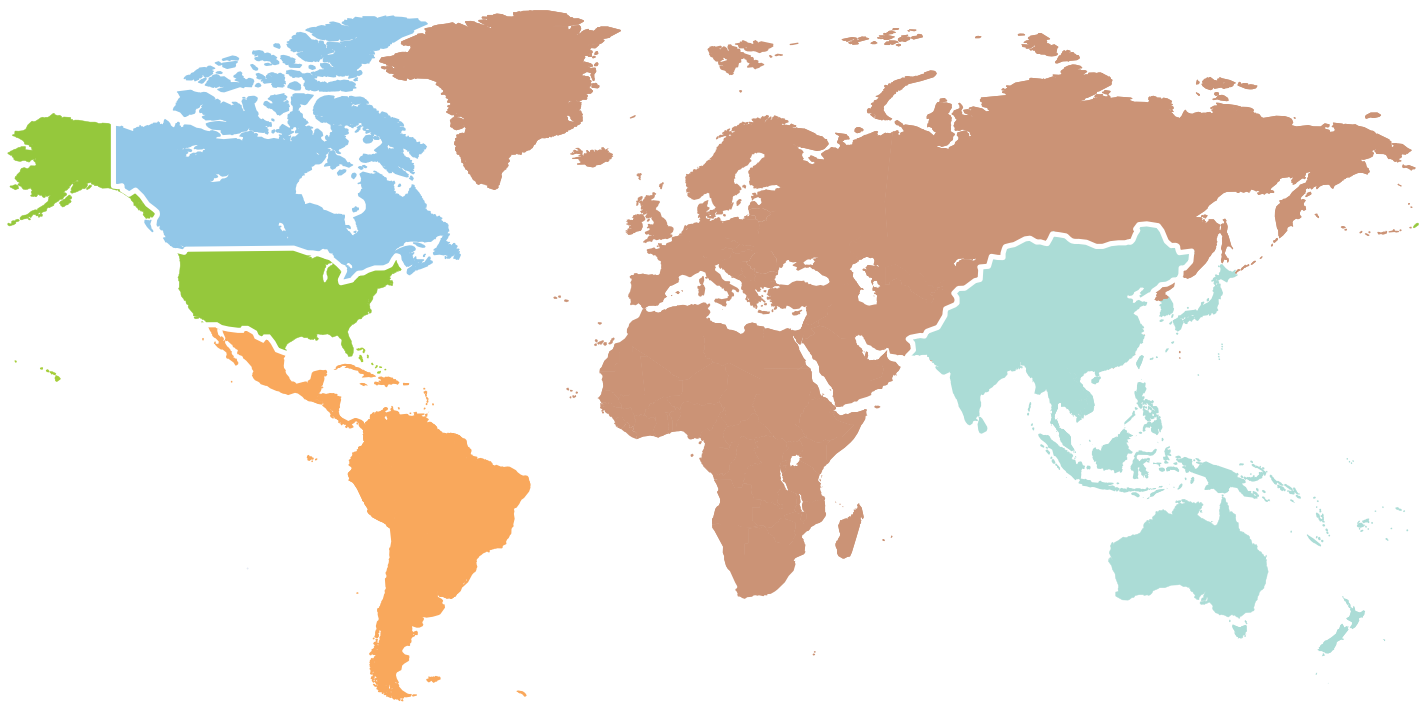


## VOLUME 41 • ISSUE 1 • MARCH 2017 • THEINSTITUTE.IEEE.ORG

# The New Wireless Frontier





# REGION NEWS

**REGION 1** **NORTHEASTERN UNITED STATES**

- Student branch at **New York City College of Technology** forms IEEE Women in Engineering (WIE) affinity group.

**REGION 3** **SOUTHEASTERN UNITED STATES**

- Student branch at **Florida Atlantic University, Boca Raton**, forms IEEE Power & Energy Society chapter.

- Student branch formed at **Florida Polytechnic University, Lakeland**.
- Student branches at **University of North Carolina, Charlotte**, and **University of Virginia, Charlottesville**, form chapters of IEEE Power & Energy Society.

**REGION 4** **CENTRAL UNITED STATES**

- **Central Illinois Section** forms IEEE Young Professionals (YP) affinity group.
- Student branch at **Saginaw Valley State University, University Center, Mich.**, forms IEEE Industry Applications Society chapter.
- **Southern Minnesota Section** forms IEEE YP affinity group.

**REGION 5** **SOUTHWESTERN UNITED STATES**

- **Central Texas Section** forms chapters of IEEE Computer and IEEE Engineering in Medicine and Biology societies.

- Student branch at **University of Texas, San Antonio**, forms IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society chapter.

**REGION 6** **WESTERN UNITED STATES**

- **San Fernando Valley (Calif.) Section** forms IEEE Robotics and Automation Society chapter.

- Student branch at **Washington State University, Vancouver**, forms IEEE Industry Applications Society chapter.

**REGION 7** **CANADA**

- **Montreal Section** forms chapters of IEEE Consumer Electronics Society and IEEE Nanotechnology Council.

**REGION 8** **EUROPE, MIDDLE EAST, AND AFRICA**

- Student branch formed at **Bahrain Polytechnic, Isa Town**.

- **Egypt Section** forms IEEE Technology and Engineering Management Society chapter.

- Student branch at **German University, Cairo**, forms IEEE Robotics and Automation Society chapter.

- **Italy Section** forms chapters of IEEE Broadcast Technology, IEEE Consumer Electronics, and IEEE Dielectrics and Electrical Insulation societies.

- Student branch at **University of Pavia, Italy**, forms IEEE Microwave Theory and Techniques Society chapter.

- Student branch formed at **Al-Zaytoonah University, Amman, Jordan**.

- Student branch formed at **Gulf University**

- for Science and Technology, **Mubarak Al-Abdullah, Kuwait**.

- Student branch formed at **Lebanese University, Beirut**.

- Student branch formed at **Muscat College, Oman**.

- Student branch formed at **Shaheed Zulfiqar Ali Bhutto Institute of Science and Technology, Karachi, Pakistan**.

- Student branch at **National Research University of Electronic Technology, Zelenograd, Russia**, forms IEEE Engineering in Medicine and Biology Society chapter.

- **Saudi Arabia Section** forms IEEE WIE affinity group.

- **Tunisia Section** forms IEEE Control Systems Society chapter.

- Student branch at **National Engineering School of Tunis, Tunisia**, forms IEEE Power & Energy Society chapter.

- Student branch at **Karadeniz Technical University, Trabzon, Turkey**, forms IEEE WIE affinity group.

- Student branch formed at **Sakarya University, Turkey**.

**REGION 9** **LATIN AMERICA**

- Student branch formed at **Universidad Tecnológica Nacional, San Nicolás de los Arroyos, Argentina**.

- Student branch at **Universidade Federal de Campina Grande, Brazil**, forms IEEE Power & Energy Society chapter.

- Student branch at **Universidade de Brasília** forms chapters of IEEE Communications and IEEE Power & Energy societies.

- Student branch at **Universidade Federal do Rio de Janeiro** forms IEEE Power & Energy Society chapter and IEEE WIE affinity group.

- Student branch at **Londrina State University, Brazil**, forms IEEE Robotics and Automation Society chapter.

- Student branch at **Universidad de Concepción, Chile**, forms IEEE Engineering in Medicine and Biology Society chapter.

- Student branch at **Escuela Tecnológica Instituto Técnico Central, Bogotá**, forms IEEE WIE affinity group.

- Student branches formed in **Colombia** at **Comfenalco Technological University Foundation, Cartagena**, and **Universidad Santo Tomás, Bucaramanga**.

- Student branch at **Universidad del Norte, Barranquilla, Colombia**, forms IEEE Engineering in Medicine and Biology Society chapter.

- Student branch at **Universidad Tecnológica Centroamericana, Tegucigalpa, Honduras**, forms IEEE Power & Energy Society chapter.

- **Mexico Section** forms IEEE WIE affinity group.

- Student branch formed at **Instituto Tecnológico de Ciudad Victoria, Mexico**.

- Student branch at **University of Guanajuato, Mexico**, forms IEEE Photonics Society chapter.

- Student branches formed in **Peru** at **Universidad Nacional Agraria de la Selva, Tingo María**, and **Universidad del Pacífico, Lima**.

- Student branch at **Universidad Nacional de Ingeniería, Lima**, forms IEEE Engineering

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in Medicine and Biology Society chapter and IEEE WIE affinity group.

■ Student branch at **Universidad Peruana de Ciencias Aplicadas, Lima**, forms IEEE Communications Society chapter and IEEE WIE affinity group.

#### REGION

# 10

#### ASIA AND PACIFIC

■ Student branch at **Bangladesh University of Engineering and Technology, Dhaka**, forms IEEE WIE affinity group.

■ Student branch formed at **Shahjalal University of Science and Technology, Sylhet, Bangladesh**.

■ **Beijing Section** forms IEEE Biometrics Council chapter and IEEE YP affinity group.

■ **Harbin (China) Section** forms chapters of IEEE Geoscience and Remote Sensing and IEEE Vehicular Technology societies and IEEE WIE affinity group.

■ **Nanjing (China) Section** forms IEEE Vehicular Technology Society chapter.

■ Student branch at **University of Chinese Academy of Sciences, Beijing**, forms IEEE WIE affinity group.

■ Student branch at **Wuhan University, China**, forms IEEE Geoscience and Remote Sensing Society chapter.

■ Student branches formed in **India** at **Amity School of Engineering and Technology, Bennett University, Christ College of Engineering and Technology, D.Y. Patil School of Engineering Academy, Jawaharlal Nehru Technological University, JCT College of Engineering and Technology, Keshav Memorial Institute of Technology, Marri Laxman Reddy Institute of Technology and Management, PPG Institute of Technology, Punjabi University, R.L. Jalappa Institute of Technology, Sasi Institute of Technology and Engineering, SCAD College of Engineering and Technology, Surya Engineering College, Vaigai College of Engineering, Velagapudi Ramakrishna Siddhartha Engineering College, and Vetri Vinayaha College of Engineering and Technology**.

■ Student branches in **India** at **Bishop Jerome Institute, Guru Nanak Institute of Technology, KCG College of Technology, Maharaja Agrasen Institute of Technology, Nitte Mahalinga Adyanthaya Memorial Institute of Technology, Sastra University, and Sri Jayachamarajendra College of Engineering** form IEEE WIE affinity groups.

■ Student branches in **India** at **ABES, College of Engineering Trikaripur, Mar Basilio Christian College of Engineering and Technology, and Sastra University** form IEEE Power & Energy Society chapters.

■ **Indonesia Section** forms IEEE Electron Devices Society chapter.

■ Student branch formed at **University of the Ryukyus, Nishihara, Japan**.

■ Student branch at **National University of Malaysia, Bangi**, forms IEEE Electron Devices Society chapter.

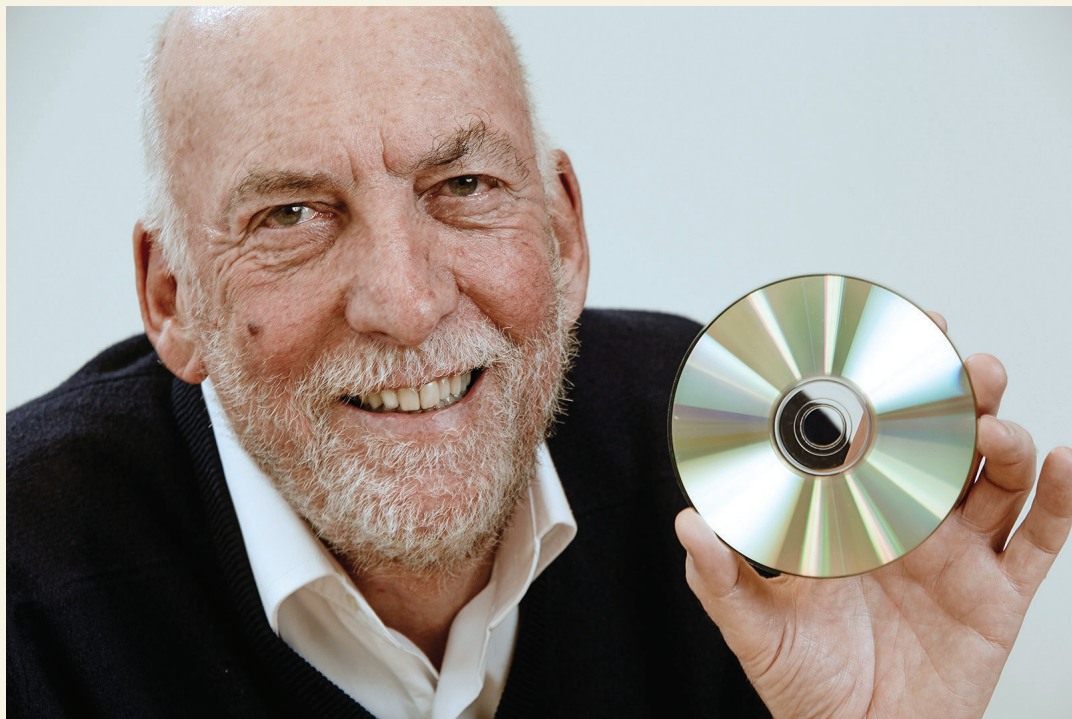
■ Student branch formed at **Habib University, Karachi, Pakistan**.

■ **Changwon (South Korea) Section** forms IEEE Industrial Electronics Society chapter.

■ **Sri Lanka Section** forms IEEE Industry Applications Society chapter.

■ **Thailand Section** forms IEEE WIE affinity group.

## BRIEFINGS



### Medal of Honor Goes to Immink

**LIFE FELLOW** Cornelis A. Schouhamer “Kees” Immink will receive the 2017 IEEE Medal of Honor “for pioneering contributions to video, audio, and data recording technology including compact disc, DVD, and Blu-ray.”

Immink joined Philips Research Labs, in Eindhoven, Netherlands, in 1968 and conducted pioneering work on optical videodisc recording. He worked with Philips and Sony in 1979 and 1980 to develop the international Red Book standard, which contains specifications for all CD formats. He also has contributed to the theory and development of constrained codes, a type of coding widely used in data storage devices. The codes accelerated the development of magnetic, optical, and solid-state data storage technologies.

His book *Codes for Mass Data Storage Systems* [Shannon Foun-

dation, 1999] is recognized as an authoritative source.

Immink left Philips in 1998 to launch Turing Machines Inc., in Rotterdam, Netherlands, which focuses on novel coding technology and signal processing for hard disk drives and solid-state memories.

From 1994 to 2015 he was an adjunct professor of mathematics at the University of Duisburg-Essen, in Germany. He also has been a visiting professor at three schools in Singapore: the Data Storage Institute, Nanyang Technical University, and Singapore University of Technology and Design.

Immink, chair of the IEEE Consumer Electronics Society's Benelux (Belgium, the Netherlands, and Luxembourg) chapter for more than 15 years, has served on the boards of governors of the IEEE Consumer Electronics and IEEE Information Theory societies.

In 2000 he was knighted by Queen Beatrix of the Netherlands. He received a 2003 Technology and Engineering Emmy Award from the U.S. National

Academy of Television Arts and Sciences for his work on coding optical formats.

The IEEE Foundation sponsors the Medal of Honor. Immink is to receive the award at the 2017 IEEE Honors Ceremony, scheduled for 25 May at the Palace Hotel in San Francisco. The ceremony is being held in conjunction with the IEEE Vision, Innovation, and Challenges Summit.

—Amanda Davis

### Meet the 2018 President-Elect Candidates

#### THE IEEE BOARD OF

Directors has nominated Fellow Vincenzo Piuri and Life Fellow Jacek Zurada as candidates for 2018 IEEE president-elect. The candidate chosen in this year's annual election will serve as IEEE president in 2019.

**Piuri** is a professor and former chair of the information technology



department at the University of Milan and an honorary professor at three other universities. His research interests include intelligent systems, machine learning, neural networks, pattern recognition, and digital architectures. Piuri has coauthored four books on biometrics.

He was elevated to Fellow in 2001 "for contributions to neural network techniques and embedded digital architectures for industrial applications." He is also a member of IEEE-Eta Kappa Nu, the organization's honor society.

Piuri was 2015 vice president, IEEE Technical Activities. He was IEEE Division X director/delegate from 2010 to 2012 and president of the IEEE Computational Intelligence Society in 2006 and 2007.



Vincenzo Piuri



Jacek Zurada

He has been editor in chief of the *IEEE Systems Journal* since 2013. He has also served on the IEEE Publication Services and Products and IEEE Technical Activities boards as well as several IEEE committees.

**Zurada** is a professor and former chair of the computer engineering department at the University of Louisville, Kentucky. He is also director of its Computational Intelligence Laboratory. His research focuses on computational intelligence, machine learning, and image and signal processing. He has authored or coauthored three books including the textbook *Introduction to Artificial Neural Systems*. His research has been cited more than 10,000 times.

He was elevated to Fellow in 1996 "for contributions to engineering education in the area of neural networks." He was elected a foreign

member of the Polish Academy of Sciences and has been awarded four honorary doctorates.

Zurada was 2014 vice president, IEEE Technical Activities, and was president of the IEEE Computational Intelligence Society in 2004 and 2005. He was editor in chief of the *IEEE Transactions on Neural Networks* from 1998 to 2003 and chaired the IEEE Technical Activities board's periodicals committee in 2010 and 2011. —A.D.

## INSIDE

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ONLINE  
at [theinstitute.ieee.org](http://theinstitute.ieee.org)

**IN MEMORIAM** IEEE mourns the loss of three of its members.

**MEMBERS IN THE NEWS**  
Read about members who have recently made headlines.



## Five Elected to the Board

**THE IEEE ASSEMBLY** in November elected five officers to the IEEE Board of Directors for 2017. They began serving their terms on 1 January. Four of the five are serving their first terms [pictured left to right]: Samir M. El-Ghazaly, vice president, Publication Services

and Products; Mary Ellen Randall, vice president, Member and Geographic Activities; William P. Walsh, IEEE secretary; and John W. Walz, IEEE treasurer. S.K. Ramesh [far right] was elected to serve a second year as vice president, Educational Activities. —A.D.

## Calendar of Events

### MARCH

**8-11**

IEEE Region 9 meeting,  
San José, Costa Rica



**25-26**

IEEE Region 8 meeting, Stockholm

**30-31**

IEEE Green Technologies  
Conference, Denver

**30 March-2 April**

IEEE Region 5 meeting, Denver

**31 March-2 April**

IEEE Region 3 meeting, Charlotte, N.C.

### APRIL

**18-21**

IEEE International Conference  
on Internet-of-Things Design and  
Implementation, Pittsburgh



**28-30**

IEEE Region 7 meeting,  
Windsor, Ont., Canada

### MAY



**21-25**

IEEE International Conference  
on Communications, Paris

**22-23**

IEEE Women in Engineering  
International Leadership  
Conference, San Jose, Calif.

**25**

IEEE Vision, Innovation, and  
Challenges Summit and IEEE  
Honors Ceremony, San Francisco



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and start connecting today.



# 5G

## The New Wireless Frontier

**OPINIONS DIFFER WHEN** it comes to fifth-generation wireless technology. Is it simply an evolution of 4G or a radically new communications network?

Some people are not waiting for the debate to be settled. Wireless carriers have started building 5G networks in China, Japan, South Korea, and the United States.

**IEEE BELIEVES 5G WILL BE TRULY REVOLUTIONARY.**

It expects 5G will become the cornerstone of future wireless networks, enabling fundamentally new applications, including the Internet of Things and connected cars. At the same time, the technology is likely to provide broadband access to millions of users at a low price.

IEEE launched its 5G Initiative in December [see article, right], concerned that 5G networks are being built before issues such as interoperability and security have been addressed. IEEE seeks to engage industry, academia, and policymakers to work together to meet 5G's challenges so the technology's full potential can be realized.

We ask IEEE Fellow Gerhard Fettweis, the initiative's cochair, about the impact 5G technologies will have in such areas as education, sports, and transportation [p. 14].

The new technology also is expected to create opportunities for entrepreneurs and their startups. IEEE Fellow Joy Laskar's Maja Systems is one such venture [p. 15]. Laskar is designing a platform to include a CMOS-based millimeter wave transceiver with a built-in antenna to connect machines wirelessly for 5G applications. Also included in this issue are tips for launching your own startup [p. 9].

To help get you up to speed on 5G, we list resources available from IEEE, such as conferences and standards projects under development [pp. 12–13].

This year *The Institute* celebrates its 40th anniversary. We present the story of how this member publication evolved from an *IEEE Spectrum* column in 1964 to a stand-alone periodical in 1977 [p. 8].

And in her first column as IEEE president, Karen Bartleson updates readers on the progress of IEEE's strategic plan [p. 11].

This issue also presents the recipient of the 2017 Medal of Honor, Kornelis A. Schouhamer "Kees" Immink, [p. 3], winners of the 2016 IEEE election [p. 17], and those senior members who joined the 2017 class of Fellows [p. 18].

Visit [theinstitute.ieee.org](http://theinstitute.ieee.org) for our latest content. To comment on what you've read in this issue, email the editors: [institute@ieee.org](mailto:institute@ieee.org) —Kathy Pretz, editor in chief

# THE FUTURE OF COMMUNICATIONS NETWORKS

*A new IEEE initiative is working to improve the next generation of wireless* BY KATHY PRETZ

**FIFTH-GENERATION** wireless technology is causing a lot of excitement in the telecommunications industry, and differences of opinions. Some see 5G as the next evolution in wireless data communications, promising higher bandwidth and data rates, with significantly fewer transmission delays. Others, however, say the technology will be revolutionary, enabling a host of new applications including humanoid robots, connected cars, and the Internet of Things, with its billions of devices laden with embedded sensors.

Wireless carriers have started building 5G networks even though issues—like defining standards to ensure interoperability and outlining security requirements—are still being worked out. How the first 5G networks, expected to debut in 2020, will be built is important because of the effect they will have on cellular-based businesses and multimedia services.

Concerned that vital issues aren't being addressed, the IEEE Future Directions Committee, the organization's R&D arm, in December launched the IEEE 5G Initiative (<http://5g.ieee.org>). Its purpose is to engage industry, government, and academia to work together and lay the foundation so that the opportunities envisioned for 5G can be realized. The initiative is run by a steering committee and organized by working groups that cover education, events, publications, standards, and other areas. The IEEE Standards Association and 16 IEEE societies and organizational units are participating.

"IEEE has a special role to play because it's a neutral organization," says IEEE Fellow Gerhard Fettweis, the initiative's cochair. "IEEE can collect ideas and feedback about 5G from operators, researchers, and government regulators to understand the dif-

ferent proposals in the works, identify any problems, and propose solutions." Fettweis is a professor at Technische Universität in Dresden, Germany, and a senior research scientist with the International Computer Science Institute, an independent nonprofit in Berkeley, Calif.

"IEEE is in a unique position to collect input from around the world and contribute to the whole 5G ecosystem," adds Fettweis's cochair, IEEE Senior Member Ashutosh Dutta. "That's because among its societies and regions are members who are experts in signal processing, network communication, software engineering, antennas, and other related technologies covering all layers of a communication system. It's a true global initiative." Dutta is a lead member of the AT&T technical staff in Middletown, N.J.

## NEW NETWORKS

Throughout the history of mobile communications, data speeds have jumped incrementally within each generation of the network. That will be the case with 5G as well, but much more is expected of it, including improved performance, capacity, and speed, and a network that operates the world over, no matter where or from which device a user connects.

Carriers will be working to reduce delays in transmission time. The 5G latency is expected to be less than 1 millisecond; 4G networks have a latency of 25 milliseconds. (Latency is the amount of time it takes for a packet of data to get from one forwarding point to another.) Low latency is particularly important for such applications as self-driving cars and robot-aided surgeries, where the slightest delay in transmission time could mean life or death.

But simply updating hardware and software with the latest technologies



won't be enough. The new networks will need to handle billions of devices expected from the Internet of Things and other new applications. It must provide connections that are 100 times faster than current network speeds.

That's where software-defined networks (SDNs) and network functions virtualization (NFV) fit in. They support the flexibility and dynamics of the growing number of advanced terminals and intelligent machines at the networks' edges. SDNs can provide improved speeds and lower latency while eliminating bottlenecks.

SDNs decouple hardware (that, say, forwards IP packets) from software (the control plane that carries signaling traffic for routing through network devices). Software is executed not necessarily in the equipment but maybe in the cloud or in clusters of distributed servers. That means networks could be built and reconfigured centrally in an automated fashion, rather than having network managers hop from

device to device to make changes manually, according to Dutta.

NFV is often paired with SDNs. The concept uses CPU and resource virtualization and other cloud-computing technologies such as orchestration, network slicing, and mobile edge computing to migrate network functions from dedicated hardware to virtual machines running on general-purpose hardware. NFV can boost speed, flexibility, and efficiency when deployed with the new services expected to be ushered in by 5G. Components can be upgraded to accommodate a service provider's needs.

#### SPREADING THE WORD

To help people get a better understanding of 5G and its capabilities as well as uncover issues and concerns, IEEE has been holding summits around the world since 2015 (<http://www.5gsummit.org>). Events have been held in Canada, China, Denmark, Germany, India, and the

United States. More are scheduled this year in Finland, Jamaica, Japan, Morocco, Portugal, and elsewhere. At the 5G summits, which are open to anyone, experts discuss topics such as applications for smart cities, bandwidth limitations, network architecture, management challenges, and the need for standards.

"We are working with each IEEE region and section to bring these summits to their doorsteps," Dutta says. "Each country has different wireless spectrums and resource allocations."

The IEEE 5G Initiative is developing a road map to help carriers, network operators, service providers, and others find the best path forward. The initiative aims to identify trends in innovation and technology, as well as report on research being conducted in areas such as application services, millimeter waves, the mobile edge cloud, and security.

"Developed in conjunction with the initiative's working groups, the road map will be a living document

with a clear set of accountable recommendations that will be updated annually," Fettweis says.

#### STANDARDS ARE A MUST

Companies including Cisco and Ericsson have already unveiled NFV infrastructures for 5G SDNs and the IoT. South Korea hopes to introduce 5G services in time for the 2018 Winter Olympics there, and the European Union wants 5G mobile broadband to be available around all its major roads and rail links by 2025.

The dilemma with those projects is that 5G standards have yet to be developed. Several standards bodies are working to create them, but Dutta says he fears they might overlook some fundamentals.

"They are focused on developing the architecture and the requirements but not on such things as the underlying technology aspects," he says.

IEEE is well-positioned to develop 5G standards, according to Konstantinos Karachalios, managing director of the IEEE Standards Association, in Piscataway, N.J. Nearly all wireless communications, he notes, go through the IEEE 802 suite of standards—which includes Ethernet and Wi-Fi, the universal enablers of wireless and localized Internet access. (See p. 13 for additional standards projects.)

"The IEEE 802 ecosystem will play a central role in the next generation of connectivity," Karachalios says. "This technology has an impact across most of IEEE's technical societies and standards activities.

"IEEE wants to work together with other groups to develop a vision for how it can help connect the unconnected and improve the connection for those who already have one."

One technology the initiative is looking at, he says, is so-called frugal 5G, which "will help those who are still using 3G technologies to transition toward the next generation of telecommunications in an effective, interoperable, and standardized way that enables greater innovation. We are also addressing the impact of 5G technology based on regional needs and requirements.

"We welcome others to join us to solve some of the regulatory, technological, economic, and consumer hurdles associated with making 5G happen," Karachalios says. ♦

*For more information on the IEEE 5G Initiative and how to participate, email Harold Tepper, IEEE Future Directions senior program director: [h.tepper@ieee.org](mailto:h.tepper@ieee.org).*



# Celebrating *The Institute's* 40th Anniversary

*The member publication evolved from an IEEE Spectrum column in 1964 to its own periodical in 1977* BY KATHY PRETZ



**T**HE INSTITUTE GOT ITS start 53 years ago as a column called “News of the IEEE” (later “Inside IEEE”), which was published in the first issue of *IEEE Spectrum*. The column covered important decisions by the IEEE governing board, election results, upcoming events, and other organizational news, as well as articles written by IEEE leaders.

But publishing such information was problematic, because *IEEE Spectrum* was not a typical association magazine. It was not just about the association; its main function was to publish articles on technical advances of interest to its members. It competed for advertising with several commercial magazines that had bigger staffs, international news bureaus, and powerful publishers. And most advertisers don’t turn first to an association publication to get their messages across.

*IEEE Spectrum* editor Donald Christiansen, who came on board in late 1971, realized that. He found it awkward to have IEEE’s flagship magazine trying to serve two masters: those who wanted to read about technology and those who were interested in how the association was being governed.

“Ideally, [reaching] those two should not be attempted in a single publication,” Christiansen said. “First, it discourages advertising. Second, the governance issues are of little or no interest to a significant number of readers—though, of course, they’re of great importance to others.”

## NOT AN EASY DECISION

It took Christiansen a few years to convince IEEE’s Board of Directors that a separate publication was needed. He gained some traction from developments within IEEE. In 1972, members voted to change IEEE’s constitution to broaden the scope from that of a strictly technical association to one involved in professional issues of concern to engineers as well. Back then those topics included unionizing, licensing, and working conditions.

The question was: How should IEEE cover such topics? *The Institute* was launched in 1977 to do this, and its approach was not uniformly accepted.

“Because of the controversial nature of professional issues at the time, many of us feared that including such material within the covers of *IEEE Spectrum* would have a significantly adverse effect on advertising revenue,” wrote Jerome J. Suran, an IEEE officer who served as 1979 IEEE president.

Suran’s comment is an excerpt from a letter he wrote in 1985 to R.J. Backe, vice president, IEEE United States Activities Board, to address Backe’s concerns over what he perceived as the independence of *The Institute’s* staff.

in a balanced and timely way, and to reserve space in the new publication for IEEE leaders to communicate their views and decisions to members.

Suran went on to write in that 1985 letter that the best hope for IEEE leaders to counter charges of conflicts of interest was to protect the independence of the reporters “to disseminate the news as they see it, free from control, and free of retributive action.”

“At times the editorial staff will err, either by a bad judgment call or by excessive zeal in responding to the initial charge of the Board that they [also] try to stir reader interest,” Suran continued. “But on the whole, I agree with you that our publication



In the letter, Suran reviewed the background related to the founding of *The Institute*, and described major debates within the IEEE Publication Services and Products Board and the IEEE Board of Directors about the new publication’s mission once it became separate.

The boards back then had resolved to allow the editorial staff, which comprised an editor and assistant editor, to report independently on IEEE issues—even controversial ones—

staff deserve our respect and support for the fine job they have done, often under difficult conditions.”

## THE LAUNCH

Eventually, the boards approved Christiansen and Suran’s plan to spin off a newspaper to cover professional and IEEE news. Christiansen, with support from Suran, took steps to launch the publication. In December 1976 a four-page insert in *IEEE Spectrum*, called *The Institute*, was introduced. It included

two subsections: “Inside IEEE” and “IEEE People.” It was printed on heavier paper than was *Spectrum*, signaling to members that change was afoot.

In April 1977, the IEEE Board of Directors passed a motion that *The Institute* “be published separately for six consecutive months, beginning in July 1977 as a non-archival, fast-reading, and fast-responding newspaper at a regular frequency.”

Expecting to get a new publication off the ground in less than three months proved to be overly ambitious. An extra month was needed. Under its first editor, Ellis Rubinstein, the inaugural issue was published in August 1977. It carried the tagline “A news supplement to *IEEE Spectrum*” and was mailed only to members in North America. It was published as a monthly beginning in 1978 and was eventually mailed to all members worldwide. This format remained the same for 25 years.

## KEEPING UP WITH THE TIMES

I became the editor in 1999. For budgetary reasons, the IEEE Board of Directors in 2002 reduced the number of print editions to four quarterly issues starting the next year; the remaining eight were to be published online. A bimonthly electronic newsletter, *The Institute Alert*, also was launched. Sent to all members who provide IEEE with their email addresses, it gives them a summary of the latest online coverage.

During the past decade *The Institute* has expanded its presence through blogs, multimedia, social media, a digital edition, a mobile-friendly website, and other platforms.

In recent years, *The Institute* has received numerous awards for its editorial excellence, technology writing, website, and special reports—which is all the more impressive when you consider that it competes against thousands of other publications, many of them well-known brands with much larger staffs.

My staff and I are committed to publishing articles that showcase the contributions IEEE members have made to society and to report on the organization’s mission to advance technology for the benefit of humanity.

In celebration of its 40th anniversary year, *The Institute* is publishing a series of timelines highlighting technologies that have moved forward significantly during the past four decades (<http://theinstitute.ieee.org/tag/TI40anniversary>). ♦

*This is an updated version of the article “The Birth of The Institute,” published in IEEE Spectrum’s March 2014 issue as part of a series that recounted some pivotal moments for the magazine’s 50th anniversary.*

## CAREERS

# When It Comes to Entrepreneurship, a Vision Is Vital

*Tips for launching a startup and keeping your team on track* BY **DEVON RYAN**

**S**O YOU WANT to be an entrepreneur? Well, I may have news for you: The first step toward entrepreneurship is the biggest one you'll have to take. Why? Because of the overwhelming uncertainty that comes with it—an uncertainty that deters many before they even start. But in my experience, the act of going headfirst into the unknown changes you for the better.

When I was at the University of Texas, in Austin, pursuing a bachelor's degree in electrical engineering, I wanted to differentiate myself from my peers—create my own path. I realized that entrepreneurship was the way to achieve this. But I had no idea where to start. And my jumping into the entrepreneurial abyss opened up a whole new world of challenges. However, it allowed me to find my own way, and that provided me with the fuel to dive even deeper.

### EMBRACING UNCERTAINTY

I started my software company, Lion Mobile, in August 2013. One of our first projects was the unWine app. The idea was that wine should not have to be complicated—people all over the world could use the app to post reviews about various kinds of wine, helping others discover new varieties and figure out what to buy.

We made several mistakes in the beginning. Instead of studying and surveying our target audience, we dove right in to developing the app. In the end, that cost us more time and money, because the first version of our app didn't address all our customers' needs. We also didn't raise enough capital from investors, so I wound up having to invest my savings in the project to keep the company afloat.

Despite all that, not only did we complete the app, but also the number of downloads has continued to grow each year since it was launched in 2014. This is the nature of entrepreneurship:

You go into the unknown with a vision, only to come out on the other side beat up and worn out, but with a new perspective and hopefully a finished product that meets the customers' needs. Embracing uncertainty is the first challenge of entrepreneurship, and how you handle it could define your level of success.

### CREATING YOUR VISION

Having a vision is essential for leading a company. If you don't have one, how will you stay focused when you lead a team? I've outlined below the key questions, and answers, for creating a sustainable vision for yourself and your team.

#### ***Why do you want to start your own company?***

It's paramount that entrepreneurs be conscious of the real reason. They must dig deep and figure out what's driving them. If you can't understand what drives you, then how can you understand how to motivate others?

#### ***Who can you reach out to for knowledge, talent, and funding?***

Given your present situation, what or who is within arm's reach that could help you launch a successful business?

#### ***What are your strengths and weaknesses?***

As an entrepreneur, you must know your strengths as shown in your business plan, then work to enhance them. Find a person—whether a business partner or mentor—who can help you overcome your weaknesses or make up for what you lack.

#### ***Where do you want to go from here?***

When you know why you are pursuing a business of your own, it's easier to determine where you want your business to go. The key is setting benchmarks that motivate progress. If the



*Devon Ryan*

goals you set are too easy, your team will quickly become bored.

### GUIDING A TEAM

When I started Lion Mobile, I found it challenging to keep my team united and focused. Getting the team to prioritize and work on the most important tasks first was difficult. It was evident that we lacked direction, because the team would bring up new app ideas at every meeting instead of focusing on the growth of our most important apps—the ones we'd already developed and launched.

In the midst of those challenges, I would question my decisions. Did I recruit the right people? Why did they seem incapable of seeing the big picture? The team needed something to keep it from drifting off course.

That is when I had an epiphany: The vision I had for myself helped me but not my team. My mistake was thinking that the others thought the way I did—that they saw the big picture and could align themselves with it. So I drafted a single statement that defined our desired future. After showing it to the team, we became more stable and focused. We finally had our North Star.

When you have a vision, it should resonate with your employees. Your vision must lift your team emotionally and provide the power to move into action. If it doesn't, then you must probe deeper and ask once again, "Why am I doing this?"

Without a vision, your team is vulnerable and fragile. People without direction are easily distracted. For a young company, that could spell disaster. A new startup does not have the luxury of time. An effective entrepreneur must keep the team members focused by uniting them to work toward a common goal.

Don't expect your vision to become clear instantaneously. Like much in life, it takes time and reflection. You might even stop thinking about it for awhile. When you return to it, your mind will be fresh and you'll feel energized. This energy will set you on your path. And then you must keep strengthening your vision as you move toward making it a reality. ♦

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*IEEE Member Devon Ryan, founder of Lion Mobile, a mobile app development company in Austin, Texas, is IEEE-USA membership chair. He is a regular blogger for The Institute.*



# Sparking Conversation

Readers commented on several articles on our website, including one on Dolby A, a noise-reduction system, developed by IEEE Life Fellow Ray Dolby [photo below], used for the soundtrack of A Clockwork Orange.

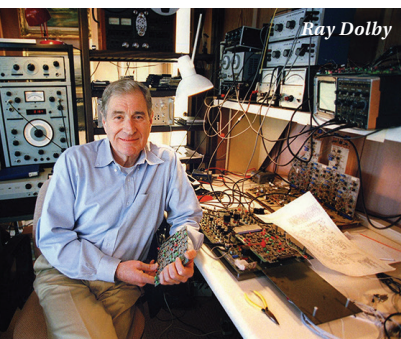
Another article featured bio-electronic implants—devices that adjust the electrical signals in the nervous system to treat disease. A blog post offered ways to inspire preuniversity students to pursue careers in the engineering field.

And several readers paid tribute to Director Emeritus Eric Herz, one of IEEE's most dedicated volunteers, who died in December at the age of 89.

## BEHIND THE MUSIC

I remember when Dolby A and Dolby B noise-reduction systems were introduced in the late 1960s. I was not happy with the sound quality of the cassette tapes that came out during those years. But I liked that they were portable and I could listen to them in my car. So I bought an early Dolby B external processor (from Dolby Labs) to use with my Sony cassette player. Ray Dolby made quite a difference in my awareness and appreciation of music and sound reproduction.

—Doug Kline



I was born a little after audio reel-to-reel tape recording became popular, and I am always amazed at how much research goes into the recording equipment most people take for granted. Creators deserve more recognition.

—Anna Sumpter



## PROFITS FIRST

Bioelectronic implants sound like they have great potential for treating many illnesses, but the devices will never take off if they cut into the profits currently obtained from prescription medication. Implants will succeed in our current health-care system only if they are expensive enough to be profitable.

—pjgeneva

## FUTURE ENGINEERS

To inspire the next generation of engineers, I believe philanthropy is crucial. I gave a one-time cash donation to an undergraduate student physics lab at an Ivy League college. It went toward a recruitment program to get young people in the local community—especially those with disabilities—interested in science or engineering careers.

I also donated to the U.S. National Science Foundation to support an undergraduate or graduate student to attend an annual American Institute of Physics meeting so the student could learn about the meaningful and exciting possibilities of a career in science. In both cases, I wanted to do something for young people who do not yet understand what a science or engineering career really can be in terms of personal and societal reward.

—Harold M. Frost

## A TIRELESS VOLUNTEER

Eric Herz was a legendary leader at IEEE, and I was deeply saddened to hear the news of his passing. His perseverance and dedication to IEEE was truly inspirational, and he will be missed deeply by his numerous friends and colleagues. I learned that his wife, Lottie, had

decided that gifts to the IEEE Foundation in Eric's memory would be directed to IEEE-Eta Kappa Nu [the organization's honor society]. That is incredibly thoughtful and generous of Lottie and is a testament to the amazing legacy of Eric. He will live forever in our minds and hearts.

—Sundaram Ramesh

Eric was the first one I consulted when I needed advice about anything related to IEEE, especially during my term as 2009 IEEE president. He was wise and kind, and he knew more about IEEE and its history than anyone else I know.

—John Vig

I admired Eric for his enthusiasm, optimism, good humor, and intelligence. He went to great lengths to explain his ideas and invited his listeners to engage him in an open discussion based on logic and facts. I learned a lot when he involved IEEE volunteers in spirited debates about IEEE policy regarding the engineering profession. He was a great catalyst in accelerating and channeling the early growth of the organization. I am saddened by his passing.

—Peter Wiesner

During many years as an IEEE volunteer, I learned that Eric Herz could answer almost any question about the internal and external activities of IEEE. However, I did not fully appreciate his capabilities and knowledge until I served as IEEE president in 1989. Eric knew technical leaders throughout the world and helped us negotiate many formal and informal agreements that helped IEEE become the truly large international organization it is today. When I served as president of the IEEE Foundation from 2000 to 2005, I continued to seek Eric's advice on critical issues.

During those years, my wife, Betsy, and Eric's wife, Lottie, developed a close personal relationship. The four of us continued to meet informally until Eric and Lottie moved from New York to Colorado. Betsy and I have missed the closeness of these wonderful people, and we deeply regret Eric's recent passing.

—Emerson Pugh

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# IEEE: The Voice of the Global Technical Community

*It's up to all members to contribute*

KAREN BARTLESON IEEE PRESIDENT AND CEO



**AS PRESIDENT** of IEEE, I have the responsibility and privilege to help guide the organization in fulfilling its

mission of fostering technological innovation and excellence for the benefit of humanity. Relationships, especially among volunteer leaders, are fundamental to the realization of this mission and are crucial to our ability to work together to ensure continuity in IEEE's strategic direction from year to year. This momentum, particularly from one president to the next, helps IEEE continue to reach its goals. Thus, it is an honor for me to continue building on the work of IEEE's past presidents.

Like all successful organizations, IEEE has a long-term strategic plan that is a vital part of its ongoing evolution. The plan provides a clear picture of IEEE as an organization, the goals our community is pursuing, and the initiatives that will move us forward in coming years.

### GLOBAL BUT LOCAL REACH

IEEE continues to expand worldwide. This globalization, the process of understanding, integrating, and influencing international economies and cultures, has led to valuable, cross-national understanding and the productive exchange of ideas as IEEE works to address diverse needs at local levels.

The opening of an IEEE office in Vienna will provide enduring local support to the European technical community and allow increased engagement for influencing public policies important to it.

Success continues to be made in building a sustainable community of IEEE members and volunteers in Africa by supporting engineering education and workforce development there. We are also working to develop strategies for holistic organizational growth within China and

India, actively looking across units, people, and cultures to empower collaboration and best meet the local and regional needs of these areas of the world.

IEEE also strives to serve our members working on challenges such as global climate change and sustainable development and on emerging technology issues on an international scale, including Internet governance and the ethical design and implementation of intelligent technologies.

IEEE has a tremendous platform across technical communities—from computers and communications to aerospace and biometrics—to explore these issues and apply technology to solve the world's most challenging problems. IEEE's expertise is bringing together the experts within IEEE who understand these emerging technologies, the policy-makers who develop the regulatory environment, and the public that has varying levels of interaction and acceptance of potential disruptive innovations. This convergence creates numerous opportunities for collaboration, economic growth, and future innovation, which is not confined to any single country but exists globally.

### A RECOGNIZED AUTHORITY

As a large and complex organization supporting the technical and professional needs of our members, our professions, and the public, IEEE recognizes both the acceleration of technological innovation and the challenges this brings. After all, IEEE members are responsible for the world's greatest technological advances and are behind much of today's scientific and industrial growth.

I am proud of the collective technical prowess of our membership. I appreciate the rich diversity of the engineering and scientific branches in which our members excel and the global makeup of IEEE. We will continue to look for

opportunities to provide more value and services to professionals working in industry, academia, and public service, while paying attention to women and entrepreneurs. And to be sure, the needs of our practitioners today are equally as important as those of our students and young professionals, who are our future technologists. We must make IEEE attractive to this next generation so they remain active members of our community as they navigate their professional

*We must make  
IEEE attractive  
to the next  
generation  
so they remain  
active members*

careers. Their enthusiasm and sense of camaraderie will bolster our efforts to build strong partnerships and cooperation with industry and other external bodies worldwide.

Let's continue to work together to ensure that IEEE is universally recognized as the voice of the global technical community and an essential contributor not just to traditional technologies but also to the development and implementation of emerging and disruptive innovations.

I encourage all our members to be engaged, be involved, and be part of the drive toward fulfilling our mission of advancing technology for the benefit of humanity.

Please share your thoughts with me at [president@ieee.org](mailto:president@ieee.org). ♦

# Getting to Know 5G

These IEEE resources can bring you up to speed BY MONICA ROZENFELD

## FIFTH-GENERATION

(5G) wireless communications are expected to significantly increase speed and data rates, and support the connection of billions of devices, including autonomous vehicles and smart appliances, through the Internet of Things. Here are just some of the IEEE resources that deal with the subject.

## WEB PORTAL

The Web portal of the IEEE 5G Initiative (<http://5g.ieee.org>) presents upcoming events, courses, news articles, and standards. The initiative was established by the IEEE Future Directions Committee, the organization's R&D arm. The portal lists a number of IEEE projects and ways for IEEE members to get involved in, for example, the 5G Initiative working groups that are developing standards, organizing conferences, and engaging people from industry. And there's the initiative's road map, which will identify research, innovation, and technology trends in the communications field.

## EDUCATION

The IEEE Communications Society offers a host of webinars and courses that may be eligible for professional development hours or IEEE continuing education units.

"On the Road to 5G," for example, provides an in-depth overview of the development of long-term evolution technology, describes a standard for high-speed wireless communications, and how LTE is likely to advance 5G.

The society's webinar, "5G's Role in the Internet of Things," covers the key

challenges of connecting billions of devices to the Internet, including how IoT networks can communicate with one another while relying on different communications protocols.

Other courses include "Enabling Wireless Towards

Communications Engineering Technologies certification (<http://www.ieee-wcet.org>). Those accepted into the program receive resources such as free tutorials and access to an online practice exam. The WCET exam is being offered 17 April to

Path to 5G," which covers new business opportunities in the industry, and "5G Myths and Realities," which focuses on the technology's capabilities and the requirements of 5G networks.

In the video "5G Cellular: It Will Work!" IEEE Fellow

Society, included the article "M-Health Solutions Using 5G Networks and M2M Communications."

The October issue of the *IEEE Network* magazine, from the IEEE Communications Society, featured two articles on 5G technology: "Anything as a Service' for 5G Mobile Systems" and "Applying VLC [Visible Light Communication] in 5G Networks: Architectures and Key Technologies," which covers optical wireless communications.

The white paper "Towards 5G Software-Defined Ecosystems" from the IEEE Software Defined Network Initiative, covers technical challenges, business models, and policy issues.

And look for a special issue of the *IEEE Internet of Things Journal*, "5G and Beyond: Mobile Technologies and Applications for IoT" in October. The joint publication, from the IEEE Sensors Council and the IEEE Communications, IEEE Computer, and IEEE Signal Processing societies, is accepting article submissions until 31 March.

## COMMUNITIES

Members can join the IEEE 5G technical community to work on the technology's development and deployment from the initiative's website. They can also keep up to date on fifth-generation activities by participating in discussions with the 5G community on IEEE Collaboratec (<http://ieee-collabratec.ieee.org>). Discussions have included how the technology is likely to affect artificial intelligence and smart cities, and how to separate fact from hype. And members can follow news from the IEEE 5G Initiative on Facebook, LinkedIn, and Twitter. ♦



2020" and "Network Function Virtualization, Software-Defined Networking, and the Road to 5G."

If you want to test your knowledge, try the 5G Trivia quiz from the IEEE Standards Association (<http://iee5g.wpengine.com/trivia-quiz>).

To sharpen your wireless communications skills, as well as demonstrate up-to-date qualifications to employers, consider applying for the IEEE Wireless

13 May and 25 September to 21 October. The exam fee is US \$450 for members and \$550 for nonmembers.

## VIDEOS

Those who want to know more about 5G but have no time for courses or to attend conferences can watch IEEE.tv videos. Dozens of recorded sessions from the 2016 Brooklyn 5G Summit, in New York City, are available. These include "The

Theodore "Ted" Rappaport discusses his millimeter-wave wireless communications research, which is enhancing 5G technology. Rappaport is the founder and director of NYU Wireless, an academic research center that combines wireless engineering, computer science, and medicine.

## PUBLICATIONS

The May/June issue of *IT Professional*, published by the IEEE Computer

# Upcoming IEEE Standards for 5G

*Besides boosting speed, they're likely to simplify network operations and increase flexibility*

BY MONICA ROZENFELD

**TECHNOLOGY FOR** fifth-generation wireless communications is expected to significantly increase speed and data rates, and support the connection of billions of devices through the Internet of Things. Here are several 5G standards projects under development by IEEE working groups.

## ■ IEEE P802.1CF

“Recommended Practice for Network Reference Model and Functional Description of IEEE 802 Access Network” is designed to support heterogeneous networks in a single terminal—which might include multiple network interfaces, network access technologies, and subscriptions. The recommended practice covers the design and deployment of access networks based on IEEE 802 technologies, and specifies their functions.

## ■ IEEE P1903.1

“Standard for Content Delivery Protocols of Next Generation Service Overlay Network (NGSON)” will enable network operators as well as service and content providers to offer their services through such networks. This standard will allow for context-aware, dynamically adaptive, and self-organizing networks. It also will provide interoperability protocols to support advanced content delivery, including caching, transport, and storage management.

## ■ IEEE P1914.1

“Standard for Packet-Based Fronthaul Transport Networks” will allow for the implementation of critical 5G technologies, includ-

ing massive multiple-input multiple-output (MIMO), as well as coordinated multipoint transmission and reception. The standard aims to simplify network design and operation, increase flexibility, and lower costs by applying Ethernet technology to support synchronization and data security. The project also expects to improve bandwidth efficiency and network scalability. In addition, it specifies the architecture for the transport of mobile traffic as well as the requirements and definitions for the network.

## ■ IEEE P1918.1

“Tactile Internet: Application Scenarios, Definitions and Terminology, Architecture, Functions, and Technical Assumptions” will facilitate the advancement of the tactile Internet as a 5G-and-beyond application by defining a framework. Such an Internet will combine low latency, short transit, and reliability with a high level of security, and encompass mission-critical applications in manufacturing, transportation, health care, and mobility, as well as non-critical applications such as edutainment and events.

The tactile Internet is a new type of network designed to operate in virtual haptic environments that call for sensitive touch and precision, and when reaction time must be no more than a millisecond. In medicine, the tactile Internet could be used in telesurgery and exoskeleton control, and to assist with the precise movements of remotely controlled robots. ♦

# Conferences Delve Into the Future of Networks

*Upcoming events explore the Internet of Things, software-defined networks, and big data*



## Rock Stars of 5G

ATLANTA; 14 NOVEMBER

TOPICS: 5G applications for health care and manufacturing, wireless broadband technology, the IoT, data traffic management, smart metering, signaling, and real-time data analysis.

SPONSOR: IEEE Computer Society

VISIT: <http://events.computer.org/rock-stars-of-5g>

## ■ IFIP/IEEE International Symposium on Integrated Network Management

LISBON; 8–12 MAY

TOPICS: 5G and cloud infrastructures, software-defined networks (SDNs), wireless and cellular networks, fault management, security and privacy, network functions virtualization (NFV), machine learning, big data, and evolutionary algorithms.

SPONSORS: IEEE Communications Society, International Federation for Information Processing  
VISIT: <http://im2017.ieee-im.org>

## ■ IEEE International Workshop on Computer-Aided Modeling and Design of Communication Links and Networks

LUND, SWEDEN; 19–21 JUNE

TOPICS: 5G network design and optimization, IoT networks, cognitive communications, energy-harvesting wireless networks, big-data analytics, mobile cloud and fog computing, optical communications, smart grids, and e-health.

SPONSOR: IEEE Communications Society  
VISIT: <http://www.ieee-camad.org>

## ■ IEEE Conference on Network Softwareization

BOLOGNA, ITALY; 3–7 JULY

TOPICS: Components and systems for 5G networks, SDNs, NFV, cloud and edge computing, the IoT, traffic engineering, self-driving vehicles, and pervasive computing.

SPONSORS: IEEE Communications Society, IEEE Software Defined Networks Initiative  
VISIT: <http://sites.ieee.org/netsoft>

## ■ IEEE 5G Summits

TO BE HELD IN MULTIPLE CITIES

TOPICS: 5G systems, modeling and optimization of future networks, deep learning, IoT networks, mobile access radio networks, cloud computing, high-performance data management, robotics, and smart homes. Summits are being held throughout 2017 in cities including Honolulu, Istanbul, Shanghai, and Tokyo.

SPONSOR: IEEE Communications Society  
VISIT: <http://www.5gsummit.org>

To find other events on this topic, visit the IEEE 5G Initiative's website: <http://5g.ieee.org/conferences>.



## PROFILE

# Gerhard Fettweis: Developing 5G and Beyond

BY KATHY PRETZ



**IT'S NO SURPRISE** that IEEE Fellow Gerhard Fettweis was tapped to be cochair of the IEEE 5G Initiative [p. 6]. After all, he has been involved in developing every generation of wireless networks, starting with 2G, the second generation.

Since 1994 he has been a professor at the Technische Universität in Dresden, Germany, where his focus is mobile communications. He's also a senior research scientist with the International Computer Science Institute, an independent nonprofit in Berkeley, Calif.

"As a researcher, you're always working on the next generation," Fettweis says. "I'm now researching things related to 6G."

In November, Fettweis received the ring of honor from VDE, the largest

technical and scientific association in Europe. He earned its highest distinction of merit in research and development for his work with mobile technology and microelectronics.

He was elevated to IEEE Fellow in 2009 for "contributions to signal processing algorithms and chip implementation architectures for communications."

An active volunteer, he serves on the IEEE Communications Society board of governors.

### **Why did you become interested in wireless technology?**

As a communications engineer, I'm concerned about transporting bits from Point A to Point B. It's amazing how wireless systems work. Cellphone users are actually doing everything

they can to disconnect a call by, say, walking from room to room, closing windows or doors, or going from indoors to the outdoors. As a researcher, I have to figure out how to keep the call connected. It's exciting to work on such challenges.

### **What 5G application excites you the most?**

A concept I introduced in 2012, called the *tactile* Internet. It will offer an instant reaction that mimics the experience of touching something in real life. With 5G wireless networks expected to send and receive data in a millisecond, that speed would match the reaction time the human body has to touching something. IEEE defines the tactile Internet as dealing with processes or objects in perceived real time (see related standard on p. 13).

This way you could, for example, catch a falling object remotely, or control a connected car at an intersection. If you provide haptic feedback, you can also feel a reaction such that it seems to be instantaneous. The tactile Internet will be used in areas such as automation, education, entertainment, gaming, farming, health care, and industrial transportation. It will also enable humans to control robots remotely in real time.

I began developing this concept during a sabbatical at Berkeley eight years ago. I spoke with psychologists and physiologists to try to understand reaction times for remote control. For example, how fast does a system have to react for the object we want to control to be seen as behaving naturally. I also looked at how robots on factory floors function as they interact with each other and their surroundings almost instantaneously.

The range of 1 millisecond speed kept popping up. For just about everything we want to control, there's this millisecond constraint. It is super challenging to tackle this from a variety of angles, like the security side and the physiological side.

For the tactile Internet, we'll need more powerful devices and a much faster wireless network, 100 times faster than the current 4G. The 5G latency rate is expected to be less than 1 millisecond; 4G networks have a latency of 25 ms.

Once there's a ubiquitous infrastructure with which we can control real and virtual objects, planet Earth will be changed big-time.

### **Which areas will 5G applications affect the most?**

Transportation, sports, and education. 5G will allow vehicles to react in an instant to 5G-enabled vehicles and

pedestrians, thereby nearly eliminating accidents, traffic jams, and even traffic lights. Pedestrians using 5G-enabled smartphones could be able to walk safely into the street without checking for cars, because 5G-enabled cars would be routed automatically around the person or come to a full stop. In 20 years, most fatalities on the road should be a thing of the past.

For sports, instead of simply watching football players from way up in their seats or on stadiums' big-screen TVs, fans wearing smartglasses will be able to actually see the action from the player's point of view, without the player having to wear a camera. Hundreds of ultrahigh-definition cameras joined together in a digital rendering system will be positioned in multiple rings around the field, and players will be tracked by vision systems. Fans will be able to activate a specific player's tracker and, through the screen in their smartglasses, see what the player sees on the field.

In classrooms, students will be able to learn by doing, using virtual reality technology to interact. And 5G will deliver more realistic, immersive, and interactive VR experiences than do today's systems. Headsets will be mobile, and not plugged into computers. Students will be able to virtually wander the streets of, say, ancient Rome, touching its famous landmarks.

People will no longer learn a new language from a book or tape but by having real conversations with fellow students within virtual settings. According to experts, learning a new language could be 10 times more efficient when done interactively.

Ultimately 5G will revamp education. It's going to be an exciting world.

### **What is your hope for 5G?**

That the technology will cover every corner of the planet and provide Internet access to the nearly 3 billion people who live in rural and remote areas where Internet connectivity does not exist today.

With 5G, everyone is talking about rolling out services for high-density networks, using smaller cells for urban areas with ranges of 10 to 100 meters. In general, 5G initiatives are not concerned with sparsely populated areas that need to connect to a base station located 100 kilometers away. The need is being addressed only by the airborne balloon of Google X's Project Loon and Facebook's Aquila solar-powered drone project, both of which transmit connectivity from above.

Because IEEE covers the entire globe, we believe we can easily address all needs globally, whereby every individual counts. ♦

# STARTUP

## IEEE Fellow's Venture Prepares for 5G

*Maja Systems has developed a chip for next-generation wireless networks*

BY MONICA ROZENFELD

**SEEING THE ENORMOUS** potential of fifth-generation (5G) wireless systems—namely connecting billions of devices to the Internet and providing faster service with fewer interruptions—IEEE Fellow Joy Laskar three years ago helped found Maja Systems. Based in Milpitas, Calif., the startup has developed a first-of-its-kind chip to connect machines wirelessly to one another over millimeter waves while sending data to the cloud in real time.

The company's 60-gigahertz CMOS single-chip transceiver integrates with a high-performance antenna for multigigabit wireless connectivity. The chip includes all millimeter wave com-

ponents, a modulation engine, and analog-to-digital and digital-to-analog converters. It consumes fewer than 400 milliwatts and fits in a module. Aimed at 5G applications including the Internet of Things, robotics, and virtual reality, it is available now to select customers and is expected to debut to the general public later this year.

The challenge for Maja Systems is designing a chip for an industry so new that standards have not yet been established. That's why the company began by developing and selling chips for 4G networks.

"Our products have hooks in them that can be adapted as 5G standards

evolve," Laskar says, explaining that they can operate in the millimeter wave region, allow for low latency, and enable devices to communicate with one another.

### QUICK AND NIMBLE

Laskar and Maja Systems' team, whose members have backgrounds in design, engineering, and operations, have designed their chip with several goals in mind. The first is it must allow for a 1-millisecond latency—the time it takes for a packet of data to get from one forwarding point to another. Today's 4G networks have a latency of 25 ms.

The new chip's antennas can work with frequencies up to 80 GHz. Today's 4G cellular systems have frequencies below 6 GHz. Antennas for 5G are shorter, between 1 and 10 millimeters instead of centimeters for 4G.

Operating in millimeter waves, a 5G network could transmit much more data and could be used, for example, to send and receive high-quality videos and multimedia faster than today's networks can.

Maja's 4G products support data rates of 3.5 gigabytes per second, moving toward 10 Gb/s and higher for 5G. The 5G chip would be integrated into machinery and gadgets, whether robots, appliances, or—eventually

when the cost is down to just a few dollars—LED lamps for smart lighting systems. By incorporating the chips, such objects will be able to communicate with one another through the Internet, Laskar says.

Information could be uploaded to a smart lighting system's software to track, for example, where people are in a room so the lights could be adjusted accordingly. The smart lighting also could communicate with the heating and cooling systems to change the temperature based on the number of people in the room.

The new chip will be able to replace Ethernet cables used in factory automation equipment such as robotic arms, Laskar says. It eventually could be used in augmented and virtual reality applications to provide a high-quality video game-like experience. Users will be able to view images through a headset as clearly as they see them on television, but without interruption caused by streaming, Laskar notes, and the headsets will be mobile and no longer tethered to a computer.

The chip enables complete multigigabit wireless links (including an antenna and any additional elements) which sell for less than US \$500 each. However, he says, Maja Systems is working to reduce the price to \$50 or less in the next few years.

### GETTING THE WORD OUT

In the past few months, Maja Systems has shown its chip at industry conferences and events. "It has been surprising to me, in a good way, the amount of thought potential customers are putting into how they might incorporate our platform into their work," Laskar says.

In anticipation of rapid growth this year in the 5G market, Maja plans to double its current staff, and it expects to turn a profit this year, he says. To date, Laskar and his cofounders have funded the company with their own money, and help from family and friends, as well as an angel investment of \$3 million.

Laskar adds that while there is a lot of hype surrounding 5G technologies, there is no question the next-generation network will be deployed faster and on a larger scale than anyone imagined a few years ago. "The pace of development and innovation in this area is unprecedented," he says. "The applications that 5G will enable are about to explode." ♦



IEEE Fellow Joy Laskar holds a CMOS wafer containing Maja Systems' 60-gigahertz transceiver chips. The wafer yields several thousand chips, each with a modulation engine, and is made in a standard digital process modified for millimeter wave frequencies.

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# Countdown to the 2017 IEEE Annual Election

## 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 president-elect and members-at-large, IEEE Technical Activities vice president-elect, and IEEE-USA president-elect.

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 Corporate Activities Governance staff, 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/elections>) or write to [elections@ieee.org](mailto:elections@ieee.org).

### UP FOR ELECTION IN 2017

#### 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 II delegate-elect/director-elect
- IEEE Division IV delegate-elect/director-elect
- IEEE Division VI delegate-elect/director-elect
- IEEE Division VIII delegate-elect/director-elect
- IEEE Division X delegate-elect/director-elect

#### Chosen by members of the respective regions

- IEEE Region 1 delegate-elect/director-elect
- IEEE Region 3 delegate-elect/director-elect
- IEEE Region 5 delegate-elect/director-elect
- IEEE Region 7 delegate-elect/director-elect
- IEEE Region 9 delegate-elect/director-elect

#### Chosen by members in Regions 1–6

- IEEE-USA president-elect

#### Chosen by members of the IEEE Standards Association

- Standards Association president-elect
- 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.

**12 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.

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



## The 2016 Election Results

Here is the Tellers Committee tally of votes counted in the 2016 annual election and approved in November by the IEEE Board of Directors.

#### Proposed IEEE Constitutional Amendment

|         |        |
|---------|--------|
| Against | 23,863 |
| For     | 23,840 |

#### IEEE President-Elect, 2017

|                    |        |
|--------------------|--------|
| James A. Jefferies | 23,865 |
| Wanda K. Reder     | 23,327 |

#### IEEE Division Delegate-Elect/Director-Elect, 2017

##### Division I

|                  |       |
|------------------|-------|
| Renuka P. Jindal | 2,020 |
| Rakesh Kumar     | 1,753 |

##### Division III

|                     |       |
|---------------------|-------|
| Vijay K. Bhargava   | 2,300 |
| Alexander D. Gelman | 1,597 |
| Ashutosh Dutta      | 1,089 |

##### Division V

|               |       |
|---------------|-------|
| John W. Walz  | 3,573 |
| Sorel Reisman | 2,749 |

##### Division VII

|                  |       |
|------------------|-------|
| Bruno Meyer      | 3,686 |
| Nirmal K.C. Nair | 2,308 |

##### Division IX

|                        |       |
|------------------------|-------|
| Alejandro "Alex" Acero | 2,769 |
| James M. Irvine        | 2,692 |

#### IEEE Region Delegate-Elect/Director-Elect, 2017–2018

##### Region 2

|                      |       |
|----------------------|-------|
| Wolfram Bettermann   | 2,098 |
| Murthy S. Polavarapu | 1,635 |

##### Region 4

|                    |       |
|--------------------|-------|
| David Alan Koehler | 1,692 |
| Hamid Vakizadian   | 989   |

##### Region 6

|                |       |
|----------------|-------|
| Keith A. Moore | 3,249 |
| Ram Sivaraman  | 2,547 |

##### Region 8

|                         |       |
|-------------------------|-------|
| Magdalena Salazar-Palma | 5,752 |
| Tariq S. Durrani        | 3,750 |
| Elya B. Joffe           | 1,371 |

#### Region 10

|                   |       |
|-------------------|-------|
| Akinori Nishihara | 6,567 |
| Stefan G. Mozar   | 3,242 |

#### IEEE Standards Association Board of Governors Member-at-Large, 2017–2018

|                        |     |
|------------------------|-----|
| Mark Epstein           | 867 |
| W.C. "Chuck" Adams Jr. | 851 |
| Robert S. Fish         | 814 |

#### IEEE Technical Activities Vice President-Elect, 2017

|                    |        |
|--------------------|--------|
| Susan "Kathy" Land | 17,275 |
| Sergio Benedetto   | 13,725 |

#### IEEE-USA President-Elect, 2017

|                            |        |
|----------------------------|--------|
| Sandra L. "Candy" Robinson | 10,383 |
| Edward G. Perkins          | 6,614  |
| Charles P. Rubenstein      | 6,444  |

#### IEEE-USA Member-at-Large, 2017–2018

|                  |        |
|------------------|--------|
| Peter S. Winokur | 14,428 |
| Wole Akpose      | 8,729  |



## Introducing the 2017 Class of Fellows

*The Institute* congratulates these 300 IEEE senior members named IEEE Fellows for 2017. They join an elite group of people who have contributed to the advancement or application of engineering, science, and technology.

Raviraj S. Adve  
 Sos S. Agaian  
 Alexei E. Ashikhmin  
 Nadarajah Asokan  
 Todd M. Austin  
 John Ballato  
 Hugh J. Barnaby  
 Janet M. Barth  
 Christopher Barty  
 Nader Behdad  
 Calin A. Belta  
 Valeria M. Bertacco  
 Kankar Bhattacharya  
 Petronel Bigioi  
 Sebastien Bigo  
 Filiberto Bilotti  
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 Robert W. Boyd  
 Richard M. Buehrer  
 Linda G. Bushnell  
 Alper Buyuktosunoglu  
 Raymond H. Byrne  
 Zi-Xing Cai  
 Andrea Caiti  
 Yu Cao  
 Franck Cappello  
 Michael J. Carey  
 Luca Carloni  
 Jose M. Carmona  
 Edward Y. Chang  
 Edoardo Charbon

Lap-Pui Chau  
 Yan Chen  
 Gordon Cheng  
 Graziano Chesi  
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 Christopher R. Cole  
 Gerald Cooray  
 Sorin D. Cotofana  
 Robert K. Cunningham  
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 William R. Deal  
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 Ricardo L. de Queiroz  
 Tamal Krishna Dey  
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 William J. Dickerson  
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 Dov Dori  
 Frederick Douglass  
 Pier Luigi Dragotti  
 Falko Dressler  
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 Sandhya Dwarkadas  
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# Who Will Lead IEEE in 2018 and 2019?

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

**IEEE IS GOVERNED** by volunteer members and depends on them for many things, including editing its publications, organizing conferences, coordinating regional and local activities, writing standards, leading educational activities, and identifying 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:

**2019 IEEE President-Elect (who will serve as President in 2020)**

**2018 IEEE Corporate Officers**

■ Vice president, Educational Activities

■ Vice president, Publication Services and Products  
■ Secretary  
■ Treasurer

**2018 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 2017

## WHO CAN NOMINATE?

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

A person may be nominated for more than one position. Nominators do not need to contact nominees before submitting them. The N&A Committee will contact all eligible nominees for the documentation that's required and inquire if they are 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 ([http://www.ieee.org/about/corporate/nominations/nominations\\_guidelines.html](http://www.ieee.org/about/corporate/nominations/nominations_guidelines.html)). To nominate a person for a position, complete the online form ([http://www.ieee.org/about/corporate/nominations/nomination\\_form.html](http://www.ieee.org/about/corporate/nominations/nomination_form.html)).

## NOMINATING TIPS

Each year many ineligible candidates are nominated. Make sure to check eligibility requirements on the N&A

Committee website (<http://www.ieee.org/about/corporate/nominations>).

The positions for which the N&A Committee makes recommendations represent IEEE's uppermost governance levels. The committee recommends volunteers with relevant prior experience in lower-level IEEE committees and units more often than volunteers having no such experience. Nominees for the Awards Board, for example, 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.

—Howard E. Michel,  
chair, 2017 IEEE Nominations  
and Appointments Committee

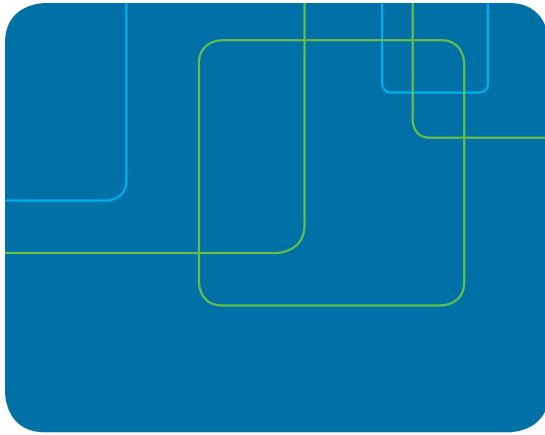
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