the institute

REINVENTING THE WAY WE DISCOVER MUSIC

Machine-learning software can recommend artists and predict hits P. 6

◆IEEE

EDITOR'S NOTE

PRACTICALLY EVERY INDUSTRY is working to adapt to the digital age, and publishing is no different. Here at *The Institute* for the past few years we've been posting articles daily on our website about new technology and pressing issues that affect our members. Many readers who see only our quarterly print issues might be missing some of our most popular and award-winning content.

Which is why, starting this year, we're selecting the best of our online content for the print edition. Some of the world's most prestigious publications have adopted this digital-to-print model, and we're following their lead.

In this issue, you'll not only find some of our most read and shared content from recent months but also feedback about it from readers. We encourage you to join them by going online to add your comments. You can find the articles by visiting http://theinstitute.ieee.org/march2018.

Our cover story, "Reinventing How We Discover Music" [p. 6] won *Folio:* magazine's min award for best technical article last year. *Folio:* covers the publishing industry.

Also included in this issue are two blog posts that sparked hundreds of comments [p. 12]. They tackled the questions of whether the title *engineer* has become meaningless and what to do about sexual harassment in the workplace.

And you might notice something different in Region News: We are including some images of IEEE activities from around the world that have been posted on Instagram, Twitter, and other social media sites. To be considered for inclusion in an upcoming issue, be sure to tag @IEEEInstitute in your post.

We'd appreciate your feedback on the changes. Tell us what you think by emailing us: institute@ieee.org.
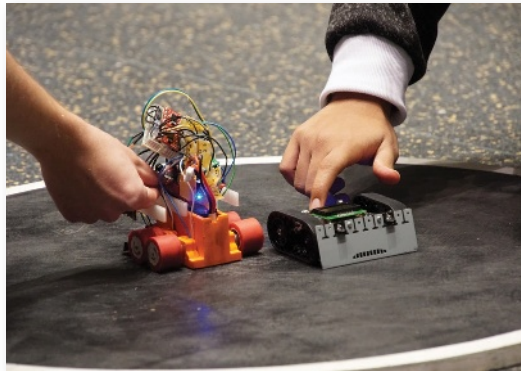
—Kathy Pretz, editor in chief
🐦 @kathypretz

REGION NEWS

REGION 1
GLASSBORO, N.J.
The IEEE student branch at Rowan University held its annual Profbots event. Small robots the students built [such as the one below] were placed in a ring and tasked with pushing each other out, similar to a sumo wrestling match.

REGION 3
SHEPHERDSTOWN, W.VA.
Shepherd University's IEEE student branch received a US $4,000 donation from BES Technology, a company in nearby Ashburn. Keisha Burns, the student branch's vice president, says the donation will support the branch's programs as well as those of its IEEE Robotics and Automation Society chapter and its IEEE Women in Engineering affinity group.

REGION 6
SAN DIEGO
An IEEE Milestone plaque [above] honors Qualcomm's 1989 public demonstration of its CDMA technology, which would pave the way for 3G cellular networks. Region 6 Director Kathleen Kramer, Qualcomm cofounder Andrew Viterbi, San Diego Mayor Kevin Faulconer, and Qualcomm cofounder Irwin M. Jacobs attended the Milestone ceremony.

REGION 7
OTTAWA
IEEE volunteers and university students received a $22,000 grant from EPICS in IEEE to construct a solar-powered water-heating system for Christie Lake Kids, a summer camp for underprivileged children.

REGION 5
WICHITA, KAN.
Members of the Epsilon Xi Chapter of IEEE Eta Kappa Nu at Wichita State University [right] are improving the lives of local children with disabilities through the university's Go Baby Go project. Members customize ride-on toy cars to meet the children's needs. The group received a $10,000 grant from Engineering Projects in Community Service (EPICS) in IEEE.

REGION 8
ESKISEHIR, TURKEY

Members of the IEEE student branch at Anadolu University gathered in front of the Dream Castle [above] at Sazova Science, Art, and Culture Park to celebrate IEEE Day in October.

REGION 9
CERRITO, PARAGUAY

An IEEE Special Interest Group on Humanitarian Technology (SIGHT) group worked with Etnia Toba Qom tribe members to build a sustainable, energy-efficient kitchen [below].

REGION 10
MUMBAI

Members of the IEEE Bombay Section's Young Professionals affinity group [below] visited a Jet Airways maintenance hangar.

For daily news about IEEE and its members, visit us at **theinstitute.ieee.org**. You can also follow us on Facebook, Twitter, and Instagram.

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Tag us on social media for the chance to be featured in an upcoming issue.

BRIEFINGS

Bradford W. Parkinson

Medal of Honor Goes to Parkinson

LIFE FELLOW Bradford W. Parkinson will receive the 2018 IEEE Medal of Honor "for fundamental contributions to and leadership in developing the design and driving the early applications of the Global Positioning System."

As a colonel in the U.S. Air Force, Parkinson was selected in 1972 to lead a program to develop a new space-based navigation system. He was named chief architect the following year to design GPS and served as the first director of the Joint-Services GPS Development Program Office, part of the Department of Defense.

All segments of the GPS system were designed and prototyped under Parkinson's leadership. The first GPS satellites were produced and launched by 1977. A ground control system was developed under Parkinson's watch and deployed to upload satellite data.

He retired from the Air Force in 1978 and joined Colorado State University, in Fort Collins, as a professor of mechanical engineering. From 1980 to 1984 he was vice president and general manager of Intermetrics, a software company in Cambridge, Mass.

He joined Stanford in 1984 as a professor of aeronautics and astronautics. He also served as a principal investigator and program manager of the NASA/Stanford relativity gyroscope experiment. The project led to the first successful test to validate Einstein's general theory of relativity using orbiting gyroscopes, which were launched into space in 2004. The researchers used GPS for precision orbit control and measurement.

Parkinson is now professor emeritus in Stanford's aeronautics and astronautics department and a researcher at the university's W.W. Hansen Experimental Physics Lab.

He has written more than 50 papers on guidance, navigation, and control, and he was coeditor of the two-volume book *Global Positioning System Theory and Applications.*

A member of the National Academy of Engineering, he received the 2016 Marconi

Award, the 2003 Charles Stark Draper Prize, and several honors from IEEE, NASA, and other organizations.

The IEEE Foundation sponsors the Medal of Honor.

Parkinson is to receive the award during the IEEE Honors Ceremony, scheduled for 11 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*

Piuri and Zurada Run Again for President-Elect

THE IEEE BOARD of Directors has nominated Fellow Vincenzo Piuri and Life Fellow Jacek Zurada as candidates for IEEE president-elect. The candidate chosen in this year's annual election will serve as IEEE president in 2020.

Piuri and Zurada ran in last year's election, which was won by IEEE Life Fellow José M.F. Moura, a petition candidate.

Piuri is a professor of intelligent systems and former chair of the information technology department at the University of Milan, as well as an honorary pro-

Vincenzo Piuri

fessor at four other universities. His interests include intelligent systems, machine learning, neural networks, pattern recognition, signal and image processing, and digital architectures.

He coauthored four books and founded a startup focused on intelligent systems for industrial applications. Elevated to Fellow in 2001 for "contributions to neural network techniques and embedded digital architectures for industrial applications," he is a member of IEEE Eta Kappa Nu, the organization's honor society.

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

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

Zurada is director of the Computational Intelligence Laboratory at the University of

Louisville, in Kentucky, where he is a professor of electrical and computer engineering and former chair of the department. His work focuses on computational intelligence, machine learning, and image and signal processing. He has served as a consultant to industry and to startups.

Jacek Zurada

He has authored or coauthored three books including the textbook *Introduction to Artificial Neural Systems*. His research has been cited more than 11,000 times.

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 five honorary professorships.

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

—*A.D.*

Five Elected to the Board

THE IEEE ASSEMBLY IN NOVEMBER elected five officers to the IEEE Board of Directors for 2018. They began serving their terms on 1 January.

Three of the five are serving their first terms [pictured left to right]: Francis B. Grosz Jr., IEEE vice president–elect, Member and Geographic

Activities; Witold M. Kinsner, IEEE vice president, Educational Activities; and Joseph V. Lillie, IEEE treasurer. Samir M. El-Ghazaly and William P. Walsh [far right] were elected to serve a second year as IEEE vice president, Publication Services and Products, and IEEE secretary, respectively.

—*A.D.*

Calendar *of Events*

MARCH

3–10
IEEE Aerospace Conference, Big Sky, Mont.

10–11
IEEE Region 8 meeting, Athens

APRIL

6–8
IEEE Region 5 meeting, Austin, Texas

19–22
IEEE Region 3 meeting, St. Petersburg, Fla.

15–19
IEEE International Conference on Computer Communications, Honolulu

24–26
IEEE European Symposium on Security and Privacy, London

MAY

11
IEEE Vision, Innovation, and Challenges Summit and IEEE Honors Ceremony, San Francisco

18–20
Maker Faire Bay Area, San Francisco

21–22
IEEE Women in Engineering International Leadership Conference, San Jose, Calif.

REINVENTING HOW WE DISCOVER MUSIC

Pandora uses machine learning to recommend artists and predict hits

BY **MONICA ROZENFELD**

F YOU'RE A FOLK ROCK FAN like me, you might be surprised when a music-streaming service suggests songs for you in other genres, such as country or reggae—and you actually enjoy them. Apple Music, Pandora, Spotify, and similar services are taking subtle cues from your listening habits, not only to recommend new artists but also to create personalized playlists for you with tracks you've likely never heard before.

To understand the technology making that possible, *The Institute* spoke with IEEE Member Josh Perline, a software engineer at Pandora, in Oakland, Calif. Perline is responsible for content personalization, which involves using data analytics and machine learning to automate the creation of suggested playlists.

As one of the first music-streaming services on the market, Pandora has some 17 years of data to work with. The company relies on data from its Music Genome Project, an undertaking that analyzes hundreds of songs' musical attributes, including which instruments are featured and the range of notes and vocal sounds.

"We have the same tracks as every other provider, but what keeps people coming back to us is the strength of our recommendations to help them discover new music," Perline says.

ROLLING IN THE DEEP

Say you're listening to Pandora's Adele station. It not only plays the songs of the Grammy award winner; it also plays artists with a similar sound, as well as artists from decades ago who influenced the singer-songwriter's music, Perline notes.

What differentiates Pandora, he says, is the human input that informs its algorithm on how to recommend music. The algorithm, based on machine learning, makes decisions by incorporating listeners' preferences as well as information about the songs. Staff members working on Pandora's Music Genome Project have backgrounds in musicology—the scholarly analysis of music. They assign attributes to the songs—some of which can have as many as 450 unique traits. That can include the emotions the lyrics convey, such as anger, sadness, or joy; each instrument in the recording and whether it's synthesized or acoustic; to what degree the vocals are nasal-sounding; and sound effects.

The metadata allows the algorithm to get much more precise. It not only classifies a song as rap, for example, but that of its sub-genre such as proto-industrial hip-hop, a fusion of industrial music and spoken words combined with hip-hop rhythms and vocals. "It gets extremely nuanced, down to even working from the liner notes," Perline says, referring to information such as the artist's biography and the lyrics.

The service can also tweak recommendations based on listeners' feedback. When people hear a song, they can tap a "thumbs up" or "thumbs down" icon. If "thumbs down" is tapped the playlist skips to the next song, and Pandora likely won't play that tune or similar ones again. In fact, the algorithm pays attention to everything listeners do, including which Pandora stations they save and listen to most. That way, when a new artist releases an album the algorithm determines that listeners might like, Pandora will recommend the music to them, Perline says.

HELPING ARTISTS SUCCEED

The data the company collects is helpful not only to listeners but to artists as well. Its Artist Marketing Platform gives the musicians free insights on, for example, how many people have listened to their songs and for how long. They can submit new music through the platform, with the potential for it to be played on Pandora.

Pandora in 2015 bought Next Big Sound, a company that provides analytics not only from its own service but also from third-party sources including social media platforms, radio stations, and video sites such as YouTube. Artists can access Next Big Sound to analyze the data and strategize on ways to reach their fans. Data showing geographic areas with concentrations of fans could be used to plan a tour, for example. In fact, Perline says, such analytics have prompted bands to perform in towns they otherwise might have skipped.

AND THE WINNER IS…

Next Big Sound has used its data to make accurate predictions as well. It determined several artists who would win Grammy awards, for instance. Data about the number of music downloads and social media shares can help inform the predictions.

Next Big Sound also can predict the next big hit or emerging artist before the music goes mainstream. That happened with rapper Lil Yachty, months before he first hit the Billboard Hot 100 chart. Such predictions are made possible in part when data shows how fast and from how many sources music has been shared.

If, for example, a YouTube music video uploaded by an unknown artist with only two dozen subscribers to his channel gets 5,000 hits in an hour, "we can see something is hot," Perline says. In other words, the algorithm can spot the activity a song is receiving and whether it surpasses the traffic it's expected to get.

Perline sees music-streaming services as leveling the playing field for independent and undiscovered artists by giving them exposure even if they don't have a record deal. "I think that's the direction music is going in," he says, with more self-made artists navigating their way to mainstream culture.

"Millions of tracks are available. Our job is to get the right ones to you." ◆

Delia Derbyshire, a pioneering musician and composer of electronic music, works in the BBC Radiophonic Workshop.

The Sound of 'Doctor Who'

BBC studio was among the first to experiment with electronic music BY **NATHAN BREWER**

SOUND DESIGN, specifically the sound effects and music used in science-fiction films and TV shows, helped introduce electronic music to mainstream audiences. The BBC Radiophonic Workshop was one of the major players, generating many influential and innovative scores for the broadcaster's programs.

The workshop was formed in 1958 in London when Daphne Oram, a pioneer in the field of radiophonics (sound effects and music produced for radio), petitioned her employer, the BBC, to open a formal production studio. Its engineers produced music and sound effects for such works as the long-running British sci-fi TV series "Doctor Who" and the sci-fi comedy radio program "The Hitchhiker's Guide to the Galaxy." The workshop closed its doors in 1998 after four decades.

AN ELECTRONIC REVOLUTION

The telharmonium (an electronic organ invented in 1897) and the theremin (a variable-frequency, single-oscillator instrument invented in 1920 with two metal rod antennas that control pitch and amplitude) each experienced brief periods of popularity. The emergence of tape recorders in the 1940s greatly expanded a composer's ability to edit and arrange musical works. At the time, music composed specifically for electronic instruments and electroacoustic devices was mostly experimental, performed by innovative musicians including John Cage and Pierre Schaeffer.

Musician and composer Daphne Oram entered the scene in 1943 when the BBC hired her as a sound engineer at the age of 18. With many men serving in the military during World War II, she entered a traditionally male-dominated space. Oram began to work after hours building a makeshift studio equipped with the BBC's tape recorders and oscillators.

One of the earliest broadcasts she worked on was the experimental radiophonic play *Private Dreams and Public Nightmares*, composed with Frederick Bradnum, a radio dramatist, producer, and director. The play, which aired on 10 July 1957 on BBC's "Third Programme," relied on tape effects extensively. The effects, such as echo, pitch shifting, and reverb, were produced by the manipulation and playback of tape. The following year, Oram produced the music and sound effects for a televised production of the play *Amphitryon 38*, which aired on 2 March.

With the increased demand for radiophonic sounds in all genres for BBC's programming, Oram petitioned the company for a production studio. On 1 April 1958 the workshop officially opened, with Oram as studio manager and her colleague, composer and sound engineer Desmond Briscoe, as senior studio manager.

One of the studio's first efforts was to produce the otherworldly sound effects for the third installment of the influential Quatermass sci-fi series "Quatermass and the Pit," which aired in 1958.

Although that and other avant-garde radio plays allowed the studio to experiment with new techniques for developing strange music and sounds, much of the studio's income came from producing advertising jingles.

LEADING LADIES

Oram left the BBC 10 months after the workshop opened to set up the Oramics Studios for Electronic Composition. There she furthered her "oramics" technique, which she had begun to develop at the BBC in 1957. Oramics is a method that involves drawing directly onto 35-mm film stock. Shapes and designs etched into the filmstrips are read by photoelectric cells and converted into sounds. This method of arranging music predated computerized composition software.

In the 1980s Oram received grant money from the RVW (Ralph Vaughan Williams) Trust and the Arts Council of England to develop oramics as software for the Acorn Archimedes and Apple II computers, but the projects were never completed. From 1982 to 1989 she also taught music part time at Canterbury Christ Church College (now Canterbury Christ Church University), in Kent, England.

During her stay at the BBC Radiophonic Workshop, she composed and created sound for nearly 200 TV programs. Oram was instrumental in establishing a creative environment with a large equipment collection for composers. Accordingly, over the course of its life span, the workshop attracted many experimental composers and popular artists including the Beatles and Pink Floyd.

Possibly the most recognized piece of music produced by the workshop is the original theme to "Doctor Who," composed by Ron Grainer and arranged by Delia Derbyshire. Derbyshire [see photo, left] joined the studio in 1962, and the theme was produced the following year by manual manipulation of tape in conjunction with oscillators and filters. "Doctor Who," which first aired on 23 November, 1963, became one of the longest running sci-fi franchises, with its initial run spanning from 1963 to 1989. The show relaunched in 2005 and is still broadcast today.

Derbyshire's theme music played over the title cards of the program until Season 18, which began in 1980. Derbyshire's compositions "Blue Veils and Golden Sands," "Nightwalker," and "The Delian Mode" also were featured in the program.

LEAVING A LEGACY

Tape manipulation was arduous and time-consuming. As synthesizers became commercially viable in the late 1960s and the 1970s, the studio shifted to them and away from oscillators and tape machines. The studio acquired several synthesizers including one nicknamed "the Delaware," an EMS (Electronic Music Studios) Synthi 100 that was one of the largest voltage-controlled synthesizers in the world. It attracted a new generation of composers and techniques, producing music and sound effects for sci-fi shows including "Blake's 7," as well as "The Hitchhiker's Guide to the Galaxy."

The BBC's investment in cutting-edge studio equipment produced a wide variety of innovative compositions, but the equipment was expensive both to buy and maintain. In 1992 the BBC appointed John Birt as its director-general. Birt evaluated each department for financial sustainability. He gave the Radiophonic Workshop five years to come up with a plan to make itself self-sufficient. The studio failed to do so and was shut down in March 1998. The last of the equipment was removed on 1 April—exactly 40 years after it opened. With the studio closed, much of the BBC's sound production was done with computers.

The BBC's use of the Radiophonic Workshop's programs introduced electronic music to millions of viewers and listeners. Oram's and Derbyshire's contributions to electronic music were massive. Several recent anthologies of their work ensure that it is available for new audiences to enjoy.

Nathan Brewer is the archival and digital content specialist at the IEEE History Center.

BBC

CAREER GUIDANCE

Betting on Intrapreneurship

Innovative companies encourage employees to pursue promising ideas BY **MONICA ROZENFELD**

NTRAPRENEURS EXHIBIT many of the same traits as entrepreneurs: They're creative problem-solvers who take risks. That's why some who have an entrepreneurial bent are turning to intrapreneurship, using the built-in financial resources and staff from the company they work for to develop a new product or service without the risks of going it alone. The key difference is that their project will benefit their employer.

Some companies have established a culture in which employees are encouraged to innovate beyond their job descriptions during the workday, but others require employees to step up and pitch their ideas to upper management to get support.

INTRAPRENEURIAL FIRMS
Companies such as Facebook, Google, and 3M encourage employees to pursue their ideas. They might offer a variety of opportunities such as letting employees devote 20 percent of work hours to side projects. Others incubate workers' projects full time.

Barbara Marder, a senior partner at Mercer in New York City, says she believes the key ingredient in a company's success is a culture of innovation. Mercer presented its intrapreneurship model at the IEEE Women in Engineering International Leadership Conference (WIE ILC). Marder runs the human resources consulting company's three innovation hubs, where employees focus on developing new products and services, many of which involve technological applications.

All of Mercer's 22,000 employees are encouraged to participate and pitch their ideas. "Innovation is everyone's responsibility," Marder says. "While we can't have everyone off innovating and not doing their day jobs, we try to take risk off the table for those who want to try out an idea that would help the company."

One product launched last year from an innovation hub is Mercer Match, powered by Pymetrics, a startup in New York City. Job seekers play 12 neuroscience games that uncover their social and emotional traits. Their profile, based on those traits, is matched with appropriate job opportunities.

Software company SAP, headquartered in Walldorf, Germany, created its iO business unit to pursue breakthrough software ventures using the company's assets—including its data and its application programming interfaces—in an open innovation model. SAP.iO's Venture Studio allows entrepreneurial-minded employees to pursue independent startups as intrapreneurs. SAP encourages all employees from its more than 130 global offices to submit proposals for new ventures that can simplify and transform how businesses operate. The only catch is the idea must have the potential to make a huge profit.

With an annual revenue of more than US $23 billion in 2016, SAP is looking for its iO unit to generate bold ideas that can bolster its bottom line, according to Marcus Krug, head of the unit's intrapreneurship team. The team reviews hundreds of proposals each year to find the ones that are most likely to move the needle.

SAP.iO gives selected intrapreneurs capital to pursue their venture as an internal startup. The seed funding allows teams to prove that a market exists for their new venture and that they can successfully tackle it. In the process, teams take end-to-end responsibility for their project, from product design and development to sales and financials. Advisory boards composed of senior executives provide oversight and guidance.

Since its start in 2016, SAP.iO's Venture Studio has made six seed investments, providing intrapreneurs with the money they need to get the business off the ground. The studio's most successful venture to date is Atlas, a geospatial data analytics product that provides a simplified platform to help companies make better decisions.

"We have audacious goals for SAP.iO," Krug says. "We understand that what we do carries high risk and that many of these new ventures will fail. That's why we're taking a venture capital approach."

But if SAP.iO continues to make enough careful, small investments, Krug says, he is sure one will have unicorn potential.

TAKING INITIATIVE
Not all companies have an intrapreneurship program, but that doesn't stop some employees from taking it upon themselves to innovate. IEEE Member Shraddha Chaplot worked for nine years as a systems engineer at a well-known technology company in Silicon Valley. She spoke about being an intrapreneur at the WIE ILC and at IEEE N3XT, a forum for engineers who are budding entrepreneurs.

Chaplot defines intrapreneurship as employees contributing to a company beyond title, team, or budget. "I made things happen by seeking and creating my own opportunities, building them out in my spare time, and convincing those I needed to support me for help, all in addition to my regular job," she says.

One of her biggest accomplishments happened while she was on a team working to make technology more accessible to people with disabilities. She took it upon herself to advocate for a university to receive a $100,000 research grant offered by her employer. With that grant, the university tested a videoconferencing system for people who are deaf or hard of hearing. After that success, her manager allotted time for her to create another system for the university to do further testing.

If you want to be an intrapreneur, it helps if you're in a supportive environment, Chaplot notes. "Unless a new role is created for you, most companies are not going to let you wander off and experiment with something new," she says. "They need measurable results."

Although many people have nurtured her ideas over the years, others stifled them. If you have an intrapreneurial spirit and you find your ideas are being ignored or stolen, find another employer as soon as possible, she says. ◆
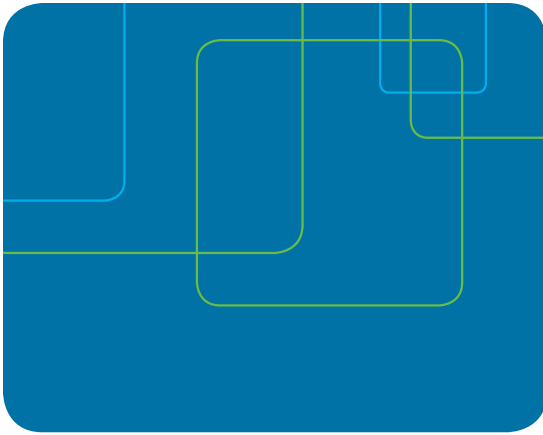
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◆IEEE

A ROAD MAP FOR ASPIRING ENTREPRENEURS

The plan takes engineering students from idea to marketplace

BY **AMANDA DAVIS**

WHEN YOU'RE OUT TO launch your first company, questions abound: Will people buy what I want to sell? Where do I get funding? How do I build a team?

To help budding entrepreneurs find answers, Aram Chavez and IEEE Member Steve T. Cho, both lecturers in technological entrepreneurship management at Arizona State University, in Tempe, came up with a graphic [right] called "Startup Map: From Aha to Exit!"

In 10 steps, and a minimum of 15 courses, students learn ways to turn their idea into a profitable venture. The steps are displayed in an infographic that provides the framework for ASU's program, which leads to a bachelor's degree in entrepreneurship and innovation. Chavez presented the map at last year's IEEE Technology and Engineering Management Society Conference, which *The Institute* attended.

ASU offers an entrepreneurship undergraduate program administered by an engineering school—the Ira A. Fulton School of Engineering—rather than a business school. Students take courses in the order shown in the infographic.

"Many of our engineering students take courses that allow them to minor in entrepreneurship—and in these courses, they're exposed to creating startups, filing intellectual property claims, building teams, launching products, and other vital skills," Cho says.

"Our years of guiding and investing in startups has given us the template to create the map," Chavez says. "It integrates the best practices in entrepreneurship and provides a comprehensive view of the journey."
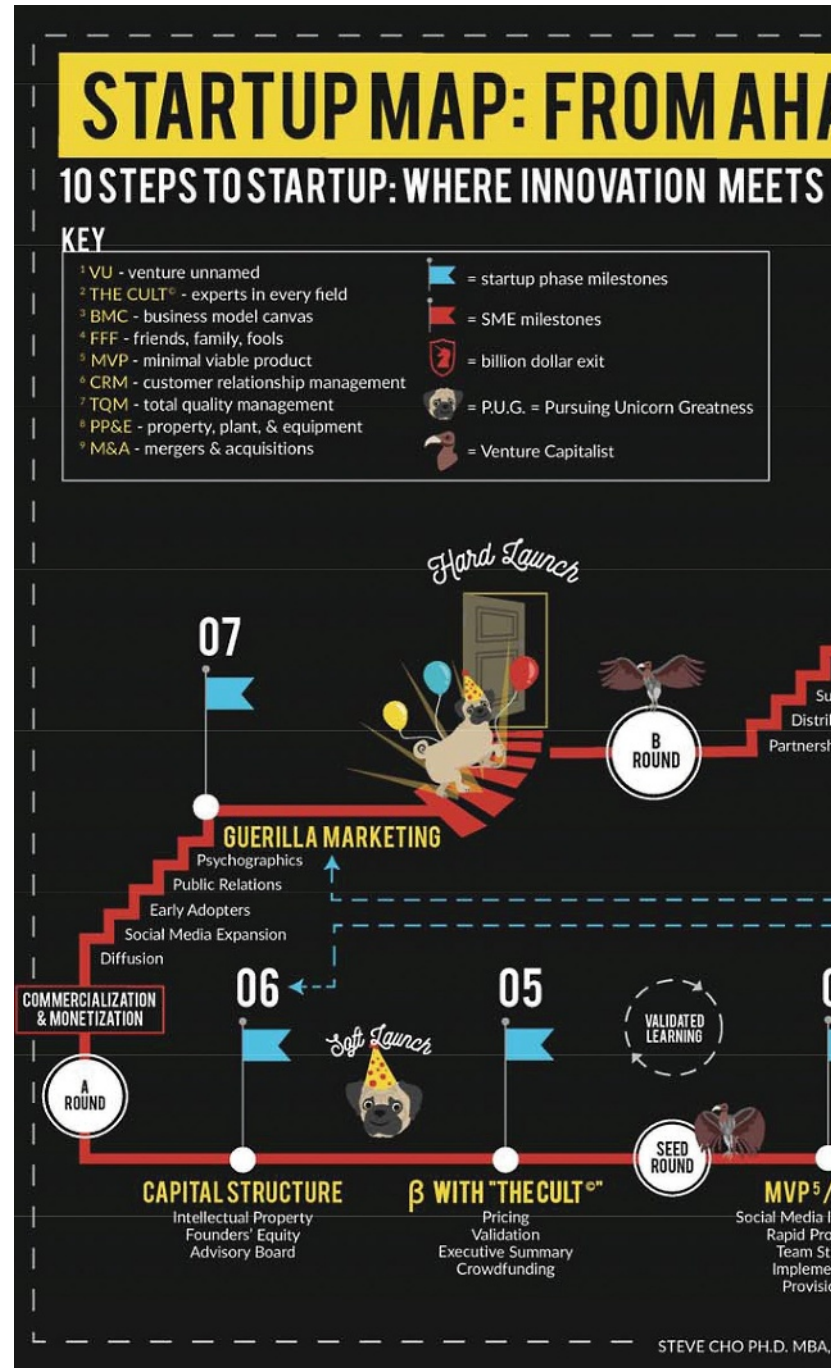
STARTUP INCUBATOR

Chavez and Cho are no strangers to the startup world. For the past two decades, Chavez has been providing funding and guidance to small businesses through Pacific Investment Partners, a private equity firm in Scottsdale, Ariz., where he is managing director.

Cho, a nanotechnology engineer, has led several engineering startups during his technical career, which spans nearly three decades.

The ASU entrepreneurship program, which has grown from 50 students in 2012 to more than 850 as of 2017, is offered online and in person. It is open to students pursuing all majors—not just those studying engineering or business.
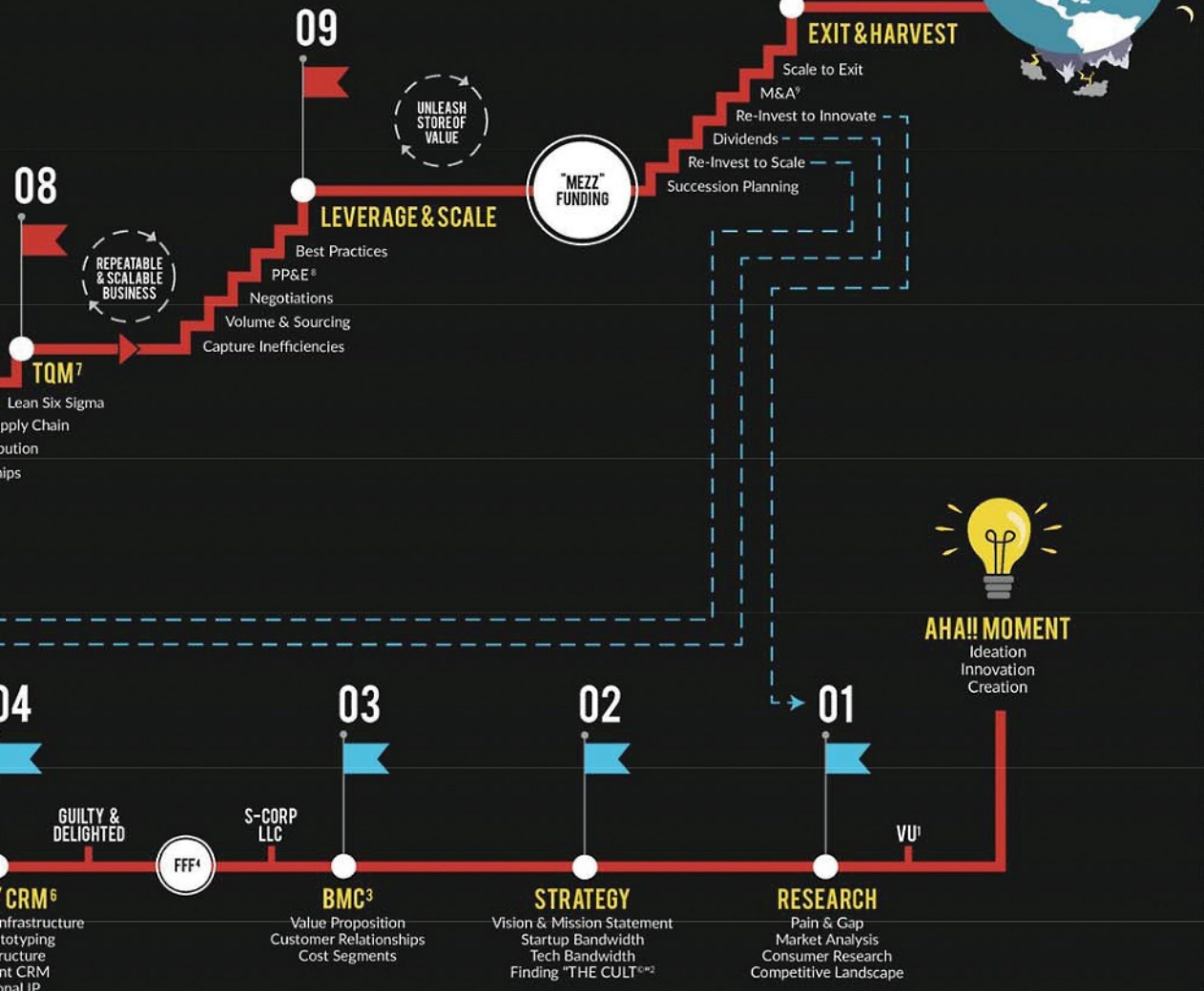
The program has helped several students launch successful ventures,

A TO EXIT!©
ENTREPRENEURSHIP

Years of researching, investing, and developing successful startups gave us the template to create the world's first roadmap for innovators to become entrepreneurs. Every step carries real-world entrepreneurial experiences, successes, and failures. Have you ever wondered where to begin or what your next step is? The Startup Map will guide you, step-by-step and in real time.

10

EXIT & HARVEST
Scale to Exit
M&A [9]
Re-Invest to Innovate
Dividends
Re-Invest to Scale
Succession Planning

09

UNLEASH STORE OF VALUE

"MEZZ" FUNDING

UNLEASH STORE OF VALUE

LEVERAGE & SCALE
Best Practices
PP&E [8]
Negotiations
Volume & Sourcing
Capture Inefficiencies

08

REPEATABLE & SCALABLE BUSINESS

TQM [7]
Lean Six Sigma
Supply Chain
...bution
...ips

AHA!! MOMENT
Ideation
Innovation
Creation

04

03

02

01

GUILTY & DELIGHTED

S-CORP LLC

FFF [4]

VU [1]

CRM [6]
...nfrastructure
...totyping
... structure
...nt CRM
...nal IP

BMC [3]
Value Proposition
Customer Relationships
Cost Segments

STRATEGY
Vision & Mission Statement
Startup Bandwidth
Tech Bandwidth
Finding "THE CULT" [2]

RESEARCH
Pain & Gap
Market Analysis
Consumer Research
Competitive Landscape

AUTHOR: ARAM CHAVEZ | DESIGNER: JENNA VAN ROOY | ADDITIONAL CONTRIBUTORS: JOHNATHAN BARONE, RUSSELL BRANAGHAN PH.D., JASON BRONOWITZ, MENTOR DIDA, RICHARD FILLEY, CAROLYN HIRATA, ADITYA JAGANNATHAN, CHAD KENNEDY PH.D., NICOLAS NEVE, QUI YUEMING (LUCY) PH.D., GARY R. WAISSI PH.D.

Chavez says. One is Lvl Up Dojo, a subscription-based service that offers online videos to help professional video game players train for competitions. Another is SCI Creations, a digital marketing firm in Chandler, Ariz., that specializes in data services.

Aspiring founders at the university also learn from each other. "Entrepreneurship can be a very lonely experience," Cho says. That's why ASU launched the Startup Village, a residential building where students who want to start their own businesses can live and network, share resources, and help each other solve problems and flesh out ideas. Professors and recent graduates often visit the building to act as mentors. There is not a similar program yet for online students.

OVERCOMING CHALLENGES

The two lecturers note that students—especially engineering undergraduates—often are knowledgeable about the technology they're working on but might not understand all its potential applications. The program helps students narrow down what they want the technology to accomplish. It has them identify a target audience and find and interview potential customers to learn what they might want from the product. Cho and Chavez refer to the audience as a *cult*—a group of influencers and experts likely to use the technology.

After students identify and consult with their cult, they learn how to develop a prototype and test it, then create a marketing campaign.

Completing those steps helps give the students confidence to present their startup to potential investors, Chavez says. "It can be a challenge for entrepreneurs to connect with investors," he says, "especially if they don't live near a major startup hub, like Silicon Valley."

"Our students often come up through the mud," he says, explaining that some start with nothing but money borrowed from friends and family. And many must pay off student loans before they have capital of their own to invest. Therefore, he says, it's especially important to develop a product and a business plan to impress angel investors and venture capital firms early on.

"The engineering school at ASU emphasizes learning by doing," Cho says. "Entrepreneurs are often afraid to get started, because they fear their idea isn't good enough, or that they won't be able to get funding. Our students are confident enough not to have those fears, because we take them through every step of the process." ◆

Sparking Conversation

Several of our blog posts inspired comments from readers
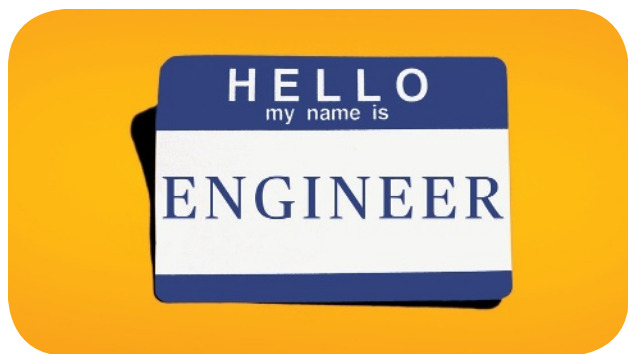
Has the Title *Engineer* Become Meaningless?

WE PUBLISHED A PAIR OF BLOG POSTS about Mats Järlström and his case with the Oregon Board of Examiners for Engineering and Land Surveying. Last year the state board ruled he was illegally practicing engineering when he critiqued traffic-light systems. Järlström has a bachelor's degree in engineering, but without a state license, the board said, he had broken the law by describing himself using the word *engineer*. He sued the board, which in June admitted that its interpretation had violated Järlström's First Amendment rights.

Many readers complained the title *engineer* was being used to describe too many positions. These include garbage collectors, technicians, mechanics, and locomotive operators. Others wondered whether people who write software should be called engineers. And what about circuit designers? Don't they engineer?

In response to those concerns, we published a post in October that cited an article by the Institution of Mechanical Engineers. In that article, Tony Gray, a chief engineer in the United Kingdom, suggested that professional associations develop a strategy to protect the title. Peter Finegold, IME's head of education, disagreed. He said the problem was the public's perception of the nature of engineering, and protecting the title wouldn't solve that. Instead, he argued, engineers need to talk about the contributions they make to society. Here are some readers' comments to that post.

If you graduated from an ABET-accredited college, you should be able to use the title *engineer.* If you pass a state licensing exam you can use the title *professional engineer (P.E.).*

My first boss had the title *principal engineer* even though he never took the state licensing exam. Despite this, he gave advice to many professional engineers who heeded his word because his experience and knowledge were clear and evident. Let's establish some simple rules and work together.
—Edward B. Farkas

We don't have a problem calling people with Ph.D. degrees *doctors.* If we're referring to a person who is licensed to practice medicine we say *M.D.* You don't see states or medical boards going after anyone using the title *doctor* who is not claiming to practice medicine.

So, we use the P.E. title for licensed professional engineers. I think it's extreme to have laws against the generic use of the title *engineer.*
—David N.

In some cases, the title of *engineer* is overused. It should be limited. *Sanitation engineer*, for example, should be reserved for people who design water treatment, sewage processing systems, and landfills—not those who pick up your trash. An engineer's job is to innovate, design, build, maintain, and improve.

Nothing needs to be done to elevate the stature of the engineering title. However, the regulations need to allow people who do engineering to accurately identify themselves and their work as engineering. The use of a protected title should be granted to those with the appropriate license, but that should be distinct from being called an engineer.
—Thomas Owens

I have an electrical engineering degree and was a practicing engineer for 30 years. But most of my time was writing firmware, and later I was given the title *software engineer.* I can't imagine that some group might decide that it is illegal for me to write software because I don't have a computer science or software engineering degree. Software engineering didn't even exist as a major when I went to university.

The term *engineer* has been and always will be a generic one. We should use certifications to ensure competency, but make sure those certifications are open to anyone, including those who transferred from other fields.
—David Haas

Professional engineer is a specific title that makes sense for the traditional disciplines, for example, civil, mechanical, and electrical. I'm not so sure that a person with a master's degree in telecommunications engineering, for example, would find any advantage seeking a P.E. license, but they should still be considered an engineer.
—Montelaciti

After 50 years of being an IEEE member, I say it is about time engineers get some respect. Engineers are professionals, just like lawyers and doctors—yet we are treated more like day laborers. Our title is meaningless. We should be appreciated like people in the other professions and paid like them. Historically, IEEE has failed at this effort.
—Steve Stark

Real engineers possess a spirit of innovation, wonder, curiosity, persistence, and the willingness to advance through education. Having a title because you got higher education means nothing if you are not already an engineer at heart.
—Pavlos Gavrielides

What to Do About Harassment in the Workplace

AFTER WORKING AS AN ENGINEER FOR 30 YEARS, Senior Member Nathalie Gosset lost her job in 2015 at the Alfred E. Mann Institute for Biomedical Engineering at the University of Southern California. She says she was fired because she reported her boss to human resources, accusing him of making lewd and inappropriate comments to her.

Gosset's experience has been covered by CBS News and other outlets. She has been unable to secure another job in her field.

In an interview with *The Institute*, she discussed her case in pressing sexual harassment and retaliation charges against her former employer. We also interviewed her attorney, Lisa Bloom, about what others who find themselves in a similar situation can do. The blog post was published in October.

I don't know if this woman was really harassed or not. Perhaps her entire story is true. However, I will remain skeptical of these stories when there is no audio or video evidence to prove them.

—Anonymous

Women often don't report harassment when it happens, because there are reasonable odds of retaliation, such as getting fired—as proven by this incident. In many cases, human resources works to protect the company from lawsuits, not necessarily protecting employees from harassment.

—Anonymous

Women have to decide whether they want to be delicate damsels who should be protected from all mention of sex, or equal members of a team who may be exposed to banter. If something someone says would not offend a male team member, then the female staffer should simply ignore it. There is a big difference between an off-color joke and being propositioned by a boss. We seem to be labeling both *sexual harassment*.

—George Reeves

I'm sick of companies having politically correct harassment training for all employees. That doesn't mean I'm in favor of harassment, but this sort of training creates fear over what you say or do in case it might be misinterpreted.

We should focus not on what we shouldn't do but on what we should do when interacting with our coworkers. We need to have respect for each other—which not only means being considerate of other people but also sometimes cutting people some slack.

—postingcarefully

As a female engineer, I've found that companies that have sexual harassment training in the format of a manager showing a video and having discussions afterward are by far more welcoming workplaces than those that do not.
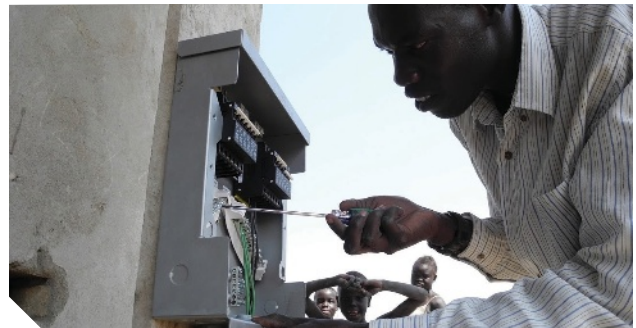
Although it was uncomfortable being the only woman in the room, it was worth having the men think about the way they interact and learn that it's okay to ask questions and start a dialogue about harassment.

I've also been in hostile workplaces, like the one Gosset describes, and those companies had no such training. Although offenders will always find loopholes, the good guys are sometimes afraid they'll be fired for just saying hello to women. Setting guidelines on how to interact professionally is crucial to everyone.

I'm grateful to any company that is willing to spend money on showing the entire workforce a video and then to pay them to talk about it. It shows how important a subject it is.

—rtj

These discussions are still ongoing. To weigh in, visit http://theinstitute.ieee.org/mar18responses.

ISTOCKPHOTO

Defining the Future

Priorities for IEEE as a 21st-century professional membership organization

JIM JEFFERIES IEEE PRESIDENT AND CEO

T'S CLEAR THAT the professional association landscape is changing. Organizations such as IEEE must adapt to these changes to stay relevant, both to members and to society.

Many know who we *are*, but not necessarily all that we *do*. To be sure, IEEE is a great organization with breadth both in discipline and geography. It's a powerful brand that can open new opportunities and has an enviable mission that members, potential members, and the general public can all support. But IEEE is facing challenges in growing membership, in responding to revenue-impacting changes in publishing and conference business models, and in asserting our leading-edge position in technology policy.

It is responses to these challenges that are defining our strategic approach as we position IEEE to purposefully serve our membership and mission throughout the 21st century. This requires setting priorities, improving accountability, and creating a collaborative environment with a commitment to innovation and a forward-looking perspective while also creating the diverse next generation of IEEE leaders. The outcome will be more engaged members who are at the forefront of developing emerging technologies and the recognition of IEEE as the voice of technical professionals worldwide.

GLOBAL CONVENER

IEEE has made great strides in effective global public policy activities by engaging and leveraging the knowledge and insights of our international community. We believe that successful technology implementation often depends as much on the actions of governments as on the discoveries of scientists and the creativity of engineers. And that wise technology-related public policies are best developed through consultation between policymakers and technologists.

Our IEEE Global Public Policy Committee enables us to serve as a worldwide source of information to governments and to society at large about the social responsibilities and implications of technology and the roles innovations can play in enhancing quality of life and increasing well-being.

And our European Public Policy Committee, now a permanent committee of IEEE, is focused on expanding the dialogue between Europe's engineering community and public authorities for the benefit of IEEE members, engineering professionals, and the general public. Opportunities for further engagement exist throughout the world.

INDUSTRY OUTREACH

The IEEE Industry Engagement Committee was also established as a permanent committee of IEEE effective this year. It works to improve coordination of activities across IEEE and provide opportunities for the development of products and services for industry professionals. The committee is the result of extensive outreach and engagement with international technology leaders to explore current and emerging issues in established and entrepreneur businesses. These efforts were essential in learning how IEEE can better provide value to industry and helped establish the framework for the IEEE Industry Advisory Board.

We are committed to working across our organization and with our members, volunteers, and professional staff to develop and implement an engagement strategy that delivers renewed value both to our members who work in industry and to our industry partners.

MISSION-FOCUSED

IEEE is dedicated to advancing technology for the benefit of humanity. Through our diverse humanitarian and philanthropic programs, there are many opportunities to contribute to

> *My years of membership and volunteer service at IEEE have reinforced for me the relevance and importance of professional associations*

improving the human condition worldwide. The IEEE Humanitarian and Philanthropic Opportunities Initiative launched in August during Sections Congress 2017 in Sydney. This collaboration brings together the wide range of IEEE programs that aim to do social good. This initiative further highlights the mission-driven focus of IEEE and helps us incorporate a humanitarian component into all that we do.

My years of membership and volunteer service at IEEE have reinforced for me the relevance and importance of professional associations. There is significance in being part of a group of people with a shared purpose that goes beyond one's own personal interests and current career.

Our strength is in our unity. We are at our best when we have active collaboration, communication, and cooperation among our units, whether it be boards, societies, or sections. With a joint focus on member value, we can share education, career, policy, and other high-interest materials among our units through communal, cross-discipline events.

The world's leading technological professional organization can grow its lead with attention to crisp execution of our strategic plan, maintaining our greatest strengths in technical leadership, and expanding our global public policy and humanitarian impact—all with a renewed focus on membership. Our value is multiplied through our cooperation.

I can see an IEEE where private and public organizations facing major decisions involving our fields of interest routinely say they better check with IEEE first, where members regularly ask how they can be more involved, and where students enthusiastically ask how soon they can become higher grade members.

I encourage all our members to be engaged with IEEE's activities, to inspire participation from colleagues, and to celebrate all that your IEEE membership does for you, for our professional community, and for the benefit of humanity.

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

DAVID SUTPHIN

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BENEFITS

Standard to Boost Battery Life of IoT Devices

BY **KATHY PRETZ**

INTERNET OF THINGS devices likely will be ubiquitous soon—in homes, offices, grocery stores, and hospitals—with many applications designed to improve our quality of life and make the services we use more efficient. But before the devices can be implemented effectively, their short battery life must be addressed.

It's been estimated by the IEEE 802.11ba standards task group that half of Internet-connected sensors and devices will run on batteries by 2020—which is concerning because replacing batteries is costly. Putting them on sleep mode helps, but that lowers device performance.

That's why the IEEE Standards Association (IEEE-SA) and the task force are working on a new standard for low-power radio receivers. IEEE Wake-Up Radio technology could significantly increase battery life, from just a few hours to almost two years, and could allow some devices to remain accessible at all times without draining their battery.

IEEE-SA and IEEE Educational Activities released a report in November explaining how the Wake-Up Radio standard works and exploring its potential applications.

THE CONCEPT

Most smart devices connecting to the IoT rely on three radios: short-range Bluetooth, medium-range wireless local area network (WLAN or Wi-Fi), and longer-range cellular radio. Wi-Fi, which carries the lion's share of digital data, has a reputation for consuming a lot of battery power.

Various amendments to IEEE 802.11 have called for transmitting data at lower power when appropriate. But such transmissions also lower data rates—which in turn necessitates longer transmissions and requires more power.

One solution for conserving power is to put the Wi-Fi radio in sleep mode. In this power-saving setting, the IEEE Wake-Up Radio wakes up every few milliseconds to see if a signal is trying to get through. The receiver listens for a signal that informs the device that information is being sent its way, and wakes up the Wi-Fi radio so that the data exchange can begin. An always-on 100-milliwatt Wi-Fi radio can drain a 3-volt 130-milliampere-hour battery in about four hours.

By adding a second low-power IEEE Wake-Up Radio receiver, the battery life could be stretched to 694 days, according to the IEEE 802.11ba standards task group.

"IEEE Wake-Up Radio is an add-on to existing IEEE 802.11 radios that substantially improves power-saving performance of IEEE 802, removing the need to compromise between power savings and latency," Senior Member Adrian Stephens, chair of the IEEE 802.11 working group, said in a news release. "This makes the technology suitable for a new class of battery-powered devices that will drive innovation and exciting new applications in the market."

As engineers continue to streamline signal handling, consumers can look forward to thousand-fold increases in battery life and years of operation on a single charge, according to the report.
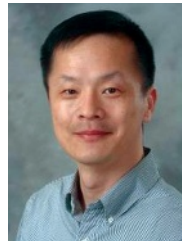
IEEE Wake-Up Radio will greatly reduce the need for frequent recharging or replacement of batteries while still maintaining optimal performance.

The November report says that IoT devices that run over short-range wireless networks—like those used in transportation and logistics, health monitoring, and smart homes—will benefit the most from the new standard. ◆

ISTOCKPHOTO

Member Achievements

SUNGEUN KIM

■ Member Sungeun Kim is developing a computer program to quickly parse and compare medical data from a large pool of patients and help diagnose and treat neurodegenerative diseases. The U.S. National Institutes of Health awarded him a US $119,000 grant to further his research.

The program examines massive data sets to analyze genes, biomarkers, and patient data and more accurately predict the onset of diseases such as Alzheimer's—which could pave the way for early detection and more effective drugs.

Kim is an assistant professor of computer engineering at the State University of New York in Owego. He's also an adjunct assistant research professor at the Indiana University School of Medicine, in Indianapolis, where he has worked for several years on projects related to Alzheimer's, Parkinson's, and other diseases.

JON KLINGENSMITH

■ Member Jon Klingensmith is working to create a low-cost ultrasound tool for measuring a person's cardiac adipose tissue—an increase of which is a risk factor for heart disease. His project received a $154,000 grant from the American Heart Association.

The software-based tool would measure the tissue based on the results of an echocardiographic ultrasound imaging test rather than magnetic resonance imaging, the current method. Echocardiography, the researchers say, is safer and less expensive than MRI, and can assess the heart's function.

Klingensmith is an assistant professor of electrical and computer engineering at Southern Illinois University in Edwardsville.

SHRIKANTH NARAYANAN

■ A team at the University of Southern California, in Los Angeles, led by Fellow Shrikanth Narayanan is using artificial intelligence and data from sensors to study the causes of workplace stress. The U.S. Intelligence Advanced Research Projects Activity has awarded the team a four-year, $12 million grant.

IARPA is an organization within the Office of the Director of National Intelligence.

The researchers are analyzing data from wearable sensors and self-assessment questionnaires collected from 250 Keck School of Medicine nurses at USC. Numerous physical and emotional factors will be tracked continuously, including sleep quality, work performance, and social interaction, according to an article on USC's website.

The team plans to work with behavioral psychologists at the university to interpret the results. The researchers will use the data to analyze how stress affects workers, specifically those in demanding jobs where long shifts are the norm.

Narayanan is a research director at USC's Information Sciences Institute and a professor of electrical engineering. He is a member of the IEEE Signal Processing Society.

ARUN NETRAVALI

■ Life Fellow Arun Netravali received the Marconi Prize, which recognizes significant contributions in the field of communications. The award includes a $100,000 honorarium. The Marconi Society, established in honor of Guglielmo Marconi, presents the award.

Netravali, a former president of Bell Labs, was cited for pioneering work in video compression based on motion estimation. He led the company's research and development of high-definition television and is widely acknowledged as a digital-video pioneer.

After retiring from Bell Labs, he founded and now serves as managing partner of OmniCapital Group, a private-equity firm in Westfield, N.J.

ROSALIND SADLEIR

■ Member Rosalind Sadleir received a $2 million grant from the U.S. National Institutes of Health to study transcranial electrical stimulation (TES), a noninvasive procedure in which electrodes are placed on a person's scalp to direct a low current through the brain. The technique might eventually help treat a variety of ailments and improve cognitive function and learning ability.

Sadleir is an assistant professor of biomedical engineering at Arizona State University, in Tempe. To form a clearer picture of how a current travels through the brain, she is using magnetic resonance electrical impedance tomography. Patients are treated with TES while inside an MRI machine—which allows researchers to determine where the current spreads.

Countdown to the 2018 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 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 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.

UP FOR ELECTION IN 2018
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 division
- 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 region
- 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

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, 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.

11 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.

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

The 2017 Election Results

Here is the Tellers Committee tally of votes counted in the 2017 annual election and approved in November by the IEEE Board of Directors.

IEEE president-elect, 2018
José M.F. Moura	18,883
Vincenzo Piuri	13,976
Jacek M. Zurada	12,879

IEEE division delegate-elect/director-elect, 2018
Division II
David B. Durocher	2,472
Reza Zoughi	1,739

Division IV
John P. Verboncoeur	2,803
Elie K. Track	1,589

Division VI
Manuel Castro	1,565
Greg Adamson	1,408

Division VIII
Elizabeth L. "Liz" Burd	4,197
Sorel Reisman	1,762

Division X
Ljiljana Trajkovic	2,635
John R. Vig	1,804
Okyay Kaynak	1,676

IEEE region delegate-elect/director-elect, 2018–2019
Region 1
Eduardo F. Palacio	2,286
Ali Abedi	1,702

Region 3
Jill I. Gostin	2,215
John Kenneth "Ken" Pigg	1,304

Region 5
James R. Look	1,663
Timothy R. Weil	1,228

Region 7
Jason Jianjun Gu	973
Adam Skorek	806

Region 9
Alberto Sanchez	1,085
Enrique A. Tejera M.	674

IEEE Standards Association president-elect, 2018
Robert S. Fish	765
Dennis B. Brophy	617

IEEE Standards Association board of governors member-at-large, 2018–2019
Walter Weigel	715
Masayuki Ariyoshi	710

IEEE Standards Association board of governors member-at-large, 2018–2019
Stephen D. Dukes	862
Robby Robson	560

IEEE Technical Activities vice president–elect, 2018
K.J. Ray Liu	15,156
Douglas N. Zuckerman	12,870

IEEE-USA president-elect, 2018
Thomas M. Coughlin	13,548
Guruprasad "Guru" Madhavan	8,579

Introducing the 2018 Class of IEEE Fellows

The Institute congratulates these 296 senior members named IEEE Fellows for 2018. They join an elite group of people who have contributed to the advancement or application of engineering, science, and technology.

Pieter Abbeel
Pamela Ann Abshire
Haithem A. Abu-rub
Erik Agrell
Fauzia Ahmad
Anastasia Ailamaki
Matteo Albani
Andrew Alleyne
Pietro Andreani
Walid G. Aref
Kohtaro Asai
Hajime Asama
Bertan Bakkaloglu
Bijnan Bandyopadhyay
Paul Barford
N. Scott Barker
Erik P. Blasch
Glenn D. Boreman
Vicente E. Boria
Timothy B. Boykin
Maurizio Bozzi
Oliver Brock
Alexander Bronstein
Charles F. Bunting
Karen L. Butler
Marco Caccamo
Yigang Cai
Giuseppe Carlo Calafiore
Jeffrey P. Calame
Linda J. Camp
Mark E. Campbell

Gustavo Camps-Valls
Emmanuel Candes
Leo F. Casey
Sherman M. Chan
Chip Hong Chang
Kun-Yung K. Chang
Ni-Bin Chang
Tsung-Yung J. Chang
Kuan-Neng Chen
Wen-Hua Chen
Yi-Jan Emery Chen
Yiran Chen
Po-Tai Cheng
Richard Chernock
Yiu-Ming Cheung
Carla F. Chiasserini
Gianfranco Chicco
Gary E. Christensen
Oscar Cordon
Thomas M. Coughlin
Jian S Dai
Swaroop Darbha
Ewa Deelman
Andreas C. Demosthenous
Jaydev P. Desai
Po Dong
Qian Du
Alan Edelman
Lieven Eeckhout
Karen O. Egiazarian
Daniel P. Ellis

Ehab F. El-Saadany
Fariba Fahroo
Liping Fang
Hany Farid
Dario Farina
Steven K. Feiner
James W. Feltes
Massimo Franceschetti
James R. Friend
Pascal Frossard
Kevin Fu
Akira Fujiwara
Thomas Furness
Andrea A. Galtarossa
Dave Garrett
Alexander D. Gelman
Mounir Ghogho
Maria L. Gini
Yihong Gong
Stefano Grivet-Talocia
Cuntai Guan
Xinping Guan
Minyi Guo
Yongxin Guo
Jung-Ik Ha
Martin Haardt
Harald Haas
Hashem M. Hashemian
Haibo He
Tian He
Jeffrey S. Herd

Yoshihito Hirano
Michel J. Houssa
Naira Hovakimyan
Jonathan P. How
David Howe
David Hsu
Biao Huang
Qingming Huang
Pan Hui
Brad Hutchings
Jaroslav Hynecek
Kullervo H. Hynynen
Leon D. Iasemidis
Anil K. Jampala
Somesh Jha
Jiaya Jia
Lynette Jones
Sergei V. Kalinin
George Karypis
Aleksandar Kavcic
Noriko Kawakami
Thomas E. Kazior
Angelos D. Keromytis
Sung J. Kim
Brian E.D. Kingsbury
Roberta L. Klatzky
Lang D. Klaus
Xenofon D. Koutsoukos
Michael R. Krames
D. Richard Kuhn
Ajay Kumar
Isaac Lagnado
Pablo Laguna Lasosa
Susan K. Land
Jungwon Lee
Riccardo Leonardi
Hui Li
Qun Li
Tao Li
Zhuo Li
Ben Liang
Jiao Li-cheng
Chia-Wen Lin
Wei Lin
Zhouchen Lin
Giuseppe Lipari
Chee Wee Liu
Jie Liu
Ming Liu
Shengyi Liu
Guo-Quan Lu
Jie Lu
Wei Lu
Yilong Lu
John W. Luginsland
Richard A. Lukaszewski
Xiaobing Luo
Shugen Ma
Zhenqiang Ma
Udaya K. Madawala
Guoqiang Mao
Vladimir Marik
Sonia Martinez
Saverio Mascolo
Andrea Massa
Sanu K. Mathew
Earl W. McCune
Paul M. Meaney
Deepankar Medhi

Russell D. Meier
Tommaso Melodia
Abraham Mendelson
Olgica Milenkovic
Jelena V. Misic
Andrea Montanari
Mehul Motani
Hideki Motoyama
Saibal Mukhopadhyay
Chandra M. Nair
Girish N. Nair
Hans Peter Nee
Silviu-Iulian Niculescu
Konstantina S. Nikita
Barbara A. Oakley
Hideo Ohno
Yew-Soon Ong
Hidetoshi Onodera
Javier Ortega-Garcia
Lawrence Ozarow
Hitay Ozbay
Philippe Paillet
Patrick Panciatici
Stefan Parkvall
Jignesh M. Patel
Constantinos S. Pattichis
Shanthi Pavan
George Pavlou
Joseph T. Pawlowski
Peter E. Perkins
Alexei N. Pilipetskii
Josien Pluim
Massimo Poncino
John R. Potter
Paras Prasad
Konstantinos Psounis
Hairong Qi
Jianmin Qu
Ronghai Qu
Tony Q.S. Quek
C.J. Reddy
Jennifer L. Rexford
Brian D. Rigling
Michael D. Riley
Kim Roberts
Justin K. Romberg
Luca Roselli
Tajana Simunic Rosing
Eugeniusz Rosolowski
Badrinath Roysam
Karen G. Rudie
Kazuhiro Saitou
Seiji Samukawa
Kevin J. Sangston
Venkateswara Anand Sankaran
Rahul Sarpeshkar
Ronan Sauleau
Hiroshi Sawada
Dieter Scherer
Alex W. Schneider
Clint Lee Schow
Bjoern W. Schuller
Assaf Schuster
Andrew W. Senior
Sanjit A. Seshia
Shihab A. Shamma
Dinggang Shen
Riichiro Shirota

Jiwu Shu
Hava Tova Siegelmann
Lowell S. Smith
Gregory L. Snider
Yan Solihin
Min Song
Miguel Ángel Sotelo Vázquez
Siddhartha S. Srinivasa
Salvatore J. Stolfo
Peter Stone
David G. Stork
Weifeng Su
Rahul Sukthankar
Hong-Bo Sun
Hongbin Sun
Shuji Tanaka
Mark Mohammad Tehranipoor
Juergen Teich
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Tao Xie
Hao Xin
Dong Xu
Jianbin Xu
Yang Yang
Anthony Yen
Dong Yu
Richard F. Yu
Habib Zaidi
Changshui Zhang
Lei Zhang
Yanyong Zhang
Zhensheng Zhang
Zhengming Zhao
Tong Zhou
Xiaofang Zhou
Peiying Zhu
Thomas Zwick

Nominate the Next Leaders of IEEE

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

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:

2020 IEEE president-elect (who will serve as president in 2021)

2019 IEEE corporate officers
- Vice president, Educational Activities
- Vice president, Publication Services and Products
- Secretary
- Treasurer

2019 IEEE committee chairs and members
- Awards Board
- Election Oversight
- Employee Benefits and Compensation
- Ethics and Member Conduct
- European Public Policy
- Fellow
- Global Public Policy
- Governance
- History
- Humanitarian Activities
- Industry Engagement
- New Initiatives
- Nominations and Appointments
- Public Visibility
- Tellers

DEADLINES TO NOMINATE
The deadlines are 15 March for corporate officers and committee chairs and 15 June for committee members.

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 need not contact their nominees before submitting the form. The N&A committee will contact all eligible nominees for required documentation 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, visit http://www.ieee.org/about/corporate/nominations/nominations_guidelines.html. To nominate a person for a position, visit 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 at the N&A committee website (http://www.ieee.org/about/corporate/nominations) before submitting a nomination.

The positions for which the N&A committee makes recommendations represent IEEE's uppermost governance levels. Volunteers with relevant prior experience in lower-level IEEE committees and units are recommended by the committee more often than volunteers without such experience. Candidates for the Awards Board, for example, have a greater likelihood of being recommended if they have already served on an awards committee of a society, section, or region or on another IEEE board.

Individuals nominated for president-elect and corporate officer positions are more likely to be recommended if they possess 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 standing 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 online nominations guidelines.

—Barry L. Shoop,
chair, 2018 IEEE Nominations
and Appointments committee

What + If = IEEE

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KNOWLEDGE   COMMUNITY   PROFESSIONAL DEVELOPMENT   CAREER ADVANCEMENT