New Technologies Promise Greener Networking

Dramatic improvements in the efficiency of communications networks are possible – and researchers have been collaborating to test new approaches.

By Masha Zager / *Broadband Communities*

Most people think of the Internet as an energy saver because it moves bits and bytes instead of atoms and molecules. As music downloads replace trips to the record store and webinars replace face-to-face meetings, important aspects of home and work life are "dematerialized."

However, even moving bits and bytes takes energy – and as network traffic grows, so does energy usage. Researchers from iMinds – Ghent University, a Belgian digital research and incubation center, estimated in 2014 that worldwide electricity usage by communications networks was increasing by 10 percent per year. Because today's technologies, even with improvements, can't reduce the growth rate to zero, the industry is on track to account for nearly 2 percent of worldwide carbon emissions in 2030, according to the Global e-Sustainability Initiative. So the energy efficiency of networking equipment and operations is a cause for serious concern.

> Telecom networks are built to accommodate peak, not average, demand; saving energy requires powering down unused equipment.

The biggest challenge, says Dr. Bart Lannoo of iMinds – Ghent University, is that today's telecom networks are built to accommodate peak demand, not actual average bandwidth consumption. Unlike electricity generating plants, which power up and down to match demand fluctuations, telecom equipment tends to stay on all the time.
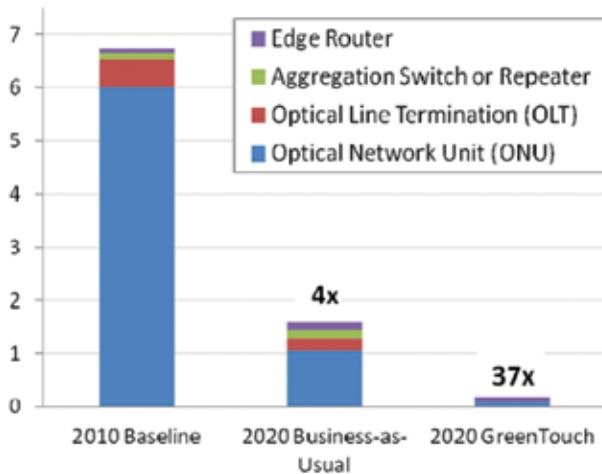
THE GREENTOUCH PROJECT

In 2010, a group of industry, academic, government and nonprofit researchers formed a consortium called GreenTouch, whose mission was to significantly reduce the carbon footprint of ICT devices, platforms and networks. The driving force behind GreenTouch was Bell Labs, the research arm of Alcatel-Lucent (recently merged with Nokia), but more than 40 other organizations joined the consortium, including iMinds – Ghent University.

GreenTouch set a specific, very ambitious goal: to deliver, by 2015, the architecture, specifications and technologies – and demonstrate key components – needed to increase network energy efficiency by a factor of 1,000 compared with 2010 levels. It didn't aim to commercialize any technology; rather, it hoped to identify promising new avenues for the industry to pursue, to fundamentally rethink network technologies and to demonstrate a path to a sustainable Internet. Because of the limitations caused by building to peak demand, GreenTouch focused on finding ways to run equipment at
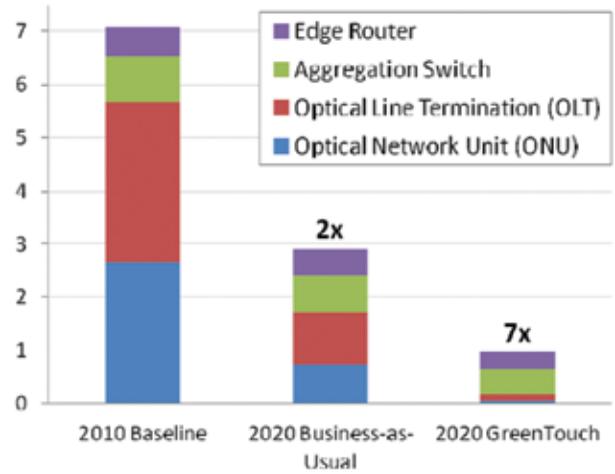
Figure 1: Power consumption improvement in residential and business access networks, as shown by the Green Meter

lower power or even put it into sleep mode when full power isn't needed.

By the time the consortium wrapped up its five-year effort, it had exceeded its original goals. The new approaches it introduced can improve the energy efficiency of mobile networks by more than 10,000 times; its research in core networks and wired residential and enterprise networks also yielded significant results. Overall, with these energy-efficiency improvements,
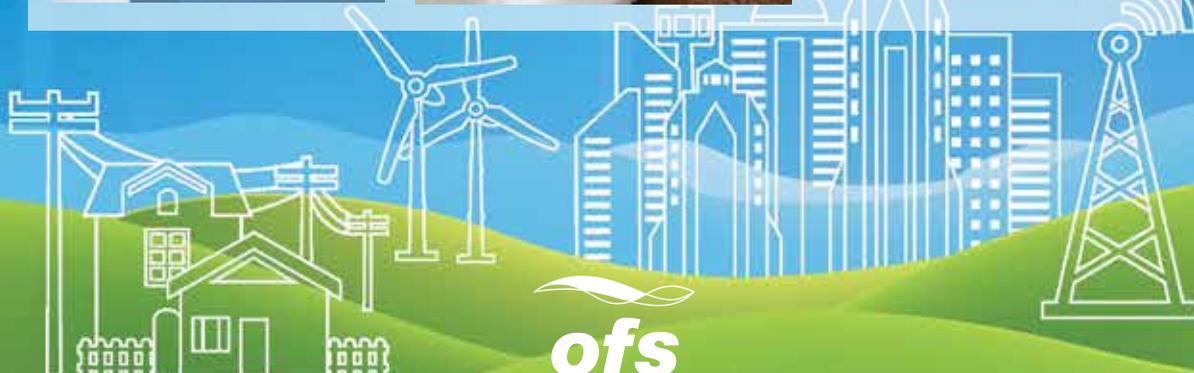
GreenTouch says, the net energy consumption of communications networks could be reduced by 98 percent from 2010 to 2020 even while traffic continues to grow. This savings is equivalent to the greenhouse gas emissions of 5.8 million cars.

FIXED ACCESS NETWORK

Following are some technologies and tools the GreenTouch researchers introduced for wireline networks:

Virtual Home Gateway: As reported in the article 2016 Forecast on p. 34, technology for virtualizing many gateway functions (authentication, parental controls, and so forth) is already being commercialized. The Virtual Home Gateway concept that a team at the Institute for Research in Computer Science and Control in France proposed replaces residential in-home gateways with lightweight, extremely low-power devices and moves most functionality

to servers in the central office. In-home gateways tend to be on all the time; servers can be selectively shut down to match demand at different times of day. This approach is expected to reduce power consumption in the residential access network by 19 percent. In addition, consumers can more easily order new services or features.

Point-to-Point Optical Transceiver: The Point-to-Point Optical Transceiver project, led by a team of researchers from the Centre for Energy-Efficient Telecommunications (CEET) at the University of Melbourne and Bell Labs/Alcatel-Lucent, offers a new hardware design and a custom-built, optimized chip for point-to-point optical transceivers. The new transceiver, which is 30 times more energy efficient than today's optical transceiver, can be made even more efficient with adaptive powering schemes. GreenTouch is exploring its use for two applications:

- Active Ethernet, or point-to-point, high-speed broadband used to provide dedicated service to businesses
- In-home connections between home electronics gear (such as wireless routers) and wired in-house networks.

According to Thierry Klein, chairman of the GreenTouch technical committee, the in-home networking scenario alone would reduce the overall power consumption of an entire metro access network by 27 percent. Sofie Lambert, a Ph.D. student on the iMinds team for GreenTouch, explains that the in-home point-to-point transceiver uses only 27 milliwatts, a tiny fraction of what an Ethernet LAN port would use, and has a longer reach.

Bit Interleaving and Cascaded Bit Interleaving Passive Optical Networks: Bit Interleaving Passive Optical Network (BiPON) technology,

first announced in 2012, enables a power reduction of 30 times while improving performance and reducing cost. BiPON uses selective data processing to discard the 99 percent of data not relevant for the optical network terminal (ONT) at a customer premises; further ONT processing is done at the lower user rate. Recently, the BiPON concept was generalized to multiple cascaded levels, so that any network node in the access, edge and metro networks can efficiently process only the portion of the traffic relevant to that node. Though this technology is still in an experimental stage, it promises to significantly reduce total power consumption across the entire network, especially as network speeds increase. Lannoo explains, "For NG-PON2, with its 40 Gbps bitrates, BiPON technology can become really important. For current standards at lower bitrates, it's less interesting."

Green Meter: The iMinds – Ghent University researchers, in collaboration with Bell Labs, developed a "green meter" that assesses the individual and collective impact on energy consumption and energy efficiency improvements of GreenTouch technologies for fixed access networks. GreenTouch made these findings accessible through GWATT, a Web-based, interactive application that provides a complete view into the entire GreenTouch portfolio of technologies and the energy impact from an end-to-end viewpoint.

WIRELESS NETWORKS
Some GreenTouch technologies proposed for wireless networks are the following:

Beyond Cellular Green Generation: This architecture uses densely deployed small cells with intelligent sleep modes and completely separates the signaling and data functions in a cellular network.

Large-Scale Antenna System: This replaces today's cellular macro base stations with a large number of smaller, lower-power, individually controlled antennas that deliver many user-selective data beams.

Distributed Energy-Efficient Clouds: A new architecture of distributed "mini clouds" close to end users minimizes the power consumption of content distribution networks used to deliver video, photo, music and other large files, which constitute more than 90 percent of the traffic on core networks.

Green Transmission Technologies: This set of technologies optimizes the trade-off between spectral efficiency and energy efficiency in wireless networks.

BEYOND GREENTOUCH
Though the GreenTouch project is officially completed, there is plenty more work to do on network energy efficiency. Two areas of concern to the iMinds team are the Internet of Things and the possibility of energy shortages.

The Internet of Things poses a challenge because the number of Internet-connected devices is growing rapidly, and this growth will only accelerate. The iMinds team is modeling the energy efficiency of possible solutions to this challenge, including software-defined networking. Lambert says, "The main benefit of doing things with software is that it offers more flexibility – you can aggregate equipment or put it in sleep mode. For a specific task that is constant, dedicated hardware would be more efficient. With changing tasks, a virtual structure is better."

The "post-peak scenario" is a different kind of problem; if fossil fuels become prohibitively expensive or unavailable, or if a network is dependent on unpredictable solar and wind power, keeping communications networks running may be difficult. Lannoo says, "If, in the future, the energy supply is not enough, how can we scale down operations to make sure key performance is running as it should be and less important tasks are not being dealt with? We need to find a way to scale down gracefully rather than taking down the whole network." ❖

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