of high BW
- Service aware and adaptive network with ultra-low energy information and content delivery
- Low Power, ultra-high energy efficiency, energy-follows load components everywhere

Still challenging ourselves to think beyond the full mesh

SUMMARY

- **Ensuring sustainable ICT network growth is necessary** to enable large reductions in global carbon footprint, and for economic and societal growth
- **GreenTouch™** consortium is a game-changer, focusing on innovation that **will increase network efficiency a thousand-fold**
- **Green access is key** to GreenTouch™ goals
- **GreenTouch™** is starting to deliver and will need more **partners and support**. For more info, please visit www.GreenTouch.org
- **Customer pull** will accelerate **commercialization** of green innovations

AT
THE
SPEED
OF
IDEAS

