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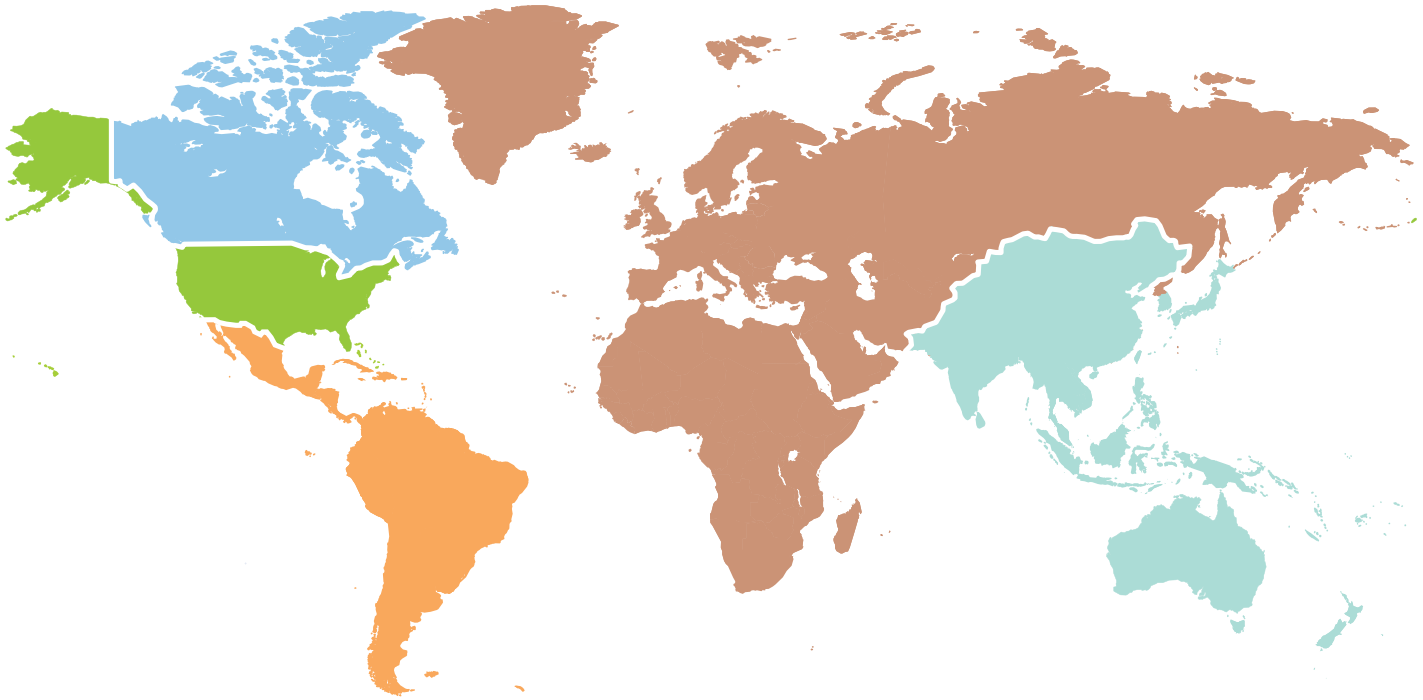
Greener and More Robust Networks

IEEE



REGION NEWS

REGION 2

EASTERN UNITED STATES

■ Student branches formed in **Poughkeepsie, N.Y.,** at **Marist College** and **Vassar College.**

■ Student branch at **State University of New York, Binghamton,** forms IEEE Power & Energy Society chapter.

REGION 3

SOUTHEASTERN UNITED STATES

■ **Orlando (Fla.) Section** forms IEEE Technology and Engineering Management Society chapter.

■ Student branch at **Embry-Riddle Aeronautical University, Daytona Beach, Fla.,** forms IEEE Women in Engineering (WIE) affinity group.

■ Student branch at the **University of South Carolina, Columbia,** forms IEEE Power & Energy Society chapter.

■ Student branch at the **University of Tennessee, Knoxville,** forms chapters of IEEE Power & Energy and IEEE Power Electronics societies.

REGION 4

CENTRAL UNITED STATES

■ **Chicago Section** forms IEEE Information Theory Society chapter.

REGION 5

SOUTHWESTERN UNITED STATES

■ **Denver Section** forms IEEE Consultants Network affinity group.

■ **Dallas Section** forms IEEE Sensors Council chapter.

REGION 6

WESTERN UNITED STATES

■ Student branch at the **University of California, Berkeley,** forms IEEE Power Electronics Society chapter.

■ **Hawaii Section** forms IEEE Antennas and Propagation Society chapter.

■ Student branch at **Portland State University, Oregon,** forms IEEE Power & Energy Society chapter.

REGION 7

CANADA

■ **Windsor (Ontario) Section** forms IEEE WIE affinity group.

■ Student branch at the **University of Calgary, Alberta,** forms IEEE Microwave Theory and Techniques Society chapter.

■ Student branch formed at **York University, Toronto.**

REGION 8

EUROPE, MIDDLE EAST, AND AFRICA

■ Student branch formed at **October High Institute for Engineering and Technology, Sixth of October City, Egypt.**

■ Student branch formed at **University of Tartu, Estonia.**

■ **France Section** forms IEEE Control Systems Society chapter.

■ Student branch formed at **Basrah University College of Science and Technology, Iraq.**

■ Student branch at **Jordan University of Science and Technology, Irbid,** forms IEEE Computer Society chapter.

■ Student branch formed at **Islamic University of Lebanon, Khaldeh.**

■ Student branch at **Universidade do Porto, Portugal,** forms IEEE Engineering in Medicine and Biology Society chapter.

■ Student branch formed at **Qassim University, Buraidah, Saudi Arabia.**

■ Student branch at **Chalmers University of Technology, Gothenburg, Sweden,** forms IEEE WIE affinity group.

■ **Switzerland Section** forms IEEE Geoscience and Remote Sensing Society chapter.

■ Student branch formed at **Glasgow Caledonian University.**

■ Student branch at **University of Strathclyde, Glasgow,** forms chapters of IEEE Industry Applications and IEEE Power Electronics societies.

REGION 9

LATIN AMERICA

■ **Argentina Section** forms IEEE Geoscience and Remote Sensing Society chapter.

■ Student branch at **Universidad Nacional del Sur, Bahía Blanca, Argentina,** forms IEEE Robotics and Automation Society chapter and IEEE WIE affinity group.

■ Student branch at **Universidad Católica Boliviana "San Pablo," La Paz, Bolivia,** forms IEEE Engineering in Medicine and Biology Society chapter.

■ Student branch at **Universidade Federal do Pará, Belém, Brazil,** forms IEEE Communications Society chapter.

■ Student branch at **Universidade do Estado do Rio de Janeiro** forms IEEE WIE affinity group.

■ Student branch at **Universidad de Santiago, Chile,** forms IEEE WIE affinity group.

■ **Colombia Section** forms IEEE Instrumentation and Measurement Society chapter.

■ Student branch at **Universidad El Bosque, Bogotá,** forms IEEE Industry Applications Society chapter.

■ Student branch at **Pontificia Universidad Javeriana, Bogotá,** forms IEEE Aerospace and Electronic Systems Society chapter.

■ Student branch formed at **Corporación Universitaria Comfacauca, Cauca, Colombia.**

■ Student branch at **Universidad Francisco De Paula Santander, Cúcuta, Colombia,** forms IEEE Robotics and Automation Society chapter and IEEE WIE affinity group.

■ Student branch at **Universidad Tecnológica de Pereira, Colombia,** forms IEEE Power & Energy Society chapter.

■ Student branch at **Universidad Don Bosco, San Salvador,** forms chapters of IEEE Engineering in Medicine and Biology and IEEE Power & Energy societies.

■ Student branch at **Universidad de San Carlos de Guatemala, Guatemala City,** forms IEEE Computer Society chapter and IEEE WIE affinity group.

■ Student branch at **Instituto Tecnólogico de La Laguna, Torreón, Mexico,** forms IEEE Engineering in Medicine and Biology Society chapter.

■ Student branch formed at **Universidad Peruana Los Andes, Huancayo, Peru.**

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BRIEFINGS

REGION 10

ASIA AND PACIFIC

■ **New South Wales (Australia) Section** forms IEEE Electromagnetic Compatibility Society chapter.

■ Student branch formed at **Edith Cowan University, Perth, Western Australia.**

■ Student branch at **American International University, Dhaka, Bangladesh,** forms chapters of IEEE Industry Applications and IEEE Microwave Theory and Techniques societies.

■ Student branch formed at **Daffodil International University, Dhaka.**

■ **Chengdu (China) Section** forms IEEE Geoscience and Remote Sensing Society chapter.

■ **Xi'an (China) Section** forms IEEE Dielectrics and Electrical Insulation Society chapter.

■ Student branch formed at **Tongji University, Shanghai.**

■ **Hong Kong Section** forms IEEE WIE affinity group.

■ Student branches in **India** at **Delhi Technological University, Mody University of Science and Technology,** and **Rashtreeya Vidyalaya College of Engineering** form chapters of the IEEE Computer Society.

■ Student branches in **India** at **Engineering College Ajmer, Indian Institute of Information Technology,** and the **International Institute of Information Technology** form WIE affinity groups.

■ **Tokyo Section** forms IEEE Magnetics Society chapter.

■ Student branch formed at **Lahore Leads University, Pakistan.**

■ **Republic of Philippines Section** forms WIE affinity group.

■ **Seoul (South Korea) Section** forms IEEE Photonics Society chapter.

■ Student branch formed at **Wayamba University of Sri Lanka, Dandagamuwa.**

■ **Thailand Section** forms IEEE Control Systems Society chapter.

■ Student branch formed at **King Mongkut's University of Technology, Bangkok.**

SEND US YOUR NEWS

We announce the formation of new groups once they've been approved by IEEE Member and Geographic Activities. To send us local news of student branch events and competitions, WIE or preuniversity outreach efforts, or other IEEE group activities, use the form on the Region News page at http://theinstitute.ieee.org/region-news.

G. David Forney Jr.

MIT

Medal of Honor Goes to Forney

LIFE FELLOW G. David Forney Jr. will receive the 2016 IEEE Medal of Honor "for pioneering contributions to the theory of error-correcting codes and the development of reliable high-speed data communications."

Forney began his career in Watertown, Mass., at Codex Corp., one of the first companies to focus on finding practical applications for information theory. He developed error-correcting codes in the late 1960s for NASA's Pioneer deep-space satellite program. In 1970, he designed the first modern high-speed quadrature amplitude modulation (QAM) telephone-line modem, which became an international standard.

He was vice president of R&D at Codex when it was acquired by Motorola in 1977, and he continued to serve as a Motorola vice president until he retired in 1999. Since 1996, he has been an adjunct professor of electrical engineering and computer science at MIT, as well as a researcher in the school's Laboratory for Information and Decision Systems.

Forney served as president of the IEEE Information Theory Society in 1992 and 2008 and as editor in chief of the *IEEE Transactions on Information Theory* from 1970 to 1973.

The IEEE Foundation sponsors the Medal of Honor. Forney is to receive the award on 18 June in New York City at the annual IEEE Honors Ceremony. *—Amanda Davis*

INSIDE

ONLINE

at theinstitute.ieee.org

IN MEMORIAM IEEE mourns the loss of three of its members

ACHIEVEMENTS Read about members who have been recognized for their career accomplishments

Proposed Amendment to the IEEE Constitution

AT ITS NOVEMBER 2015 meeting, the IEEE Board of Directors endorsed revisions to the IEEE Constitution that will be sent to the IEEE membership for approval this year in the form of one amendment. Here is a summary of what the amendment accomplishes:

1. Separates the role of an IEEE delegate from an IEEE director, so that directors need not also be delegates. This modification will allow the IEEE organizational structure to change in the future to better respond to the demands of a complex and changing world. Ultimately this will better serve the needs of members, the profession, and the public.
2. Separates the requirement that corporate officers must also be directors. This will allow corporate officers as currently defined to serve in important leadership positions other than on the Board of Directors.
3. Provides members with an increased role in selecting the Board of Directors by allowing the Board to be elected by the full eligible voting membership of IEEE.
4. Adds the executive director, who is the most senior IEEE staff executive, as a nonvoting member of the Board of Directors to participate in setting the strategic direction of IEEE.
5. Establishes a new role for IEEE delegates, who are members of the IEEE Assembly, to advise the Board of Directors on revisions to IEEE bylaws.
6. Adds language to the IEEE Constitution that explicitly ensures a richly diverse Board of Directors.

To see the revisions, visit http://www.ieee.org/about/

corporate/election/2016_constitutional_amendment.html.

We will continue to work on complementary bylaws and communicating proposed changes to our members. Background information can be viewed at http://www.ieee.org/about/corporate/ieeein2030_archive_m.html, a page that will be updated throughout the year. The IEEE in 2030 Committee may be contacted at feedback2030@ieee.org.

—2015 IEEE President Howard Michel, 2016 President Barry Shoop, and 2016 President-Elect Karen Bartleson

Meet the 2017 Candidates

THE IEEE BOARD of Directors has nominated Life Senior Member Jim Jefferies and Fellow Wanda Reder as candidates for 2017 IEEE president-elect. The winner in this year's annual election will serve as IEEE president in 2018.

Jefferies is a retired AT&T and Lucent Technologies executive who in 33 years rose from manufacturing engineer to vice president. He was responsible for the teams that transferred glass technology from Bell Telephone Laboratories and developed fiber-optic cables at AT&T. He also served as logistics vice president, responsible for international distribution, quality assurance, and export planning. After he retired in 2000, he teamed with fellow Stanford graduates and served as chief operating officer of USBuild.com, a company in San Francisco that worked on nationwide supply chain solutions for homebuilders.

Jefferies has been an active IEEE volunteer for years. As 2015 IEEE-USA president, he led the organization to expand its focus on young professionals and public policy and visibility.

Jim Jefferies

He was on the IEEE-USA board of directors from 2009 to 2015 and served as vice president of government relations and of professional activities. He has provided valuable expertise to the IEEE Audit and Employee Benefits committees, and he is currently chair of the IEEE-USA Entrepreneurship and Innovation Policy Committee. He served as 2012–2013 director of Region 5 and was 2008 chair of the IEEE Denver Section.

Jefferies is a registered professional engineer and a member of IEEE–Eta Kappa Nu, the organization's honor society.

Reder is the chief strategy officer at S&C Electric Co., a provider of switching, protection, and control systems for electric power systems, in Chicago. Prior to S&C, she served as vice president at Exelon, overseeing asset management, engineering, and standards.

Throughout her 29-year career, Reder has led efforts in the development and deployment of smart-grid technologies. She also serves on the U.S. Department of Energy's Electricity Advisory Committee, chairing the smart grid subcommittee.

She was a member of the IEEE Board of Directors in 2014 and 2015, serving as director of Division VII. She also led the IEEE Ad Hoc Committee on Industry Engagement and served on the IEEE Public Visibility Committee and the IEEE Ad Hoc Committee on Holistic IT Development. Reder now serves on the IEEE Foundation board and leads the Audit Committee.

She was the first female president of the IEEE Power & Energy Society (PES) in 2008 and 2009 and has served on its governing board since 2002. As president, she initiated strategies to rebrand the society, effectively growing a more diversified membership worldwide and improving overall financial results.

Reder helped launch the IEEE PES Scholarship Plus Initiative in 2011, a scholarship and internship program that encourages electrical engineering undergrads to pursue careers in power engineering, in partnership with the IEEE Foundation.

In 2010 she helped launch the IEEE Smart Grid initiative and was involved in the global development of several smart-grid resources including the *IEEE Transactions on Smart Grid* and the Innovative Smart Grid Technologies conference series.

Wanda Reder

She was elevated to IEEE Fellow in 2012 "for leadership in power engineering implementation and workforce development." Reder also received the 2014 IEEE Richard M. Emberson Medal "for leadership in the IEEE Smart Grid program and in the continued growth of the Power & Energy Society, including the creation of its scholarship fund." *—A.D.*





Five Elected to the Board

THE IEEE ASSEMBLY in November elected five officers to the IEEE Board of Directors for 2016. All began serving their terms on 4 January. Four were elected to serve a second year [pictured left to right]: Parviz Famouri, secretary; Jerry L. Hudgins, treasurer; Wai-Choong "Lawrence" Wong, vice president, Member and Geographic Activities; and Sheila Hemami, vice president, Publication Services and Products. And S.K. Ramesh [right] began his one-year term as vice president, Educational Activities. *—A.D.*

Calendar of Events

MARCH

2–5
Region 9 meeting in Port of Spain, Trinidad and Tobago

5–6
Region 10 meeting in Bangkok

12–13
Region 2 meeting in Pittsburgh

11–20
South by Southwest in Austin, Texas

19–20
Region 8 meeting in Monte Carlo, Monaco

APRIL

1–3
Region 3 meeting in Norfolk, Va.

16–17
USA Science and Engineering Festival in Washington, D.C.

MAY

13–15
Region 7 meeting in Vancouver, B.C., Canada

23–24
IEEE Women in Engineering Leadership Conference in San Jose, Calif.

FROM TOP: DAVID SUTPHIN STUDIO, BUDDY CASANOVA/S&C ELECTRIC CO.; BOTTOM, FROM LEFT: WEST VIRGINIA UNIVERSITY, IEEE (2), NORTHEASTERN UNIVERSITY, IEEE; CALENDAR, FROM TOP: GETTY IMAGES, ISTOCKPHOTO (2)

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Electrical Engineering Student,
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IEEE

SPECIAL REPORT

GREENER Technologies and Networks

OUR ELECTRONIC GADGETS and office equipment and their networks use a lot of power. The greenhouse-gas emissions produced globally by information and communication technology (ICT) are about the same as that of the global aviation industry: more than 2 percent of the worldwide total, and rising. That's not nearly as high as the largest worldwide emitter: the production of electricity. But ICT is contributing to a surge in demand for electricity, with network traffic doubling every year and billions of devices expected to be added to the Internet by 2020.

One group that's doing something about reducing the ICT sector's carbon footprint is the year-old IEEE Green ICT initiative. *Green ICT* refers to the design and application of information and communication technology to offer environmental benefits. In this issue, we describe the initiative's efforts in raising awareness of how to design more energy-efficient technologies. The group is working with IEEE societies, other IEEE initiatives, and organizations including Bell Labs/Alcatel-Lucent (now part of Nokia) and the University of Leeds.

IEEE Member Thierry Klein at Bell Labs leads the technical committee of the GreenTouch consortium [p. 8]. The consortium has found ways to decrease the carbon footprint of communication and data networks.

There's also a profile of IEEE Senior Member Jaafar Elmirghani, co-chair of the Green ICT initiative, [p. 15].

And we've rounded up some of the resources, standards, and conferences that IEEE offers on green ICT [pp. 12–14].

Elsewhere in this issue, IEEE President Barry Shoop discusses the skills he says tomorrow's technology leaders must possess [p. 11]. The issue also presents the recipient of the 2016 Medal of Honor [p. 3], winners of the 2015 IEEE election [p. 17], and those senior members who joined the 2016 class of Fellows [p. 18]. And read about the proposed revisions to the IEEE Constitution that members will be asked to vote on this year [p. 3].

—Kathy Pretz, editor in chief

Environmentally Friendly
Information and Communication Technology

A new IEEE initiative is working to reduce energy consumption BY **KATHY PRETZ**

INFORMATION AND communication technology are power hogs. Computers, printers, servers, mobile devices, and telecommunication networks are not energy efficient. Although improvements have been made, it has not been enough of a priority. And that's a problem, because projections show that by 2020 the global greenhouse gas emissions from ICT will double from today's 2 percent to 4 percent.

The largest worldwide emitter is by far the production of electricity, with 30 percent of that power typically generated by fossil fuel sources. And demand for electricity is growing, especially for powering networks. More people than ever are using the Internet and other communication networks; annual growth in traffic doubles every two years. By 2020, 21 billion devices will be connected to the Internet, according to the technology research company Gartner. By 2035, the International Energy Agency projects that total demand for electricity will be almost 70 percent higher than today.

Some energy-efficiency gains for ICT have been achieved by using more renewable energy sources and by cooling data centers more efficiently. But that's not enough to shrink the sector's overall carbon footprint. What's needed is a complete rethinking of how to design, build, and use ICT. That's the mission of the IEEE Green Information and Communication Technology initiative (http://greenict.ieee.org), launched in January 2015 by the IEEE Future Directions Committee, IEEE's R&D arm.

Green ICT refers to the design and application of information and communication technology to create environmental benefits. Such practices include improved manufacturing processes for its components and systems and disposal systems that also reduce carbon emissions. The Green ICT initiative calls for the application of green metrics and standards when a project's research and design concepts are first being developed. The initiative works with IEEE societies and other IEEE initiatives dealing with, for example, cloud computing, the Internet of Things, big data, and smart cities.

Because its technical committees have been active in green ICT, the IEEE Communications Society manages the initiative. Collaborators include 16 other IEEE societies as well as representatives from organizations including Bell Labs/Alcatel-Lucent (now part of Nokia), British Telecom, Ericsson Research, the University of Arizona, the University of Leeds, and the University of Melbourne.

"With 40 percent annual traffic growth, if we are able to improve the energy efficiency of today's networks by a factor of 1,000, then in 20 years they would consume the same amount of energy used today," says Senior Member Jaafar Elmirghani, who co-chairs the initiative along with Senior Member Charles Despins. "Whatever is designed—whether it's a communication system, a cloud system, a computer system, or if there's an electron device, photonic device, or an antenna propagation project—it needs to be done with the environment in mind."

OUTREACH ACTIVITIES

The initiative raises awareness of how to design green and clean technology by providing forums for the exchange of information. It has done so through existing publications [p. 13], and it plans this year to launch two new ones dedicated to green ICT.

The group has held information sessions at the IEEE International Conference on Communications, IEEE Globecom, and other gatherings, and is in the process of organizing its own events, workshops, and symposia. It is working to expand the library of green ICT–related standards [p. 12]. And there are tutorials in the works to be given at IEEE conferences and made available on the Green ICT website.

"IEEE knows how to do conferences, how to publish journals, and it has a framework for standards," Elmirghani says. "We are trying to make use of all these capabilities."

OTHER BENEFITS

Improving the environment might be noble, but practical concerns are also at work: Electricity is expensive; reducing its use cuts costs. The National Resources Defense Council, the environmental action group, found that U.S. data centers used 91 billion kilowatt-hours of electricity in 2013 and are on track to consume up to 140 billion kWh per year by 2020—equivalent to electricity bills of nearly US $13 billion annually.

"Companies are very aware of these costs," Elmirghani notes. "That's why a lot of the green ICT projects are being led by industry."

The GreenStar Network project, launched in 2010, seeks to encourage cloud-based ICT services using only renewable energy sources such as the sun, wind, and hydroelectricity. The project, an alliance of Canada's leading IT companies and universities, is led by École de Technologie Supérieure, in Montreal. A summary of that and other projects are on the Green ICT initiative's website under the technology spotlight tab.

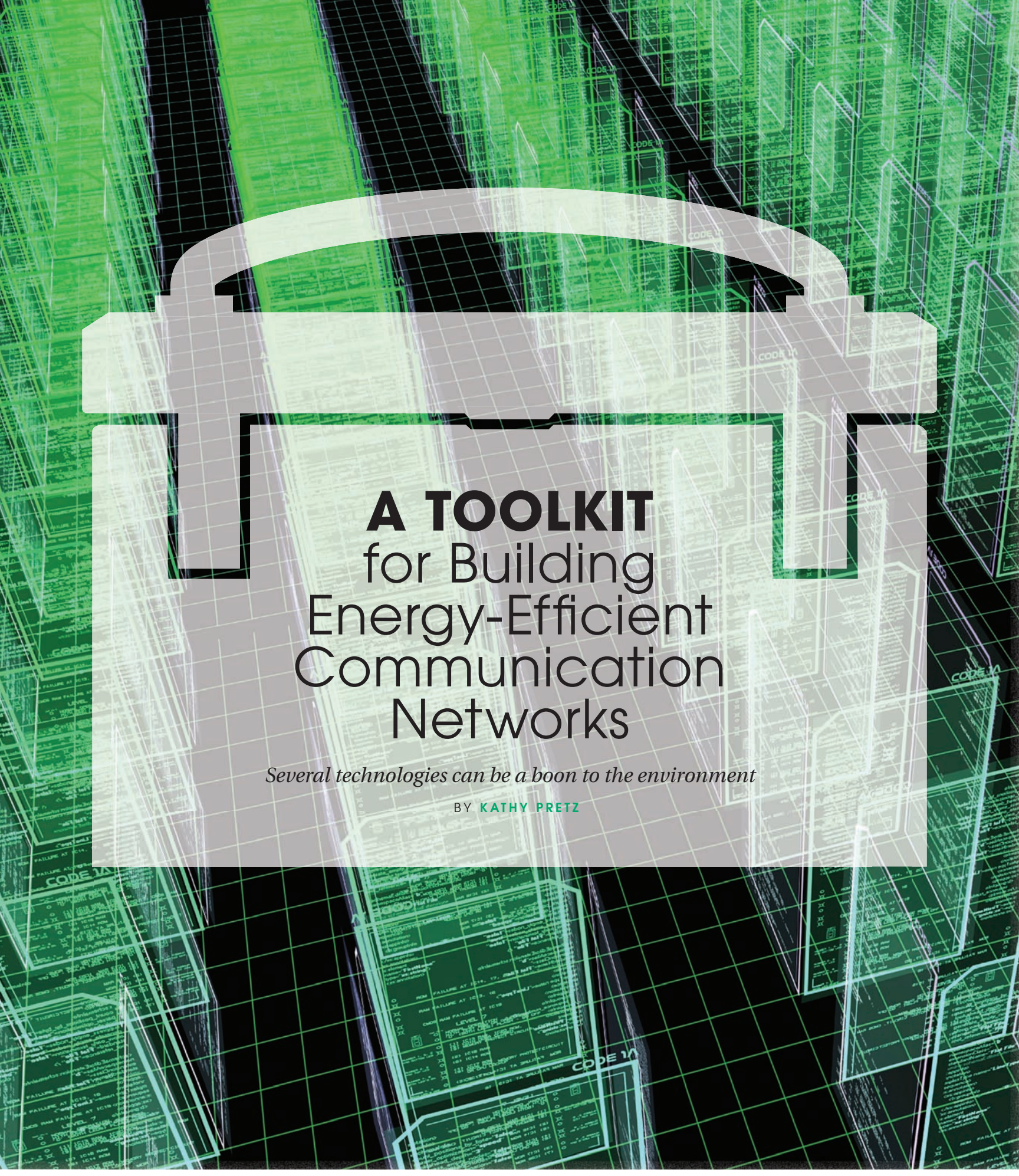
A side benefit of making data centers, wireless networks, and the core networks of telecommunication service providers more energy efficient, known as "greening ICT," would be its adoption in other industries as well. That is known as "greening *by* ICT," Elmirghani says. Sending e-mail rather than postal mail, and using video conferencing instead of flying to attend a meeting, for example, decreases the carbon emissions from postal trucks and airplanes.

Elmirghani cites the decrease in carbon emissions pinpointed in the SMARTer 2030 report issued in June by the Global e-Sustainability initiative. It found greening by ICT could enable a 20 percent reduction of global CO_2 emissions by 2030, effectively holding ICT emissions at 2015 levels, and that ICT can reduce global CO_2 emissions by an amount equal to approximately 10 times its own carbon footprint. The Global e-Sustainability initiative is a collaboration of major ICT companies and a leading source of information, resources, and best practices for achieving integrated social and environmental sustainability through ICT.

The SMARTer report notes that the overall effect of ICT could generate more than $11 trillion in sustainable benefits annually, such as saving more than 300 trillion liters of water and reducing the need for oil by 25 billion barrels. Greening by ICT can benefit society in other ways as well. The report predicts that by 2030, ICT could potentially give 1.6 billion more people access to medical services via telemedicine and provide half a billion with e-learning tools.

"The Green ICT initiative is an ideal opportunity to lead the thinking on what industry and governments should be doing," Elmirghani says. "It fulfills IEEE's mission of fostering technological innovation and excellence for the benefit of humanity." ◆

JOHN LAMB/CORBIS



A TOOLKIT for Building Energy-Efficient Communication Networks

Several technologies can be a boon to the environment

BY KATHY PRETZ

The components that make up today's traditional communication networks were built primarily with performance, not energy efficiency, in mind. As more of everything comes online, the energy consumption of cellphone towers, set-top boxes, routers, and the rest of the infrastructure, to say nothing of data centers, is rising—and so is the cost of running a network.

SOME OPERATORS already have energy bills of more than US $1 billion annually. And socially conscious consumers and governments are demanding that the environmental impact of such systems be reduced drastically.

Finding ways to increase the energy efficiency and shrink the carbon footprint of communication and data networks, including the Internet, was the mission of the GreenTouch consortium (http://www.greentouch.org). This precompetitive research consortium, launched in 2010, is composed of experts from 48 information and communication technology (ICT) companies, as well as academia and nongovernmental organizations. GreenTouch members include Bell Labs/Alcatel-Lucent (now part of Nokia), China Mobile, Huawei, Orange, the Politecnico di Milano, Swisscom, the University of Leeds, and the University of Melbourne.

The group set a lofty goal: improve by 2020 the energy efficiency of communication networks by a factor of 1,000 compared with those in use in 2010 (the year GreenTouch was launched), all without compromising performance and while supporting the larger traffic volumes expected. The group also committed to deliver a road map by last year of what architectures and technologies would accomplish the feat and to demonstrate the key technological contributors.

"We ran studies and found that a factor of 1,000 improvement in energy efficiency would be a bold but feasible grand challenge," says Thierry Van Landegem, who chaired the consortium.

"Achieving that factor of improvement was one important objective," explains IEEE Member Thierry Klein, who led the consortium's technical committee. "But more importantly we wanted to go after a new way of looking at networks. We gave ourselves the freedom to think differently to achieve this ambitious goal."

GreenTouch not only met the goal, it exceeded it. The group announced in June that it found ways to improve the energy efficiency of mobile access networks, which connect cellphones and other mobile devices, by a factor of 10,000. The group delivered on its promise of detailing the architectures, specifications, and technologies that could help lower power consumption. Its research results are expected to enable significant improvements in areas that include fixed-access networks for residences and businesses that use copper or fiber access, and the IP and optical core networks making up the regional and national interconnects that are the backbone of the Internet.

"We asked ourselves what we could do from a hardware, software, architecture, and algorithms perspective if we put energy efficiency at the forefront of network design," Klein says. "We weren't saying make the network more efficient at the expense of decreased performance and reliability. Maintaining high throughput, high performance, and high capacity was a given. Energy efficiency should be achieved on top of that."

A BROAD VIEW

GreenTouch conducted Green Meter, a comprehensive, first-of-its-kind study to assess the overall energy efficiency of everything the group's members were interested in: technologies, architectures, components, devices, algorithms, and protocols. The study didn't quantify the energy benefits of just a single technology but had an end-to-end network perspective to capture the combined and the relative energy-efficiency benefits of different technologies. The study took into account traffic growth until 2020.

For its baseline, the researchers used the most energy-efficient commercially available mobile, fixed-access, and core network technologies that existed in 2010.

According to Klein, if networks supporting the traffic volumes of 2020 were to be built using technologies from the GreenTouch portfolio, they would consume 98 percent less energy than those of 2010. If implemented, the corresponding annual energy savings would be equivalent to eliminating the greenhouse-gas emissions of 5.8 million cars. And the networks would handle more traffic.

The study found there would be a 10,000-fold increase in energy efficiency in the mobile access networks compared with 2010, with an estimated traffic growth of 89 times; a 254-fold increase in energy efficiency in residential fixed access networks, with an estimated traffic growth of 8 times; and a 316-fold increase in energy efficiency in core networks, with an estimated traffic growth of 12 times.

NEW TECHNOLOGIES

Here are a few examples of the energy-saving technologies that GreenTouch members have developed, evaluated, and demonstrated.

Mobile-access networks—cellphone towers and base stations, which are often located a kilometer away from the caller—could be replaced with low-power radio-access nodes that operate in licensed or unlicensed spectrum with ranges of 10 to 100 meters. The smaller cells use the radio spectrum more efficiently and cover the same geographic area but provide better service. They can be located in homes, buildings, and public access spaces, like coffee shops and airports, as well as outdoors.

"These are inherently more efficient because the signal doesn't have to travel as far," Klein says. "Small cells have a small footprint but provide a lot of capacity in a more energy-efficient way."

For residential access networks, the group has proposed that the dedicated set-top boxes in each home be replaced by a virtual gateway in the cloud. "We could host them on a single machine that performs the same functions virtually for everybody," Klein explains. "By moving to the cloud, you can share the resources more effectively and turn the services on only when you need them."

Turning to routers and transponders, the core networks' main power consumers, the GreenTouch group found that optical interconnects and improved digital signal processors with voltage and frequency scaling can lower power consumption. It also has suggested that sleep modes of components be programmed with traffic patterns in mind, saving more energy, along with energy-optimized caching and content distribution algorithms.

"The GreenTouch technologies and results pave the way to a more energy-efficient future and ensure that communication networks remain environmentally and economically sustainable," Klein says. "ICT technologies are increasingly being used to reduce carbon emissions in other industry sectors and are vital to bridge the digital divide and connect the unconnected in the world. Energy efficiency and our results are key contributors and enablers to a more productive and sustainable future for all of us." ◆

ISTOCKPHOTO

Can Tech Moguls Slow Climate Change?

Bill Gates, Mark Zuckerberg, Jeff Bezos, and others who made their fortunes in technology have joined forces to invest in clean energy startups in hopes of slowing the effects of global warming. Zuckerberg, for one, says the progress toward sustainable energy is too slow, which is why the group says private investors should step in.

CHIME IN *Tell us what you think by commenting online at http://theinstitute.ieee.org/opinions/question.*

Sparking Conversation on Smart Homes

In December, *The Institute* dedicated its issue to that once-futuristic vision of a home full of smart gadgets that anticipate our needs, keep us healthy, and save us money. The conversation continued on our website.

AC VERSUS DC

In the blog post "DC Microgrids Need to be Part of the Smart Home Technology Mix," editor in chief Kathy Pretz argued that, for those living in areas without reliable AC electricity, DC microgrids would be reliable sources of power. They generate electricity locally and can minimize transmission losses by covering a smaller area using shorter lines.

"DC is already used where it makes sense; the same goes for AC. Pointing out the obvious, that most circuits use DC internally, does not make DC distribution a no-brainer. Far from it, because the need for voltage conversion and regulation remain, as well as safety isolation where hazardous voltages are present. Quite often that involves chopping DC into AC, then converting it back to DC again. So, why not just start with AC power distribution?"

—Amabo Kcarab

THANKS, BUT NO THANKS

In his column, 2015 IEEE President Howard E. Michel wrote that society will benefit from smarter homes as long as developers of smart-home technologies address issues of privacy and security adequately. One commenter had doubts.

"Society will not benefit. Smart appliances, smart thermostats, etc., are gadgets that no one really needs. And they are a perfect vehicle for hackers to get into your computer or cellphone and perfect for implementing 'Big Brother' style surveillance. No, thank you!" ***—simonts***

THROWAWAY CULTURE

In our question of the month, we asked readers if smart-home gadgets are making our lives easier or if they are adding to the digital divide. One commenter saw another potential drawback.

"The real question is: How long will a manufacturer support a smart appliance? One year? Two? Does that mean we have to throw away our appliances, like we do our smartphones, when the manufacturer stops providing security patches? Some 'non-smart' appliances can last for decades. I guarantee that not one manufacturer will provide software or firmware security updates for that long.

We already live in a throwaway society. We dispose of our phones, laptops, and other devices that connect to the Internet after only two years. We don't need the world to start throwing away refrigerators simply because they're getting hacked and the manufacturer has moved on and no longer supports those models." ***—Kevin C.***

ASK THE EXPERTS

Bill Ash, strategic technology program director of the IEEE Standards Association, in Piscataway, N.J.; Sri Chandrasekaran, the director of standards and technology at the IEEE India office, in Bangalore; and IEEE Fellow Tariq Samad, a 30-year veteran at Honeywell, answered readers' questions about smart homes.

Q: *What will become the standard protocol for home automation?*

Ash: I am not sure we will see a single protocol, because so many technologies and protocols are in use today, depending on the application. For those looking at a vertical application, I hope they standardize protocols and not rely on proprietary ones that would in the long run end up raising the cost for the consumer.

Q: *With streaming video, security cameras, and text messages already taking up many Wi-Fi channels, how will smart-home devices avoid being disrupted?*

Chandrasekaran: As more data-intensive applications are driven through the router, they will affect some applications, depending on the router's bandwidth. Typically, channels in a router are chosen to avoid noise and interference. The quality of the experience will be driven by the bandwidth. Some applications allow you to manage or adjust settings for bandwidth restrictions that make it possible to perform slightly better when data-intensive applications, such as streaming movies, are running in parallel.

Q: *Can smart-home devices interfere with medical implants and, if so, will that be taken into account when the devices are designed and implemented?*

Samad: Almost all smart-home devices, whether they are Internet-connected or not, are being built on communication protocols that permeate a modern home. The 2.4-gigahertz operating frequency of Wi-Fi is especially attractive for device makers, since it is an "open" frequency band worldwide. From that perspective, smart devices should not cause any interference with medical implants if those implants do not experience interference in such places as coffee shops. ◆

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The New Face of Leadership

Future leaders must be able to draw from a breadth of expertise

BARRY L. SHOOP IEEE PRESIDENT AND CEO

ED CARREON

TECHNOLOGY has repeatedly reshaped our world since the foundations of IEEE were laid more than a century ago. In the past, technology played a secondary but supportive role. The primary drivers of change involved social, political, and cultural forces. Today, however, in its influence on society and humanity, technology has the lead role.

Humanity has experienced a global sea change as distributed computing, robotics and automation, personal communications, and cyberspace have evolved. Take just one example: the evolution of the telephone in the past 30 years. Today's telephone is a multifunctional device that provides for interaction that includes face-to-face video chats, text messaging, e-mail, and social media, along with the same voice calls that people have been making for more than a century. In addition, our mobile devices can help us when we're lost, provide real-time language translation, and monitor our personal health and fitness—all while providing the computing power of the supercomputers of decades past.

The telephone's evolution as a driver of social change, however, has been even more remarkable. Mobile phones in Africa are reshaping commerce. Using a mobile money transfer tool called M-PESA (*pesa* is Swahili for *money*), funds can be transferred between bank accounts with text messages. In Europe, mobile phones are vital tools for health monitoring and for enabling the elderly to live more independently. Inexpensive smartphone attachments, for example, monitor blood sugar levels for people with diabetes and even image the eye and prescribe corrective lenses. And everywhere, continuously, viewers and listeners alike are using mobile phones as their gateway to information and entertainment.

Mobile telephones, however, are only one of many technologies driving change in our world. Cloud computing has altered the way we create, process, store, and access information. Robotic assistants are changing how surgery is done. Wars are waged in cyberspace, and crimes are committed with a mouse click. Intel futurist Brian David Johnson, an IEEE member, predicts that in the next few years, the size of meaningful computational power will shrink to near-zero, enabling a present-day supercomputer to be contained in a wristwatch or an article of clothing.

It is, to paraphrase Shakespeare, a brave new world.

AN EYE TO THE FUTURE

But who will be the leaders in this brave new world? What skills will technology professionals and organizations need to lead in this environment?

A recent survey of CEOs by PriceWaterhouseCoopers, an accounting services company, provides insight. According to the survey, industry leaders are looking for employees to do more than perform well as skilled professionals. They also want them to anticipate external issues—such as public policies and regulation, and the convergence of technologies—that affect their fields of interest. The CEOs also place high value on the ability to work collaboratively—with fellow professionals, stakeholders, and others—to create comprehensive, balanced, and effective initiatives and solutions. The ability to build diverse and well-aligned partnerships will be a hallmark of successful leaders in our fields.

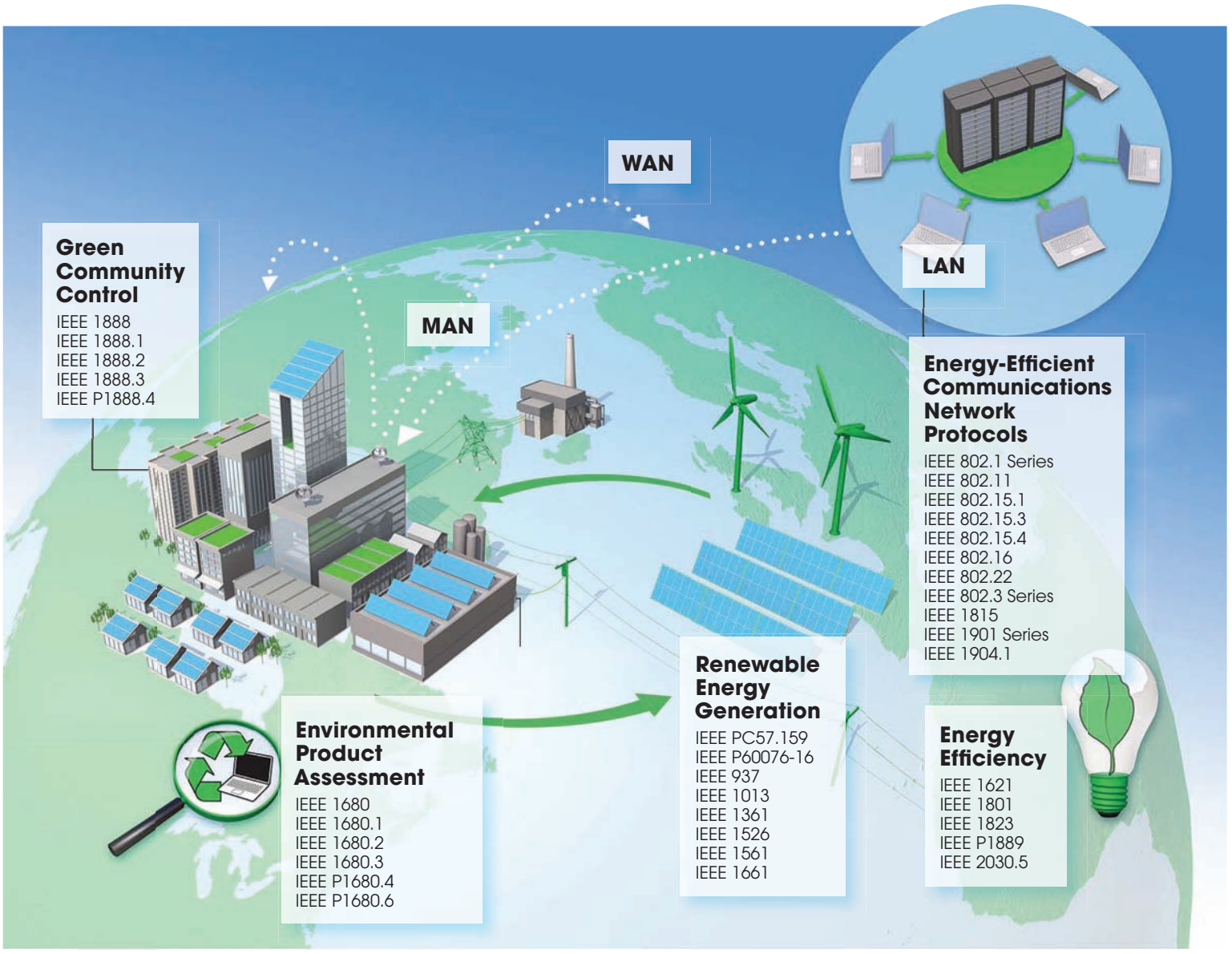
Similarly, tomorrow's technology leaders must work as synthesists—individuals who can draw expertise from an array of disciplines and bring that knowledge to bear on multidisciplinary problems. And they will need to solve these problems as part of a more mobile workforce. A little more than one third of the global workforce is currently mobile; that percentage will only increase as advances in technology redefine what it means to be at work.

A successful leader in such an environment will have to draw not only on knowledge acquired from formal education and experience but also on what are considered the modern professional's "soft" skills: written and oral communications, teamwork, critical thinking, innovation, and entrepreneurship.

Some have called this the rise of the T-shaped individual, a reference to a deep knowledge of a single field of interest coupled with other broad abilities—the aforementioned soft skills and a firm grounding in collaboration.

Organizations also must evolve if they're to lead in this changed environment. Our world is becoming more complex and competitive as technological advances arrive with ever-increasing speed. IEEE as an organization must evolve to provide responsive and adaptable leadership that supports the needs of our members, our professions, and the public. It must be done in an environment of increasing strategic complexity, amid the uncertainties of a changing and dynamic world.

Please share your thoughts with me at president@ieee.org. ◆



IEEE Standards for Greener ICT

Five sets can benefit the environment BY KATHY PRETZ

MORE THAN 50 IEEE standards in five groups—many of them listed above—are helping make information and communication technology more energy-efficient and produce less amounts of greenhouse gases.

The IEEE 1888 Standard for Ubiquitous Green Community Control Network Protocol and the others in the suite are aimed at helping cities, houses, factories, and commercial buildings become green through the use of more efficient sensors; surveillance monitors; heating, ventilating, and air conditioning units; and lighting systems. The standard was initiated by a number of Chinese organizations to address their country's surging energy use.

The IEEE 1680 suite of standards for the environmental assessment of electronic products provides performance criteria that manufacturers must meet when designing environmentally friendly computers, monitors, tablets, and other products. For example, in the IEEE 1680.1 standard for PC products, more than 20 criteria are enumerated.

IEEE also has standards for energy-efficient communications network protocols, which can have significant impact on a system's overall energy dissipation.

There are also a number of standards that describe how to connect renewable energy sources to the grid.

And standards focused on energy efficiency cover a wide variety of concerns including control of power to electronic devices and developing low-power ICs.

The IEEE 2030.5 Standard for Smart Energy Profile Application Protocol, for example, defines how utilities should manage the end user's energy environment, including offering demand response, load control, and distributed generation.

Also in this group is the IEEE P1889 guide, which provides instructions for evaluating and testing the electronic performance of energy-saving devices.

For more information, visit http://standards.ieee.org.

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Green ICT Resources

BY MONICA ROZENFELD

IEEE PROVIDES A HOST of resources for helping engineers improve the energy efficiency of ICT technology.

WEB PORTAL
The IEEE Green ICT initiative's Web portal (http://greenict.ieee.org) contains information on articles, standards, upcoming conferences, and case studies of projects involving green information and communication technology.

TECHNICAL COMMUNITY
From the Web portal, you can join the IEEE Green ICT Technical Community. The group helps promote IEEE's role in advancing green ICT technology. It does so by furthering research, organizing conferences, and analyzing the impact of existing projects. Its members also participate in discussions of research topics and recent developments.

PUBLICATIONS
Several journals and transactions have published special reports that cover how to make technology more environmentally friendly. They include *IEEE Network*, *IEEE Wireless Communications*, *IEEE Transactions on Communications*, *IEEE Transactions on Signal Processing*, and *IEEE Transactions on Vehicular Technology*.

For example, the May/June 2014 issue of *IEEE Software* magazine published "Green Software: Greening What and How Much?" The article covers ICT systems that make industrial processes more efficient, reducing waste and using less raw material, and help protect the environment.

IEEE Access, which publishes open access articles, ran "Green Internet of Things for Smart World" in November. The article highlights ways to reduce energy consumption of technologies involving the Internet of Things, such as the cloud and wireless sensor networks.

The IEEE Communications Society in December launched the "Green Communications and Networking" series of articles in its *IEEE Journal on Selected Areas in Communications*. The series will cover topics such as energy harvesting and storage, the smart grid, and government policies and regulations for reducing the ICT industry's CO_2 emissions.

The initiative this year plans to launch its own transactions composed of technical peer-reviewed papers as well as a magazine with articles on the topic.

Look for the publications in the IEEE Xplore Digital Library.

EDUCATION
Tutorials on ways to reduce the carbon footprint of technologies and their networks are being offered at IEEE conferences. Look for the tutorials this year on the initiative's Web portal.

IEEE's eLearning Library, which you can find in the IEEE Xplore Courses section, has several tutorials. Topics include sustainable green energy; wind turbine design and manufacturing; and green production management for "lean manufacturing," which refers to the process of reducing waste while producing a better product. ◆

Conferences Focus on Sustainable Systems

Upcoming events cover green computing, big data, and the Internet of Things

International Conference on Smart Cities and Green ICT Systems (SmartGreens)

ROME; 23–25 APRIL

TOPICS: Smart cities, smart homes, intelligent transportation systems, big data, e-health, renewable energy resources, energy monitoring and storage, wireless systems and networks, green computing, embedded sensor networks, and the Internet of Things.

SPONSORS: IEEE Power & Energy Society and the Institute for Systems and Technologies of Information, Control, and Communication
VISIT: http://www.smartgreens.org

International Conference on Communication Systems and Network Technologies

CHANDIGARH, INDIA; 5–7 MARCH

TOPICS: Green computing, smart transportation systems, information and network security, remote sensing, e-commerce, big data, the Internet of Things, sensor networks, computational intelligence, and IT management.
SPONSOR: IEEE Delhi Section
VISIT: http://www.csnt.in

IEEE Green Technologies Conference

KANSAS CITY, MO.; 7–8 APRIL

TOPICS: Green technologies for power generation, renewable energy, water conservation, power distribution, energy storage and monitoring, smart transportation systems, power management, and power system interoperability.
SPONSORS: IEEE-USA, IEEE Region 5, and IEEE Kansas City Section
VISIT: http://sites.ieee.org/greentech2016

IEEE International Conference on Multimedia Big Data

TAIPEI, TAIWAN; 20–22 APRIL

TOPICS: Green computing for big-data applications, high-efficiency compression and transmission of multimedia big data, big-data security and privacy, content analysis, data mining, and cloud computing.
SPONSOR: IEEE Computer Society
VISIT: http://bigmm2016.asia.edu.tw

IEEE International Conference on Communications

KUALA LUMPUR, MALAYSIA; 23–27 MAY

TOPICS: Green communication systems and networks, cloud communications and networking, smart-grid communications, data storage, the Internet of Things, ad-hoc and sensor networks, communication and information systems security, and wireless communications.
SPONSOR: IEEE Communications Society
VISIT: http://icc2016.ieee-icc.org

International Symposium on Quality of Service

BEIJING; 20–21 JUNE

TOPICS: Green computing, cloud computing, quality of service in software-defined networking and the Internet of Things, data-traffic management, energy-aware computing and communication systems, and network security and reliability.
SPONSORS: IEEE Communications Society and the Association for Computing Machinery
VISIT: http://www.ieee-iwqos.org ◆

ISTOCKPHOTO

Building a More Eco-friendly Telecom Industry

Jaafar Elmirghani is leading efforts to reduce energy consumption worldwide BY PRACHI PATEL

THE AVIATION INDUSTRY produces about 2 percent of the world's greenhouse-gas emissions and faces great pressure to reduce its carbon footprint. Another industry with comparable emissions, however, flies under the radar with little pushback: information and communication technology (ICT).

"People are unaware that the carbon footprint of ICT is so large," says IEEE Senior Member Jaafar Elmirghani. He is co-chair of the IEEE Green ICT initiative, director of the Institute of Integrated Information Systems, and chair of the communication networks and systems department at the University of Leeds, in England.

What's more, ICT is growing much faster than the aviation industry. Internet traffic is increasing 30 percent to 40 percent each year, Elmirghani points out, adding, "If this rate continues and nothing is done, ICT in 10 years could consume about 60 percent of the world's energy resources."

Elmirghani is leading the initiative's global efforts to make ICT greener. The initiative is:

- Identifying ways to help the telecom industry become more energy efficient.
- Promoting uses of ICT that can make other industrial sectors greener, including manufacturing and transportation.
- Working with ICT companies to develop standards for green technologies and for assessing the full environmental impact of their technologies during their life cycles.

ABOVE AND BEYOND

Elmirghani has led two projects to reduce the carbon footprint of telecom systems by implementing more energy-efficient hardware, architecture, and protocols as well as using renewable energy. One is the INTERNET (for INTelligent Energy awaRe NETworks) project, which received US $9 million in funding from the Engineering and Physical Sciences Research Council, the United Kingdom agency for funding research and training in engineering and the physical sciences.

The other is a five-year project that is part of the GreenTouch Consortium [see p. 8], composed of experts from 48 information and communication technology companies, academia, and nongovernmental organizations. It wants to develop ways to improve network energy efficiency.

In June, he received the GreenTouch 1000x Award, one of the most prestigious honors in the green communications industry.

UNIVERSITY OF LEEDS

His recommendations for improving energy efficiency include equipping all new telecom hardware with a sleep mode to power down equipment when network traffic is low. Better caching—which stores data closer so future requests can be retrieved faster—is another simple way to minimize power use.

Another recommendation is to improve the protocols for data transfer and optimize the placement of network nodes, or connection points, which would also impact energy use.

"If I want to send information from point A to point B, the best way to minimize power consumption may not always be to take the shortest route but the one that goes through the fewest nodes, which transmit messages toward the final destination," he says. Sending larger data packets also would help because there would be fewer packets to switch and route.

During the next two years, Elmirghani is working with the IEEE Green ICT group to demonstrate hardware that relies on those techniques. Many of the upgrades would be software-based, making them relatively easy to set up. But it would be up to the telecom industry to put them into practice. Telecom companies replace on average a fifth of their equipment each year, Elmirghani says, giving them opportunities to buy more energy-efficient equipment.

The key drivers for the changes are not likely to be solely economic but will also depend on government mandates for companies to reduce their carbon footprints, he adds.

Besides changes in equipment and architecture, renewable energy sources also could drastically cut networks' carbon footprints. Elmirghani has addressed the possibility of using solar and wind energy in optical telecom networks, for example. Today's networks assume that their power sources are constant. Incorporating variable renewable sources raises a number of questions, such as how to deal with power that varies, where to place solar and wind farms, how many to employ, and how to route data to make the best use of renewable energy.

Elmirghani showed that running central network nodes on renewables best minimizes a network's carbon footprint, and he has developed data-routing algorithms for networks that would use the largest amount of renewable energy. He also has demonstrated that it's more efficient to build data centers closer to power sources than to customers so as not to waste energy over power lines. Fiber-optic communication networks would, of course, avoid that power loss. Google and other major players already have started to build data centers near hydroelectric dams.

DEVOTED TO GREEN

Elmirghani grew up in the northeastern Sudanese city of Port Sudan. He received a bachelor's degree in electrical engineering from Sudan's University of Khartoum in 1989. He later earned a Ph.D. in 1994 from the University of Huddersfield, in England, for work on optical receiver design, and he earned a doctor of science degree in 2014 in communication networks and systems from the University of Leeds.

In 2000, he joined Swansea University, in Wales, as a professor of electrical engineering. He went on to found and direct the university's Institute of Advanced Telecommunications, developing cutting-edge concepts in optical wireless systems that led to significant data rate increases. With optical networks exploding in size and energy use, he recognized the importance of green ICT.

Now as co-chair of the Green ICT initiative, he has been helping to organize symposia, workshops, and conferences, including the IEEE OnlineGreenComm virtual conference on green communications held in November. He also is working to launch two publications—*IEEE Transactions on Green ICT* and *IEEE Green ICT Magazine*—this year and next.

Elmirghani says his main goal is to make all IEEE societies aware of the importance of green ICT so they'll keep environmentally friendly metrics in mind when designing systems and products: "I hope to see ICT systems so well designed that we no longer have to worry about their carbon footprint." ◆

A Telecom Entrepreneur

IEEE Member Eileen Healy has founded two multimillion-dollar ventures

BY **MONICA ROZENFELD**

AN ELECTRICAL engineer by training, IEEE Member Eileen Healy always has had a knack for solving problems. So when she saw gaps that needed to be filled in the telecom industry, she started a company to address them. In fact, she founded a pair of ventures to meet the growing needs of the mobile phone market.

In the mid-1990s, Healy was working at an AT&T affiliate, developing a strategy for launching a mobile network. "There were gaping holes in the telecom industry's knowledge of how to quickly build a mobile network and to scale engineering and operations processes," she says. When she could not find anyone to help with those needs, she decided to create the go-to company.

"I went to my CEO at the time and said, 'If I start a business to help with these problems, would you hire me?'" Soon after, in 1995, she launched Healy and Co., in San Francisco, to help telecom companies with engineering tasks related to building and migrating traffic on mobile networks. And, indeed, her former CEO did eventually give her a contract.

In 15 years, the company delivered engineering service solutions for more than 90 different regional and national mobile networks including AT&T and T-Mobile. Annual revenue for Healy's company has ranged from US $3 million to $8 million. And in 2000 she patented an algorithm to forecast geographic traffic and market sizes for the telecom industry—which led her to found TeleCompetition, an early data analytics company, also in San Francisco.

DEFINING A NEED

Healy didn't have much entrepreneurial experience before launching her first company. She learned quickly by necessity as the business rapidly grew. She says she believes her relatively high tolerance for risk and her willingness to fail were what gave her the confidence to push ahead.

She also understood one cannot run a business alone. "Bring in the smartest people you can find," she recommends, "preferably smarter than you." But that doesn't necessarily mean hiring them. Healy set up a volunteer advisory board made up of telecom and other business leaders to help guide her through the process of running the company.

One of the biggest gambles of setting out on your own is the financial risk, Healy notes. But as a self-proclaimed workaholic, she launched her company while also keeping her day job, quitting that a year later when the new enterprise had grown.

Many first-time entrepreneurs have a hard time growing their businesses because they don't believe anyone can do the job as well as they can, she says, adding, "They try to do everything." Healy knew she could not. Building a stellar management team is crucial, she says. An early hire was a chief financial officer who, besides managing the finances, was also responsible for the pricing strategy and protecting the company and shareholders.

Healy also sought out legal counsel and built strong relationships with banks. She advises entrepreneurs to keep anyone with a stake in the company informed, of the good and the bad. "Never surprise your banker or your investors," she says.

Her two ventures have had as many as 100 employees at any given time, but she says it doesn't matter how many employees you have. What's important is demonstrating the leadership to make the staff feel empowered and part of the team.

Because Healy and Co. has remained relatively small, it is agile, which can be a real competitive edge. When AT&T hired the company to replace outdated equipment with more energy-efficient systems, for example, or T-Mobile needed help with a merger without disrupting service to customers, Healy and Co. was able to help much faster than its larger competitors.

Healy says she considers herself a bootstrap entrepreneur because she didn't seek out investors. Instead, she worked the first year to support the business at research firm Gartner, which is where she came up with the idea for her second startup, TeleCompetition. After successfully using the platform to correctly forecast global adoption of mobility services such as infotainment and machine-to-machine communications, she sold the intellectual property from TeleCompetition in 2008 for an undisclosed amount.

"Entrepreneurs have to be good at transitioning and knowing when to sell a company as well as when to start one," she says. For now, Healy and Co. still operates as a consulting business, providing guidance for mobility networks, as she looks for her next venture.

NEXT STOP

Healy continues to be involved in next-generation networks and studying how the information and communication technology (ICT) ecosystem will be affected by software-defined networks as we move into 5G (fifth-generation) networks. SDNs are networks of equipment that decouple hardware from software, which is executed in the cloud or in clusters of distributed IT servers.

This development is expected to have far-reaching impacts by digitizing and automating processes, optimizing resource usage, and creating new forms of cooperation and competition in the marketplace. SDNs are being implemented for applications such as autonomous cars and the Internet of Things. Healy is the co-chair of the IEEE SDN initiative, which is leading an effort to radically change the radio access networks that deliver mobile phone service.

She is also involved in green ICT practices to reduce energy costs. Those have included migrating network traffic to newer equipment—a challenging task in operational public networks. She says she also envisions simple low-tech solutions to make the industry more eco-friendly, including using heavy plastic sheets to capture heat in data centers instead of unnecessarily cooling the air.

The ideal foundation for any successful startup, she says, is to find "white space," an unfilled market where there is no competition and where someone is willing to pay for a product or service. If you can fulfill a real need before anyone else, you'll have the advantage and can minimize your risk. At that point, she advises entrepreneurs, "go for it!" ◆

This article is part of a startup series introduced this year featuring IEEE members who have launched their own ventures.

HEALY AND CO.

OF NOTE

2016 Election Countdown

A look at open positions and deadlines

ON 1 MAY, the IEEE Board of Directors is scheduled to announce the candidates to be placed on this year's ballot for the annual election of officers, which begins on 15 August. Those elected take office next year. The ballot includes IEEE president-elect candidates, who are nominated by the Board, as well as nominees for delegate-elect/director-elect openings submitted by division and region nominating committees.

The ballot also includes nominees for IEEE Standards Association members-at-large, IEEE Technical Activities vice president–elect, and IEEE-USA president-elect and member-at-large. IEEE members who want to run for an office but have not been nominated need to submit a petition to the IEEE Board of Directors. The petition must include the necessary number of valid voting members' signatures, and the petitioner must meet other requirements as well. Petitions should be sent to the IEEE Operations Center, in Piscataway, N.J. The IEEE Board of Directors is also responsible for placing any proposed constitutional amendments on the ballot.

For more information about the process for getting on the ballot, visit the IEEE annual election Web page (http://www.ieee.org/election) or write to elections@ieee.org.

UP FOR ELECTION IN 2016

Chosen by all voting members
- IEEE president-elect

Chosen by members of all technical societies
- IEEE Technical Activities vice president–elect

Chosen by members of the respective technical divisions
- IEEE Division I delegate-elect/director-elect
- IEEE Division III delegate-elect/director-elect
- IEEE Division V delegate-elect/director-elect
- IEEE Division VII delegate-elect/director-elect
- IEEE Division IX delegate-elect/director-elect

Chosen by members of the respective regions
- IEEE Region 2 delegate-elect/director-elect
- IEEE Region 4 delegate-elect/director-elect
- IEEE Region 6 delegate-elect/director-elect
- IEEE Region 8 delegate-elect/director-elect
- IEEE Region 10 delegate-elect/director-elect

Chosen by members in Regions 1–6
- IEEE-USA president-elect
- IEEE-USA member-at-large

Chosen by members of the IEEE Standards Association
- Standards Association board of governors members-at-large

DEADLINES AT A GLANCE

15 March Deadline for organizational units to submit slates of candidates to the IEEE Board of Directors for inclusion on the annual election ballot.

15 April Deadline for submitting an intention to file a petition to run for an office on the annual election ballot.

1 May IEEE Board of Directors submits to the voting membership a list of nominees for IEEE president-elect, delegate-elect/director-elect, as applicable, and other positions to be elected by voting members for the coming term. The board also announces whether it intends to put forward any constitutional amendments.

13 May Signed petitions nominating an individual for placement on the annual election ballot must be received by noon EDT USA/16:00 UTC.

15 August Annual election ballots are sent to all voting members on record as of 30 June. Voters also may begin accessing their ballots electronically.

3 October Ballots must be received by 1 p.m. EDT USA/17:00 UTC.

The 2015 Election Results

Here is the Tellers Committee tally of votes counted in the 2015 annual election and approved in November by the IEEE Board of Directors.

IEEE President-Elect, 2016

Karen Bartleson	22,367
Frederick "Fred" C. Mintzer	17,887

IEEE Division Delegate-Elect/Director-Elect, 2016

Division II

F.D. "Don" Tan	2,259
Hulya Kirkici	1,628

Division IV

Jennifer T. Bernhard	2,120
John T. Barr IV	1,218
Tapan K. Sarkar	1,137

Division VI

John Y. Hung	1,374
Luke R. Maki	1,251

Division VIII

Dejan S. Milojicic	2,999
Arnold N. Pears	2,240

Division X

Toshio Fukuda	3,534
John R. Vig	1,809

IEEE Region Delegate-Elect/Director-Elect, 2016–2017

Region 1

Babak D. Beheshti	1,864
Gim Soon Wan	1,860

Region 3

Gregg L. Vaughn	1,772
John E. Montague	1,299

Region 5

Robert C. Shapiro	1,374
T. Scott Atkinson	1,370

Region 7

Maike Luiken	966
Xavier N. Fernando	681

Region 9

Teófilo J. Ramos	618
José-Ignacio Castillo-Velázquez	614
Enrique A. Tejera	500

IEEE Standards Association President-Elect, 2016

Forrest D. "Don" Wright	669
Robert S. Fish	556

IEEE Standards Association Board of Governors Member-at-Large, 2016–2017

Philip B. Winston	754
W.C. "Chuck" Adams Jr.	542

IEEE Standards Association Board of Governors Member-at-Large, 2016–2017

Paul Nikolich	692
Stanley Krolikoski	591

IEEE Technical Activities Vice President–Elect, 2016

Marina Ruggieri	13,393
Douglas N. Zuckerman	11,586

IEEE-USA President-Elect, 2016

Karen S. Pedersen	12,924
Keith D. Grzelak	7,565

IEEE-USA Member-at-Large, 2016–2017

Daniel N. Donahoe	12,885
Wole Akpose	7,438

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Introducing the 2016 Class of Fellows

The Institute congratulates these 297 IEEE senior members named IEEE Fellows for 2016. They join an elite group of people who have contributed to the advancement or application of engineering, science, and technology.

David A. Abramson
Vassilios Agelidis
Kiyoharu Aizawa
Ozgur B. Akan
Alin Albu-Schaeffer
Massimo Alioto
Alexandre P. Alves da Silva
Lorenzo Alvisi
Massoud Amin
Plamen P. Angelov
Tatsuo Arai
Huseyin Arslan
David Atienza
Ronald T. Azuma
Fan Bai
Christopher John Baker
William J. Baldygo
Sanghamitra Bandyopadhyay
Edward J. Baranoski
Kenneth E. Barner
Siegfried Bauer
B. Wayne Bequette
Karl K. Berggren
Shannon D. Blunt
Kwabena A. Boahen
Francesco Borrelli
Laura J. Bottomley
Brian P. Brandt
Michael S. Branicky
Henning Braunisch
David M. Brooks
Juergen Brugger
Tracy Camp
Eugenio Cantatore
Jinde Cao
Bruce E. Carlsten
Sandro Carrara
Umit V. Catalyurek
Tony F. Chan
Yiu Tong Chan
Chorng-Ping Chang
Chun-Hung Chen
Degang Chen
Jie Chen
Shigang Chen
Shu-Ching Chen
Xilin Chen
Gyu Hyeong Cho
C.Y. Chung
Henry S. Chung
Wan Kyun Chung
Terry C. Cisco
George L. Clark
Armando W. Colombo
Ian Craddock
Lorrie F. Cranor
Luiz A. Da Silva
Gilles Dambrine
Timothy A. Davis
Leila De Floriani
Carlos Canudas De Wit
Robert Deng
Maria-Gabriella D. Di Benedetto
Yixin Diao
Warren E. Dixon
Ananth Dodabalapur
David B. Doman
Ravindranath Droopad
Frederic Dufaux
Schahram Dustdar
Michael Eineder
Georges N. El Fakhri
Danilo Erricolo
Karu P. Esselle
Giuseppe Fabrizio
Jun Fan
Mukta Ghate Farooq
Patrick J. Fay
Faramarz Fekri
Leonard C. Feldman
Claudia Felser
Gabor Fichtinger
Dinei A. Florencio
Thor I. Fossen
F. Stuart Foster
Christina Fragouli
Michael Franz
Patrick J. French
Jessica Fridrich
Masayuki Fujita
Vincenzo Galdi
Alan Gatherer
Maryellen L. Giger
Fernando Gomide
Tibor Grasser
Anthony Grbic
Anthony Guiseppi-Elie
Gerhard P. Hancke
Edwin Robert Hancock
Alan Hanjalic
Tomohiro Hase
Dimitrios Hatzinakos
Scott A. Hauck
Aaron R. Hawkins
George F. Hayhoe
Larry P. Heck
Maurice Heemels
Gernot Heiser
Michael I. Henderson
Mark C. Hersam
John Heywood
Mark N. Horenstein
Tzyy-Sheng Jason Horng
Jiang Hu
Xiaobo Sharon Hu
Yu Hu
Xian-Sheng Hua
Jianwei Huang
Jiwu Huang
Qiang Huang
Qing-An Huang
Tony Huang
Adrian M. Ionescu
Mohammad S. Islam
Rabih A. Jabr
Yungtaek Jang
Dan Jiao
Yaochu Jin
Alvin J. Joseph
Mahmut T. Kandemir
Lance M. Kaplan
Sheldon P. Kennedy
Joungho Kim
Nam Sung Kim
Katsumi Kishino
Hitoshi Kiya
Stuart Kleinfelder
Michael A. Kneissl
Vladimir I. Kolobov
Avinoam Kolodny
Danica Kragic
William F. Krupke
Lawrence J. Kushner
Akhlesh Lakhtakia
Erik G. Larsson
Mark E. Laubach
Eugene Lavretsky
Inkyu Lee
Jong Ho Lee
Ta Sung Lee
Hui Lei
Charles E. Leiserson
Peng Li
Shaoqian Li
Zhiwu Li
Tsorng-Juu Liang
Weisi Lin
Xuemin Lin
Kai Liu
Blake A. Lloyd
Stefano Lonardi
Chenyang Lu
Shih-Lien L. Lu
Songwu Lu
Victor M. Lubecke
Fa-Long Luo
Jian-Guo Ma
Xiaoli Ma
Souvik Mahapatra
Gabriele Manganaro
Dimitris G. Manolakis
Jonathan H. Manton
Joao P. Marques Silva
Frank S. Marzano
Shinji Matsuo
Clyde V. Maughan
Sudip Kumar Mazumder
Nenad Medvidovic
Farid Melgani
Ellis Meng
Dimitri Metaxas
Risto Miikkulainen
Federico Milano
Lamine Mili
Hlaing Minn
Vishal Misra
Daniele Mortari
David J. Moss
Frank Mueller
Annette Muetze
Satoshi Nakamura
Thyagarajan Nandagopal
Antonio Napolitano
Robert J. Nelson
Andrea Neto
Branislav M. Notaros
Richard Nute
Claude P. Oestges
Haruhiko Okumura
Peggy E. O'Neill
Kenichi Osada
Pablo A. Parrilo
Mahendra C. Patel
Keith D. Paulsen
Joao Abel Pecas Lopes
Fernando Perez-Gonzalez
Luca Perregrini
Zhouyue Pi
William J. Plant
Ajay K. Poddar
Ting-Chung Poon
Petar L. Popovski
Alexandros G. Potamianos
Domenico Prattichizzo
Calton Pu
Min Qiu
Wendi B. Rabiner Heinzelman
Stojan Radic
B.M. Azizur Rahman
Sreeranga P. Rajan
Rajeev J. Ram
Sundeep Rangan
Gregory Raybon
Leonard F. Register
Andreas Reigber
Kui Ren
Wei Ren
Stefan Ritt
Pablo Rodriguez
Stergios I. Roumeliotis
Chris Rowen
Xinbo Ruan
Daniel Rueckert
Daniel D. Sabin
David Douglas Sampson
Jagannathan Sarangapani
Lorenz P. Schmidt
Noel N. Schulz
Karsten Schwans
Ivan W. Selesnick
Subhabrata Sen
Sudipta Sengupta
Ben Seng Pan U
Weisong Shi
Yuhui Shi
Thomas J. Silva
Osvaldo Simeone
Marcelo G. Simoes
Theodore Sizer
Bruce W. Smith
Jian Song
Matteo Sonza Reorda
Mehmet Soyuer
Giovanni Spagnuolo
Thomas Stuetzle
Il Hong Suh
Sun Sumei
Toru Tanzawa
Vladimir Terzija
Diane Thiede Rover
John S. Thompson
Qi Tian
Akira Toriumi
Sennur Ulukus
K.R. Venugopal
Silverio Visacro
Martin Vossiek
Sarma Bala K. Vrudhula
Bernhard H. Walke
Pengjun Wan
Cliff X. Wang
Jia Wang
Yue Wang
Zhengdao Wang
Zhong Feng Wang
David Wolpert
Kaikit Wong
Vincent Wong
Ernest Y. Wu
Jieh T. Wu
Liang-Liang Xie
Chengzhong Xu
Chenyang Xu
Li D. Xu
Shugong Xu
Lie Liang Yang
Mark B. Yeary
Kiat-Seng Yeo
Jinhong Yuan
Luca Zaccarian
Bing Zeng
Daniel Zeng
Jianzhong Zhang
Xi Zhang
Yi Zhang
Lizhong Zheng
Ping Zhou

RANDI KLETT

Who Will Lead IEEE in 2017 and 2018?

Volunteers are needed to serve as corporate officers and committee members and chairs

IEEE IS GOVERNED by volunteer members and depends on them for its operation. For example, they edit IEEE publications, organize conferences, coordinate regional and local activities, write standards, lead educational activities, and identify individuals for IEEE recognitions and awards.

The Nominations and Appointments (N&A) Committee is responsible for developing recommendations for staffing many volunteer positions, including candidates for president-elect and corporate officers. Its recommendations are sent to the Board of Directors and the IEEE Assembly. Accordingly, the N&A Committee is seeking nominees for the following positions:

2018 IEEE President-Elect (who will serve as President in 2019)

2017 IEEE Corporate Officers

- Vice president, Educational Activities
- Vice president, Publication Services and Products
- Secretary
- Treasurer

2017 IEEE Committees (chairs and members)

- Awards Board
- Election Oversight
- Employee Benefits and Compensation
- Ethics and Member Conduct
- Fellow
- Global Public Policy
- Governance
- History
- Humanitarian Activities
- New Initiatives
- Nominations and Appointments
- Public Visibility
- Tellers

DEADLINE FOR NOMINATIONS

15 March 2016

WHO CAN NOMINATE?

Anyone may submit a nomination. Nominators do not need to be IEEE members, but nominees must meet certain qualifications. Self-nominations are encouraged. An IEEE organizational unit may submit recommendations endorsed by its governing body or the body's designee.

A person may be nominated for more than one position. Nominators need not contact their nominees before submitting them. The N&A Committee will contact all eligible nominees for the documentation that's required, and inquire if they're willing to be considered for the position.

HOW TO NOMINATE

For information about the positions, including qualifications and estimates of the time required by each position during the term of office, check the Guidelines for Nominating Candidates at http://www.ieee.org/about/corporate/nominations/nominations_guidelines.html. To nominate a person for a position, complete the online form.

NOMINATING TIPS

Each year many ineligible candidates are nominated. Make sure to check eligibility requirements at the N&A Committee website at http://www.ieee.org/nominations before submitting a nomination.

The positions for which the N&A Committee makes recommendations represent the uppermost governance levels in IEEE. The committee recommends volunteers with relevant experience in lower-level IEEE committees and units more often than volunteers having no such experience. For example, nominees for the Awards Board have a greater likelihood of being recommended if they already served on an awards committee of a society, section, or region or on another IEEE board.

Individuals recommended for president-elect and corporate officer positions are more likely to be recommended if they show a strong track record of leadership and relevant accomplishments within and outside IEEE. Recommended candidates often have significant prior experience as members of IEEE boards and committees.

More information about the duties associated with the different positions, qualifications, and eligibility requirements (such as prior service in certain positions or IEEE grade) can be found in the Guidelines for Nominating Candidates.

—J. Roberto Boisson de Marca, chair, 2016 IEEE Nominations and Appointments Committee

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