ISSUE 2 2017 // VOLUME 113

THE BRIDGE

The Magazine of IEEE-Eta Kappa Nu

Rebooting Computing

From Ethics to Innovation: A Common Code

A Review of the Award-Winning Hidden Figures

The IEEE Rebooting Computing Initiative

IEEE-HKN AWARD PROGRAM

As the Honor Society of IEEE, IEEE-Eta Kappa Nu provides opportunities to promote and encourage outstanding students, educators and members.

Visit www.hkn.org/awards to view the awards programs, awards committees, list of past winners, nomination criteria and deadlines.

Alton B. Zerby and Carl T. Koerner Outstsanding Student Award (OSA)
Presented annually to a senior who has proven outstanding scholastic excellence and high moral character, and has demonstrated exemplary service to classmates, university, community, and country. (Deadline: 30 June)

C. Holmes MacDonald Outstanding Teaching Award (OTA)
Presented annually to electrical engineering professors who have demonstrated, early in their careers, special dedication and creativity in their teaching, as well as a balance between pressure for research and publications. (Deadline: Monday after 30 April)

Distinguished Service Award
Recognizes members who have devoted years of service and lifetime contributions to Eta Kappa Nu (or IEEE-HKN), resulting in significant benefits to all of the Society's members. (Deadline: Monday after 30 April)

Outstanding Chapter Award (OCA)
Recognizes chapters for excellence in activities and service at the department, university and community levels. The award is based on the content contained in their Annual Chapter Report for the preceding academic year. (Deadline: Monday after 30 September)

Outstanding Young Professional Award (OYP)
Presented annually to an exceptional young engineer who has demonstrated significant contributions early in their professional career. (Deadline: Monday after 30 April)

Vladimir Karapetoff Outstanding Technical Achievement Award
Recognizes individuals who have distinguished themselves through an invention, development, or discovery in the field of electrical or computer engineering. (Deadline: Monday after 30 April)

IEEE-Eta Kappa Nu

IEEE-Eta Kappa Nu (IEEE-HKN) was founded by Maurice L. Carr at the University of Illinois at Urbana-Champaign on 28 October 1904, to encourage excellence in education for the benefit of the public. IEEE-HKN fosters excellence by recognizing those students and professionals who have conferred honor upon engineering education through distinguished scholarship, activities, leadership, and exemplary character as students in electrical or computer engineering, or by their professional attainments. THE BRIDGE is the official publication of IEEE-HKN. Ideas and opinions expressed in THE BRIDGE are those of the individuals and do not necessarily represent the views of IEEE-HKN, the Board of Governors, or the magazine staff.

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THE BRIDGE

The Magazine of IEEE-Eta Kappa Nu

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Timothy P. Kurzweg

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Welcome to this year's second issue of THE BRIDGE,

As we continue through Spring, we have so many exciting things going on in IEEE-HKN. 2017 has already installed 5 new Chapters, including our first Chapters in Australia and Italy. We have just wrapped up a very successful Student Leadership Conference, hosted by the Beta Chapter at Purdue University. Thank you Betas for being such great hosts, organizers, and student leaders. I would expect nothing less from our IEEE-HKN members!

I had the pleasure of representing IEEE-HKN at the Electrical and Computer Engineering Department Heads Association (ECEDHA) 2017 Annual Conference. I had the opportunity to address all the ECE Department Head and Chair's, reminding them the excitement an IEEE-HKN Chapter brings to a Department, and asking them to support their University Chapter. We had engaging conversations with Chapters of all sizes - those Chapters that are thriving, those that need a little revitalization, and with some schools that would like to start a new Chapter. I left the meeting inspired, reconfirming my knowledge that HKN plays a large role in our ECE communities, and can (and will!) be a leader as ECE continues to evolve with new technology, pedagogy, and generation of students.

At ECEDHA, we recognized Dr. David Soldan with the IEEE-HKN Distinguished Service Award. Dr. Soldan has been a HKN champion for years, serving on the HKN Board of Governors, Faculty Advisor of Kansas States' Beta Kappa Chapter, and on numerous HKN committees. We thank David for all his support and help spreading the HKN word wherever he went. We also recognized Ms. Emily Hernandez with the 2016 IEEE-HKN Alton B. Zerby and Carl T. Koerner Outstanding Student Award. Emily recently graduated from Missouri University of Science &Technology where she was inducted into the IEEE-HKN Gamma Theta Chapter. She was a tremendous leader and volunteer at Missouri S&T, and is continuing her studies at Stanford University, where she is starting her Ph.D. It was a pleasure to meet Emily and her mom and dad at the event, and I know that Emily is headed for greatness in whatever she pursues.

We also celebrated 21 Outstanding IEEE-HKN Chapters from the past year with a special reception and awards ceremony at ECEDHA. Outstanding Chapter reports not only showcase their Chapter's activities in an individualized manner, they provided multiple views and instances of their work, which really brought their chapter's activities to life. Our HKN Chapters reported over 91,000 hours of community service last year, an average of 21 hours per student. This number is completely staggering and awesome. What impact our student and Chapters bring to their University and communities.

Your IEEE-HKN Board of Governors has been hard at work this year. We have been very strategically driven, finding our successes by determining what HKN can and should look like in 5, 10, and 20 years in the future. We continue our goals to be financially secure and to best serve our members, chapters, and communities around the world. We are always looking for more help and volunteers. If you are willing to help, please reach out to me. It does not have to be a long or large commitment, as there are opportunities to help and strengthen HKN even with shorter time availability.

Thank you for reading THE BRIDGE and supporting IEEE-HKN. We are off to a great start in 2017, and I know we have a very bright future this year and for many years to come.

Best wishes,
Tim

Timothy P. Kurzweg
2017 IEEE-HKN President

Steve E. Watkins
Gamma Theta Chapter
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Dear Eta Kappa Nu Members and Friends,

This issue of THE BRIDGE magazine has a theme of "Rebooting Computing." Our features discuss the work of the IEEE Rebooting Computing Initiative, the efforts to emphasize ethical issues related to artificial intelligence and autonomous systems, and the quantum alternative to classical computing technology. These papers show how computing capability and technology is changing. The IEEE Rebooting Computing Initiative and the IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems have links to ongoing developments for the former two topics.

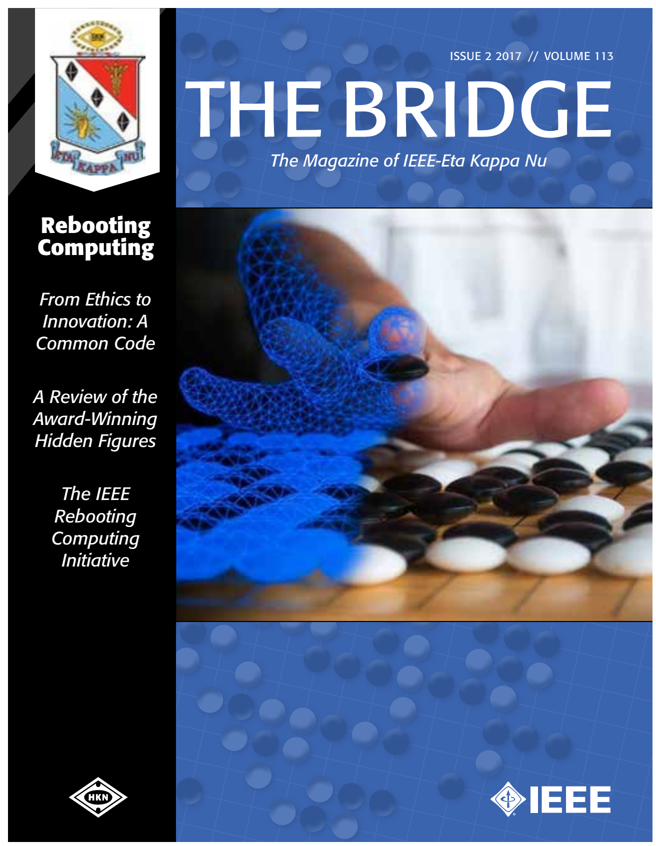
The feature papers contained within look forward to the future, while the cover spotlights and recognizes key events in the history of computing devices. The cover highlights the recent Go victory by the AlphaGo program over Ke Jie, the world No.1 ranked player in a three-game match, something that had previously been regarded as impossible for computer AI. The history spotlight describes the difference engine that was invented by Charles Babbage. (Note that Babbage is the pioneer inventor that we celebrate in our induction ritual as the father of computing.) His mechanical computer design implemented the essential elements of modern electronic computers.

If you want to learn more about the development of computers and the internet, I recommend *The Innovators* by Walter Isaacson. This book gives a fascinating look at the people behind the technology. Its subtitle is "How a group of hackers, geniuses, and geeks created the digital revolution." As the engineers and entrepreneurs for continuing innovations, I believe HKN members have much to learn from these pioneers.

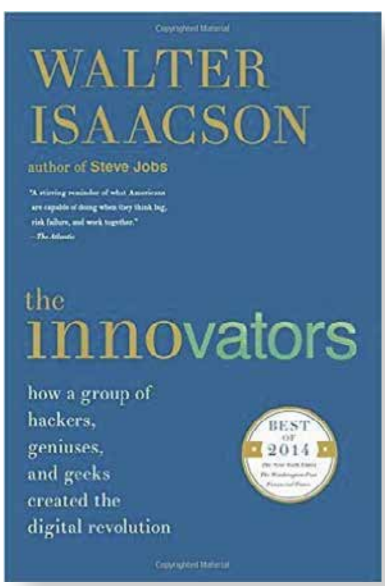
Regards,

Steve E. Watkins

2017 IEEE-HKN President-Elect



▲Our Cover: Go, another major hurdle in machine learning, what will the next decade hold?



◀*The Innovators* by Walter Isaacson

Nancy M. Ostin

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Dear HKN members and Friends:

This is my favorite time of the HKN year! Having just returned from our annual Student Leadership Conference (SLC) as well as presenting the Outstanding Chapter and Outstanding Student Awards at the Electrical and Computer Engineer Department Head (ECEDHA) meeting and our face to face meeting with the IEEE-HKN Board of Governors, there is so much excitement, energy, progress, and enthuasism for IEEE-HKN. Please join me in expressing appreciation to the Beta Chapter at Purdue University and to conference chair Nadra Guizani and members Stephen Larew, Kelsey Larson, and Dennis Ogbe. Great job and thank you for your hospitality and hard work on producing a successful SLC.

I hope you are enjoying our CHAPTER NEWS section. Chapters have been answering the call to share the programs and services they provide, such as: Beta Tau at Northeastern University "One on One Freshman Mentoring Program" which provides information on courses, professors, careers, and student success; and the award winning K-12 Outreach Program Nu Chapter at Iowa State University where they organize a wide variety of K-12 STEM outreach programs and activities at local elementary and middle schools; the Beta Delta Chapter for their "Hands on Science" event which mentored 19 high school students on building miniature traffic lights using integrated circuits on breadboards. and our Beta Nu Chapter at Georgia Tech in addition to their successful tutoring program coordinates all of the honor and service organizations in community service activities. Beyond the sheer number of hours dedicated to service by our Chapters, multiply those hours by the number of others impacted by their service.

There are many things to look forward to in the coming months:

- A new HKN.org. Look for the launch in September with new functionality and interactive processes
- Our Chapter Resource Ad-Hoc Committee is developing a suite of "best practice" and templates for your chapter to you in your recruiting and initiate process, chapter experience and activities, officer training and tools, and much more
- New optional rituals to promote the "passing of the gavel" training for new officers and recognition opportunities for graduating seniors and chapter leaders

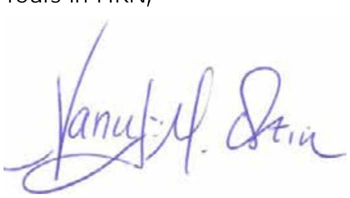
As the academic calendar 2016-2017 is coming to a close, a few reminders:

1. Submit your induction paperwork in a timely manner: *You are not officially HKN until form/payment is received by HQ*
2. Notify us of your election and all changes in officers or advisors
   The best legacy you can leave your chapter is to train and prepare the next group of officers
3. ORDER Graduation Regalia (honor cords and stoles):
4. Annual Chapter Reports are due JUNE 30th
   a key chapter requirement as well as your entry into the Outstanding Chapter Award
5. Nomination for the Outstanding Student Award: June 30th

Congratulations to all of our graduates – remember, Once HKN … always HKN

And to the alumni, stay in touch, you are a valuable asset to your chapter and to HKN, please help us support and advance opportunities for our students and future.

Yours in HKN,



Director, IEEE-HKN

Hello HKN! My name is Michael Benson and for those that I haven't met yet, I'm honored to serve as the IEEE-HKN student representative on the Board of Governors this year. It's hard to believe that we're nearly half way through 2017! The first half of this year has flown by and our chapters and alumni have accomplished a great deal in terms of activities on campus, community service, and inducting new members. Given this great start, I'm truly excited to see where we go together in the second half of the year. However, we need to continue to build momentum. The summer months are a phenomenal time to practice the skills learned in the classroom and to unwind after a fast-paced academic year. It is also a great time to reach out to alumni. For alumni and students alike, I implore you to reach out to one another and for alumni specifically, to re-engage with your chapter of induction. No matter how far removed you might be from your days as a student, you have experience and wisdom to share with our new members. I encourage you to contact our staff at info@hkn.org to get in touch with your chapter's current leadership team.

In addition to serving as a voting member of the IEEE-HKN Board of Governors, I have two specific charges that are unique to my position. First, I serve as the voice of the students and work to ensure that every decision that we make as a society keeps the student members at the forefront. And second, I work to keep our collegiate chapters informed of what the Board is doing and seek input and feedback. In addition to talking to several chapter leaders at our annual student leadership conference this past April, I've also hosted a series of meetings for chapter presidents. These meetings have focused on topics of import to individual chapters as well as the society and have included professional memberships, finances, recruitment, and more. In addition, I'm privileged to serve on several our society's committees including the ritual committee which I chair. A common thread that has emerged from talking to student members is that, as a society, we don't do a good job of transitioning our officers or in preparing our graduating students to remain engaged with HKN. That is going to change. The Ritual committee is working to develop new resources to help chapters effectively transition new members into leadership roles as well as an optional officer installation ceremony which can be used to add formality and purpose to a transition. Similarly, the committee is working on a way to properly recognize graduating students for their contributions to their chapter and its community. I look forward to sharing more on these exciting new developments as our work progresses.

Michael Benson

Beta Epsilon Chapter, University of Michigan

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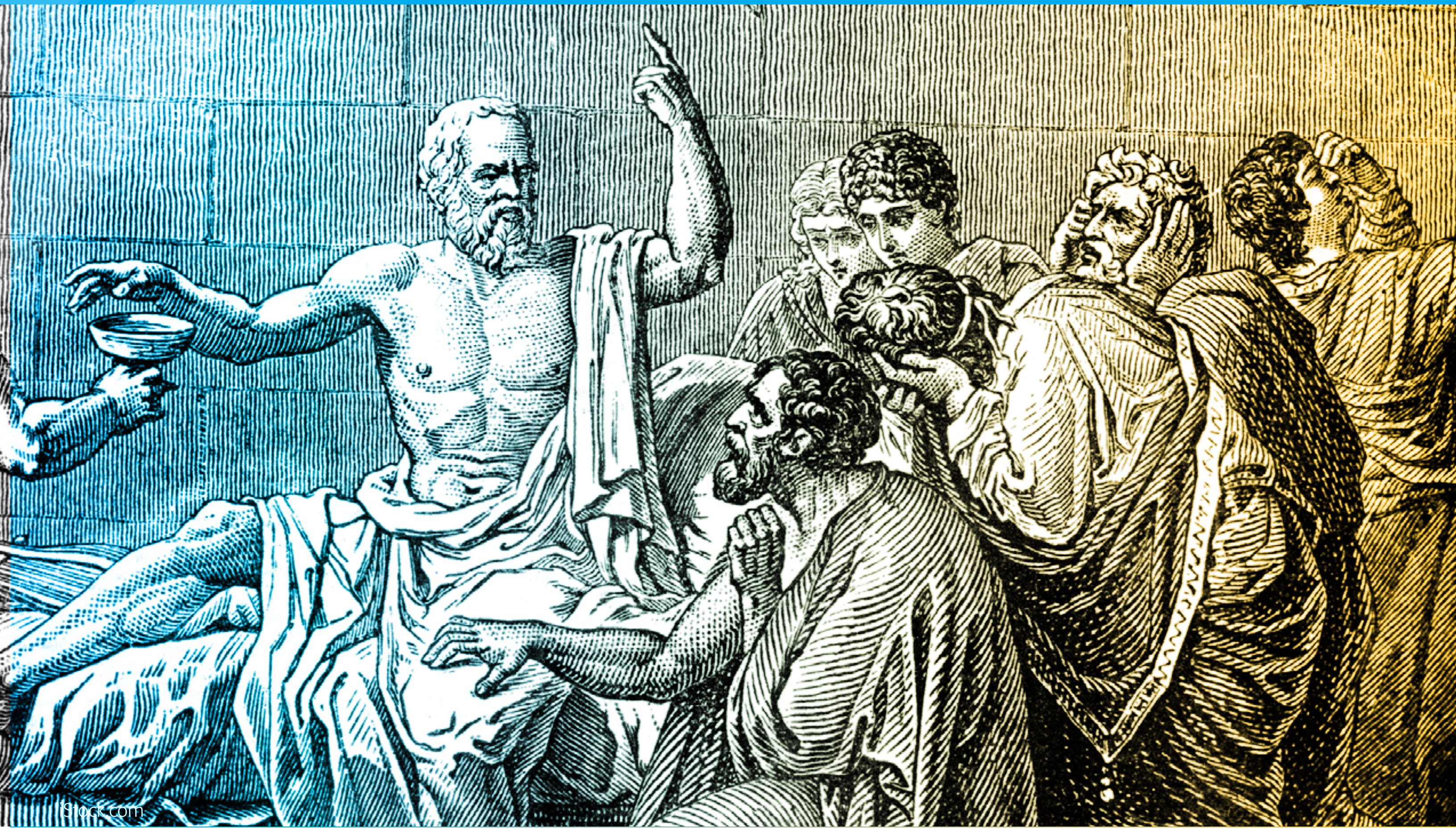
Finally, as an honor society, we hold three characteristics above all others: scholarship, character, and attitude. These are the cornerstones of our society and a set of common traits that every member shares. Individually, each attribute is important to being a well-rounded and successful professional. However, when taken together, these three attributes combine to set us apart. A strong character and positive attitude coupled with high scholastic achievement can mean only one thing: excellence. Be excellent and enjoy the warm weather!



From Ethics to Innovation: A Common Code

By John C. Havens

What does ethics mean to you?

While we all hold certain values close to our heart that drive our daily interactions and relationships, sometimes the word, "ethics" can feel somewhat distant. For some, it conjures visions of Greek philosophers from generations past who provided fascinating theories on how the world works that my now seem outdated or irrelevant. For others, ethics can be a stressful term with legal and compliance connotations involving potential Public Relations situations involving employee behavior.

But for engineers, Codes of Ethics have guided the safe and beneficial creation of technology for decades. Codes like these provide deep links to the valued traditions and culture created by engineers passionately caring for the societies they help to build. They also provide guidelines to help avoid unintended consequences based on the inevitable and unfortunate accidents that sometimes occur. These situations are often the ones at the top of engineer's minds as they design and manufacture the products and systems driving our lives today.

These types of issues have provided fundamental inspiration for key leaders within IEEE to become engineers, like Gordon Day, 2012 President and CEO of IEEE and longtime Eta Kappa Nu who stated the following in an interview for this article:

> Wise engineering educators have long emphasized the consequences of errors and unforeseen characteristics in engineering designs. For me, it started on my first day as an undergraduate when I was required to watch a movie of the 1940 Takoma Narrows bridge failure. Today, an Internet search on "engineering failure" will provide a long and humbling list of examples. With these failures in mind, it is clear why the codes of ethics of many engineering professional societies call on engineers to "hold paramount the health, safety, and welfare of the public."

The responsibility and challenge of adhering to these codes must now embrace the rapidly expanding influence of Artificial Intelligence and Autonomous Systems (AI/AS) within society today. When machines can exhibit what may appear as morally based decisions to its users, the application of ethical methodologies to the design of technology before it's released becomes of paramount importance. As Gordon day states, "How do we gain the benefits of artificial intelligence while maintaining and respecting the nuances of moral and ethical principles? Foundational questions such as these stretch our codes of ethics, and should lead us to examine the relationships between people and machines more deeply."

Ethically Aligned Design

In April of 2016, The IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems was launched with a mandate to provide a document that could provide technologists with a pragmatic guide to deal with the pressing ethical considerations of AI/AS. While it is not a Professional Code of Ethics, The IEEE Global Initiative has created the first version of a document called, *EthicallyAligned Design* featuring over eighty specific Issues and Recommendations written by more than one hundred global thought leaders in AI/AS, ethics, policy, academia and business. The purpose of The IEEE Global Initiative is to ensure every technologist is educated, trained, and empowered to prioritize ethical considerations in the design and development of autonomous and intelligent systems. *Ethically Aligned Design* was created as a complement to traditional Codes of Ethics to aid and empower engineers not familiar with these technologies to increase innovation while diminishing negative consequences in their work.

As many technologies have been transformative in the past, some may feel new codes or considerations may not be necessary for AI/AS. Many others, however, feel the nature of how these technologies affect human agency, autonomy and intelligence by design justify a deeper rigor regarding ethical considerations. Konstantions Karachalios, Managing Director of the IEEE Standards Association and Member of the IEEE Management Council noted the following in our interview:

> I would compare other technologies from the past with the *DNA* of modern technology landscapes, whereas computing and algorithms (AI/AS) are becoming their *RNA*. AI/AS technologies will be the messengers of information, transferring it to the right recipient, interpreting and suggesting courses of action regarding human choice. It is difficult to imagine any field of human activity that may escape such 'benevolent artificial assistants', while still, as with RNA, we may not be in a position to fully grasp how AI/AS exactly functions at all times.
>
> More generally, I see here a risk of loss of human agency in favor of non-human entities who 'know better than we know what is best for us'. One can easily imagine algorithmic systems deciding about credit worthiness or admission to universities with minimal human intervention (if at all). There are also other major challenges, like explicit or implicit bias in algorithmic design, transparency problems with self-learning systems, politically troublesome asymmetries in agency, use and control of the data oceans generated, and so on.

When asked how he feels these challenges should be addressed, Karachalios went on to say the following:

> Nothing less than a new wave of enlightenment, targeted at the implicit beliefs around this technology, will be necessary to mitigate the risks and materialize the benefits for humanity. For IEEE it is not a matter of ambition, it is a sense of duty that is driving us.
>
> To accomplish this duty, IEEE must grow beyond its traditional engineering tradition and make a serious effort to address the not functional challenges of AI technology, simply because there is no other actor that could

Konsantinos Karachalios opening The IEEE Global Initiative international meeting at The Hague

initiate a strong wave of enlightenment at a global level. IEEE is the ideal platform to bring together global and local communities toward a concerted action. At the same time, we – our vast scientific and engineering communities – are also the main target of such an action. Basically, it is about educating ourselves, and learning to anticipate and take into account the most critical parameters when designing algorithmic systems with ethical or social implications.

The Ethical Standards for the Algorithmic Future

Along with creating and evolving *Ethically Aligned Design*, members of The IEEE Global Initiative are encouraged to recommend Standardization Projects to IEEE-SA based on their work. Currently, there are a series of Standards in the IEEE P7000™ series as listed below:

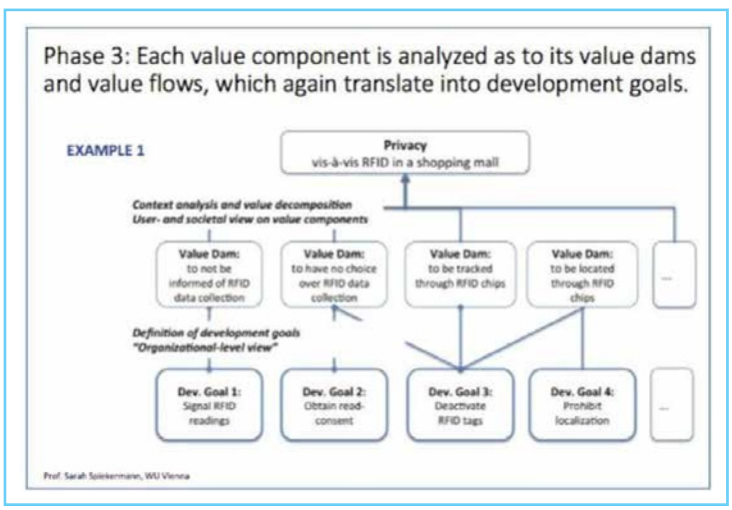
- **IEEE P7000:** Model Process for Addressing Ethical Concerns During System Design
- **IEEE P7001:** Transparency of Autonomous Systems
- **IEEE P7002:** Data Privacy Process
- **IEEE P7003: Algorithmic Bias Considerations** *(Working Group to be announced soon)*

As a pragmatic way of complementing existing Codes of Ethics, The IEEE Global Initiative believes that prioritizing applied ethical considerations at the front end of any systems or product development process will redefine innovation for the algorithmic era to encourage excellence and integrity in all of the technology we design for a positive and healthy human future. This means that along with a Code of Ethics providing direction for member behavior, technologists in the algorithmic era need to utilize methodologies that provide more rigorous due diligence regarding the values of stakeholders and end users than they may be using today. Examples of these methodologies along these lines include Value Sensitive Design and Responsible Research and Innovation (RRI). As the RRI Tools website notes, this means, "**Involving society in science and innovation** 'very upstream' in the processes of R&I to align its outcomes with the values of society."

By creating the IEEE P7000™ series of Standards based on *Ethically Aligned Design*, the goal of The IEEE global Initiative is to institutionalize the rigors of this "upstream analysis" to further aid the scientists and engineers involved in the creation of the intelligent, autonomous, and other emerging technologies driving our human future.

To provide an example of how this type of ethically oriented work can function, below is a diagram created by Professor D. Sarah Spiekermann, who chairs the Institute for Management Information Systems at Vienna University of Economics and Business (WU Vienna). She is author of the book "Ethical IT Innovation: A Value-based System Design Approach" which features a vast repository of research demonstrating the business value of prioritizing ethics at the front end of design.

While it may seem difficult to create an ethical focus for The System Development Lifecycle of an organization, it is possible to thoroughly evaluate values like privacy (as show above). By considering how an end user or stakeholder identifies with a certain value, and by



From Ethical IT Innovation by Sarah Spiekemann (used by permission)

Konstantinos Karachalios and Sarah Spiekermann in Vienna

recognizing where "value dams" would keep them from achieving values important to their lives, engineers can proactively and preemptively build AI/AS tools that align with people's ethical and deeply held beliefs. As Spiekermann noted in our interview: "P7000 will redefine innovation because it will help companies to focus on values throughout the entire system development life cycle. By doing so, companies can create more value for customers and avoid value breaches."

Innovation and IEEE

Now that we've arrived in an intelligence and algorithmic era, we can take comfort in the fact that along with strong Codes of Ethics providing a bedrock of tenets to drive conduct for engineers and technologists, by prioritizing ethical considerations at the beginning of our work we can avoid unintended consequences of AI/AS while also maximizing its positive benefits for society. In terms of the motivation for this change, Karachalios had the following to say as a reframing of innovation for IEEE's efforts for the future:

> For IEEE it is not a matter of ambition, it is a sense of duty that is driving us. To accomplish this duty, IEEE must grow beyond its traditional engineering tradition and make a serious effort to address the non functional challenges of AI technology, simply because there is no other actor that could initiate a strong wave of "enlightenment" at a global level. IEEE is the ideal platform to bring together global and local communities toward a concerted action.
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> At the same time, we – our vast scientific and engineering communities – are also the main target of such an action. Basically, it is about educating ourselves, and learning to anticipate and take into account the most critical parameters when designing algorithmic systems with ethical or social implications.

Author Biography

John C. Havens is Executive Director of *The IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems.* The Initiative created a document called, *Ethically Aligned Design* to provide recommendations for values-driven Artificial Intelligence and Autonomous Systems as well as standards recommendations. Guided by over one hundred thought leaders, The Initiative has a mission of ensuring every technologist is educated, trained, and empowered to prioritize ethical considerations in the design and development of autonomous and intelligent systems.

John is also a regular contributor on issues of technology and wellbeing to Mashable, The Guardian, HuffPo and TechCrunch and is author of *Heartificial Intelligence: Embracing Our Humanity To Maximize Machines* and *Hacking Happiness: Why Your Personal Data Counts and How Tracking it Can Change the World*.

John was an EVP of a Top Ten PR Firm, a VP of a tech startup, and an independent consultant where he has worked with clients such as Gillette, P&G, HP, Wal-Mart, Ford, Allstate, Monster, Gallo Wines, and Merck. He was also the founder of The Happathon Project, a non-profit utilizing emerging technology and positive psychology to increase human wellbeing.

John has spoken at TEDx, at SXSW Interactive (six times), and as a global keynote speaker for clients like Cisco, Gillette, IEEE, and NXP Semiconductors. John was also a professional actor on broadway, TV and film for fifteen years.

For more information, visit John's site or follow him @johnchavens.

Photo: IMDB

A Review of the Award-Winning Hidden Figures

Racial segregation inside NASA during the 1960s didn't hold back the aspirations of three female African-American mathematicians

By MONICA ROZENFELD

Katherine Johnson (center), played by actress Taraji P. Henson, worked at NASA as a mathematician, helping NASA launch its first successful manned mission around the Earth.

As the associate editor of The Institute, I couldn't miss out on seeing the film Hidden Figures, a based-on-a-true-story movie about three female African-American mathematicians who helped launch NASA's first successful manned mission around the Earth.

Known as Friendship 7, the mission took place on 20 February 1962, with astronaut John Glenn in the Mercury capsule becoming the first American to orbit Earth. While that's the background against which the movie is set, the untold story is about the women who helped make the voyage possible—and the discrimination they experienced while working at the space administration's facility in Langley, Md.

The Friendship 7 mission took place during a time when racism was still deeply seated in the United States, when bathrooms, water fountains, and classrooms were segregated. Early in the film, the main characters, called computers—a title NASA gave to employees calculating intricate math problems—were shown working in a separate room for "colored computers." As the women, who all have mathematics degrees, move up the ranks, their colleagues' innate racism seems to grow stronger.

The film centers around Katherine Johnson (played by actress Taraji P. Henson), a child math prodigy and the only NASA employee who was well-versed in analytical geometry at the time. The other two women are Dorothy Vaughan (Octavia Spencer) and Mary Jackson (Janelle Monáe).

DISCRIMINATION AT THE AGENGY

Johnson proved herself time and again. For example, she came up with the "go–no go" mathematical formula, also known as a launch status check, to ensure the Mercury's travel trajectories were safe. Glenn orbited the Earth three times—a trip that lasted a little less than five hours—before his spacecraft landed safely in the ocean near the Bahamas.

Johnson received little to no publicity at the time, but in 2015 she received the Presidential Medal of Freedom, the highest civilian award of the United States, for calculating and verifying trajectories that took the first Americans to space and to the moon.

While working on the Friendship 7 launch, she was shunned by her white male coworkers. She was not allowed to drink coffee out of the same carafe as them; instead, they designated a pot with a sticker that said colored. The only ladies room designated for African-Americans was a 40-minute round trip from her workplace.

Her friends Vaughan and Jackson also experienced racism.

Vaughan supervised the group of 20 black women who worked as computers. Despite her skills and hard work, NASA did not promote her. Vaughan, who also knew how to fix cars, decided to teach herself the early computer language Fortran from a programming book that she stole from a local library's whites-only section. Armed with her knowledge of Fortran and mechanical skills, she helped NASA's engineers program its first IBM data processing machine.

Jackson was encouraged by a NASA mission specialist—based on her real-life colleague Kazimierz Czarnecki—to become an engineer. She called the idea ludicrous. "I am a Negro woman. I am not going to consider the impossible," she said. But the idea stayed with her.

When she looked into courses required to become a NASA engineer, she discovered they were being offered only at an all-white high school. At the time, African-Americans were not permitted to attend that school, but Johnson filed a lawsuit and persuaded a judge to let her attend. He did, but only the night courses.

All three women went on to become NASA pioneers: the first African-American woman to help launch a man into space, the first female African-American supervisor, and the first female African-American engineer.

LESSONS LEARNED

Despite the women's incredible accomplishments, how many of us knew their stories until Hidden Figures? I admit that I didn't.

When, in the movie, a police officer and even a love interest (who later becomes Johnson's husband) are shocked to learn African-American women worked as mathematicians at NASA, I realized that stereotypes of female engineers and technologists still exist today. I wonder how much has really changed for women and underrepresented groups in tech.

The Institute has published several articles about the difficulty the engineering field has in recruiting a more diverse group of candidates. I believe teaching students about the unsung heroes in Hidden Figures would be an important part of that process. It's imperative that those who teach or volunteer their time with STEM (science, technology, engineering, and math) education programs show the film to students to encourage them that they, too, can do seemingly impossible things.

The three women spotlighted in the movie achieved what they did at NASA not because of their circumstances—opportunities were not handed to them—but because of their merit. And that's the message we should be teaching students today, which is that perseverance and knowledge can get them far and they should not give up because they believe a career in engineering is not for them.

Dorothy Schnabel: A Pioneer of Women in Engineering

Dorothy L. Schnabel

In 1953 when I became a member of the Beta Pi Chapter of HKN at the City College of New York, digital computers were just beginning to be developed. At City, I learned how to design binary and/or circuits using vacuum tubes. At IBM in the summer of 1955, I wrote programs to be used by an assembly program. Each program step was put on one punched card and coded in only “0” and “1” bits. Vacuum tubes were used for the logic in this computer for national defense.

In the late 1950s, as an IBM employee, I designed logic for a computer, using transistors, for the purpose of code cracking. In the 1960’s, I participated in exploring different computer designs to support the new System/360 architecture, wrote microprograms to execute decimal and floating point instructions, and evaluated the performance of designing computers.

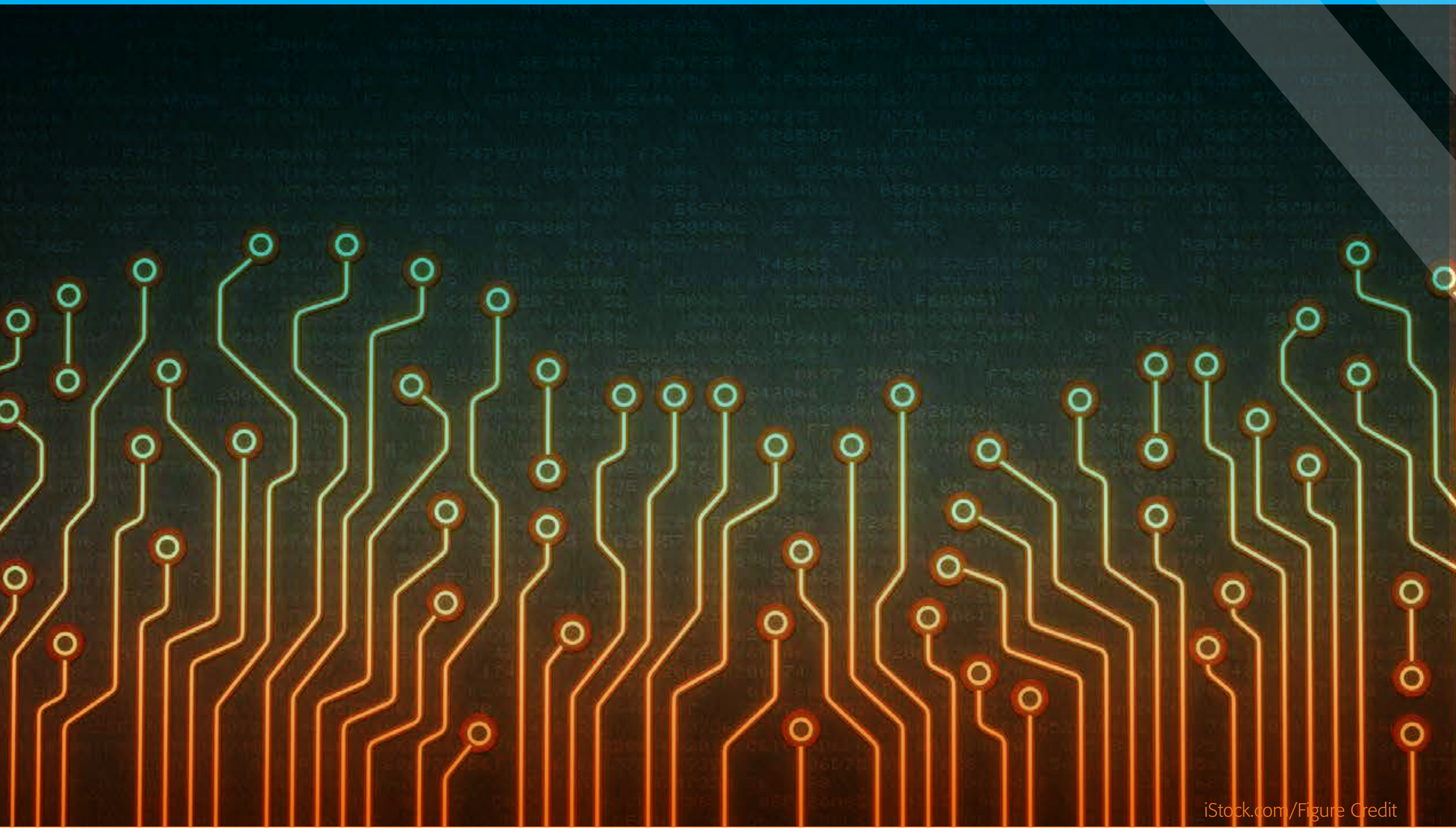
For most of the remaining 30 years at IBM, I held various positions supporting the development of high performance, large mainframe computers as an engineer and manager. It was an exciting and challenging journey.

Dorothy Schnabel
of the Class of 1954 of City College of the College of the City of N.Y.
has this day been admitted into Membership in
Eta Kappa Nu Association
in recognition of his excellent scholarship and other attainments by which he has manifested interest and ability in the Profession of Electrical Engineering.
Done by Beta Pi Chapter at New York, N.Y.
this 25th day of April, 1953

National President

President of Chapter

Secretary of Chapter



The IEEE Rebooting Computing Initiative

By Elie Track and Alan Kadin

Abstract

For over 50 years, Moore's Law scaling of smaller and denser transistors has led to exponential advances in electronics and computer technology. The end of Moore's Law is not the end of the road for improved computing, but rather a new beginning with opportunities for novel alternative approaches. IEEE has created an inter-society initiative, "Rebooting Computing," to promote rethinking the entire computing enterprise, from devices through circuits, architectures, systems, and software. Several examples of novel approaches being considered include energy-efficient computing, neuromorphic computing, and superconducting computing.

I. Introduction – Moore's Law and Computing

Electronic computers and transistors both had their origins around 70 years ago, but starting about 50 years ago, with the silicon integrated circuit (the "chip"), these two technologies really took off together. This was quantified by Gordon Moore of Intel, who projected in 1965 that the number of transistors integrated on a chip would double every two years [1]. This exponential improvement has been maintained or exceeded for 50 years, a remarkable period of growth unmatched in any other technology. While the scale of transistors is still shrinking, this is reaching its practical limit. As the atomic limit is being approached, chip manufacturing is becoming more difficult and expensive.

The core of a digital computer is the central processing unit or CPU. A CPU generally has a master clock that synchronizes operations of different portions of the circuit, with a clock frequency or clock speed, where one clock cycle corresponds to a single logical operation or switching event. For circuit reliability, the maximum clock speed is typically somewhat less than the reciprocal of the characteristic switching time for the devices. For example, if the switching time is 100 ps, the clock speed might be about 1 GHz.

Starting around 1970, a simple CPU was integrated on a single chip, known as a microprocessor. The resulting microcomputer provided the basis for the personal computer revolution, which in turn led to the internet. Smaller transistors permit more complex circuits on a chip, but also switch much faster, enabling computers to run much faster. So Moore's Law also led to scaling of computer speeds. Figure 1 shows the trends in clock speed of state-of-the-art microprocessors [2] starting around 1985, on a log-plot of clock speed and a linear plot of years. This corresponds to exponential increase in speed until around 2005, when speed saturated at a few GHz. Computer performance continued to increase through the use of multi-core chips, with two or more CPUs on a single chip. This enabled further increases in speed, at least for problems that are amenable to parallel computation. However, this approach is not very scalable, since the power is excessive, and portions of the chip must be turned off much of the time to avoid overheating. (This is known as the "dark silicon" problem.) For continued improvement in the future, entirely new approaches are needed.

II. IEEE Rebooting Computing Initiative and Roadmapping the Future

Changing the direction of the entire computer industry is a major undertaking, particularly when the new

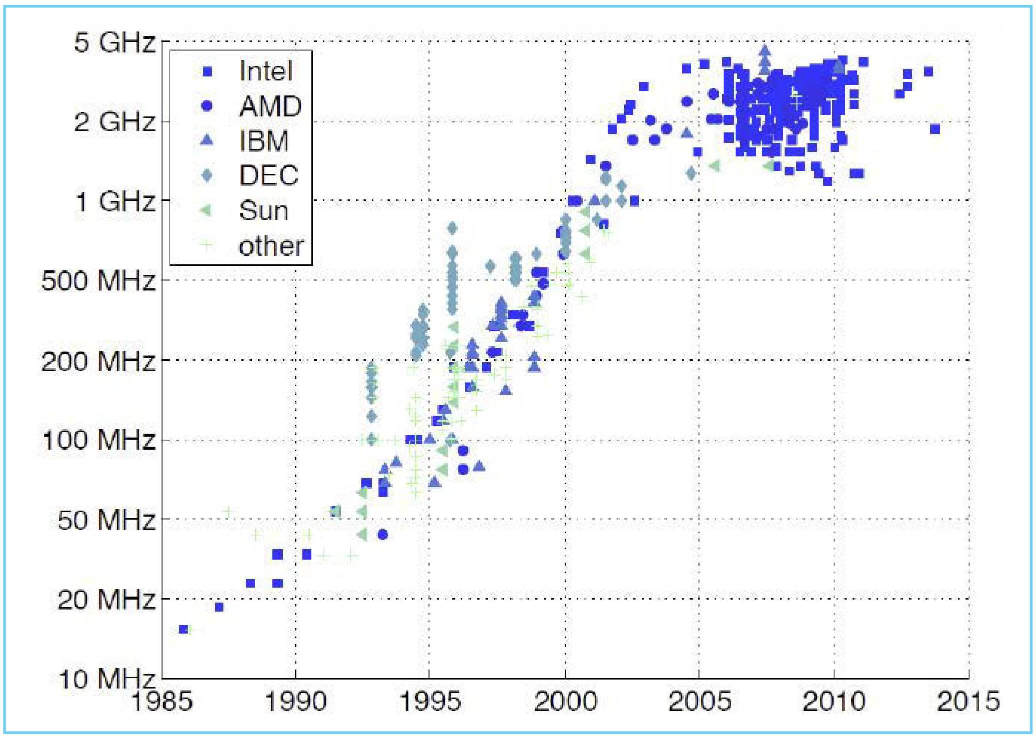


Fig. 1. Trends in clock speeds of microprocessors from 1985 to present, showing saturation of clock speeds at a few GHz after about 2005. Data from Stanford University VLSI Research Group.

directions are not clear. Furthermore, this requires a review of the entire computing stack, including both hardware and software, from the nanoscale transistors to the megascale supercomputers. Rather than embedding such a project within a single company or a single government program, this requires input from leaders in a wide range of specialties, across industry, academia, and government. Only the IEEE has the full range of expertise to address this, through IEEE Future Directions, which has created ten new inter-society initiatives to address major trends in future technology. One of these is the IEEE Rebooting Computing Initiative (RCI), which now has 10 participating IEEE societies and councils as well as the IEEE Standards Association (see Fig. 2). RCI was co-founded and originally co-chaired by Tom Conte, former president of IEEE Computer Society, and Elie Track, former president of IEEE Council on Superconductivity. The logo of RCI is an exploding infinity (see Fig. 3a), suggesting the lack of future limits. An overview video on RCI is available online, as well as an introductory video from the presentation on this topic made to the 2016 HKN Student Leadership Conference.

While we cannot predict the future, we can create a roadmap to guide the development of future computing. A key part of the RCI effort is the International Roadmap for Devices and Systems (IRDS), a new organization of volunteers from industry, academia, and governments, which operates under the IEEE Standards Association, as part of the Industry Connections Program (see logo in Fig. 3b). The IRDS follows in the tradition of the earlier International Technology Roadmap for Semiconductors (ITRS), which guided the semiconductor industry through the Moore's Law era. IRDS is somewhat broader than ITRS, and includes systems, applications, and alternative technologies, as well as the traditional focus on transistor scaling.

RCI has been sponsoring workshops and conferences for several years. The videos from the 2016 inaugural IEEE International Conference on Rebooting Computing (ICRC) last fall in San Diego are available from IEEE.tv. In November 2017, RCI is sponsoring "Rebooting Computing Week" in Washington DC, consisting of an IRDS Workshop, ICRC-2017, and a new Industry Summit on Future Computing.

There have been several feature magazine issues related to Rebooting Computing. These include the December 2015 issue of Computer Magazine [3] (also available

Fig. 2. 10 constituent IEEE Societies and the IEEE Standards Association in the Rebooting Computing Initiative.

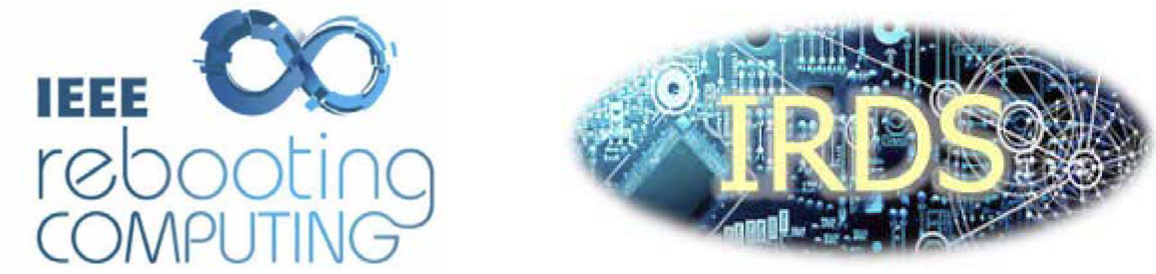


Fig. 3. Logos of IEEE Rebooting Computing Initiative and IEEE International Roadmap for Devices and Systems (IRDS)

for free online reading), and the March 2017 issue of Computing in Science and Engineering [4]. RCI also has an active presence on the web and social media, and particularly encourages student participation. For example, the IEEE Rebooting Computing Community is free to join, and consists of more than 2000 members who receive monthly emails and newsletters. RCI is also the sponsor of the Low-Power Image Recognition Challenge (LPIRC), an annual student-oriented competition that focuses on optimizing both accuracy in image recognition and low power consumption in the same system. For 2017, LPIRC will be held in Hawaii in July, and participants are now being solicited.

While the technologies being pursued under RCI are diverse, a set of common themes were identified in the first RCI Summit in 2013, and are summarized graphically as the "Three Pillars of Rebooting Computing" in Fig. 4. These pillars, which connect the devices at the lowest level (the "engine room") to the algorithms and architectures at the top levels, consist of security, energy efficiency, and applications (including human-computer interfaces). Historically, it was sufficient to have a universal micro-processor, with these key issues addressed afterward, but future computer technologies will need to integrate these in at all levels, to generate several alternative types of systems optimized for different applications. The remainder of the article will focus on the pillar of energy efficiency, and show how this may be addressed using the different approaches of superconducting technology and neuromorphic architectures.

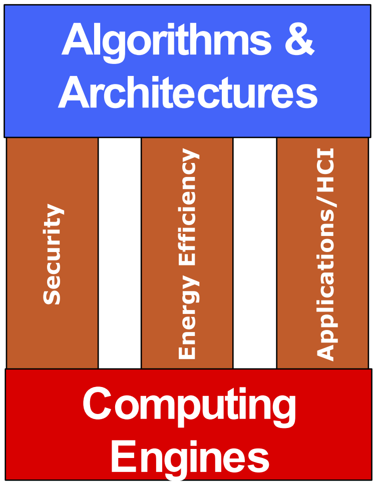


Fig. 4. The three pillars of Rebooting Computing, from the first Rebooting Computing Summit in 2013.

III. Energy-Efficient Computing

There are two distinct classes of computers: small mobile computers, and large-scale computing centers. Mobile computers include smartphones, but also components of the Internet of Things. The need for reduced power in mobile computers is obvious; they run on batteries, and the need for frequent recharging is a major concern. Large-scale computing centers include internet servers, centers for cloud computing, and supercomputers. These are plugged into the electric grid, so the need for low power is less obvious. But energy efficiency is critical for these as well, because these computers generate an enormous amount of heat, and the electrical power includes not only the direct operating power, but also the power to run the air conditioning systems to keep these systems from overheating. In some cases, large data centers that require 100 MW have been placed in cold climates, specifically to minimize the cooling power. Taken collectively, information technology consumes more than 10% of all electrical power, and this is likely to increase further.

Consider recent trends in the performance and power of supercomputers, as shown in Fig 5. A supercomputer is designed to carry out massively parallel simulations, and its performance is measured in terms of floating-point operations per second (FLOPS). State-of-the-art supercomputers may have performance approaching 100 petaFLOPS, or 10^{17} FLOPS. Such a system typically consists of a large number of identical processors operating in parallel. For example, one might have 20 million floating-point processors, each running at a speed of 5 GHz. If the power for each processor if 10 W, the total power dissipated (if they are all operating at the same time) is 200 MW! Supercomputers also have a huge footprint, as shown in Fig. 6. Superconducting computers, discussed below, may provide an alternative.

Such large-scale computing systems are rapidly approaching technical (Size, Weight, and Power, or SWaP) and economic limits, and will not be scalable beyond, or even to achieve, the next milestone, 1 exaFLOPS, where "exa" is the metric prefix for 10^{18}. Systems of this magnitude are typically called "Exascale Computing." Development of exascale computers in the next decade is a monumental effort that must be planned at the national level. China, United States, Japan, and Europe are major players in this area. The US program is being pursued as part of the National Strategic Computing Initiative (NSCI), which was announced by the White House last year.

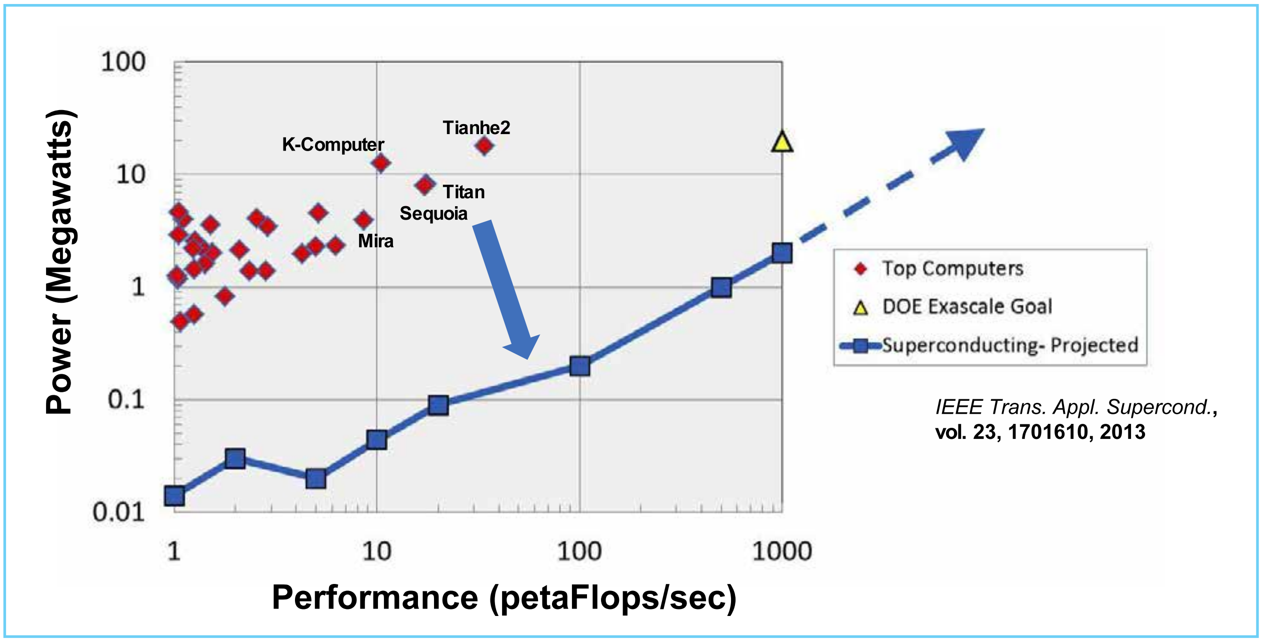


Fig. 5. Power consumption of supercomputers vs. computing performance, compared to projected performance of planned superconducting computers (bottom). The power estimates for superconductors includes the required refrigeration power, which is dominant. Adapted from ref. [7]

The NSCI is also driving research into alternative next-generation approaches that may eventually enable performance which exceeds 1 exaFLOPS. Two such approaches are superconducting computing and neuromorphic computing, which are discussed further below. But there are many other approaches being considered, focusing on devices, architectures, algorithms, and systems.

At the device level, a CMOS transistor is orders of magnitude more power-hungry than the theoretical minimum, which is kT ln(2) = 3 x 10^{-21} Joules per switching event. One could operate transistors at a reduced voltage, sometimes called "near-threshold computing", but this increases the likelihood of random bit errors, which are forbidden in traditional computing paradigms. If one can devise architectures and systems that can accommodate such errors, then lower-power operation may become feasible. This area of research is referred to as "Approximate Computing." Alternatively, one could develop a new lower-power transistor device. Tunneling field effect transistors (TFETs) and various spintronic devices (based on the spin or magnetism of an electron) may be candidates for such devices [5].

Another approach is to move from the classic universal von Neumann computer processor to specialized processors for different kinds of applications. For example, a GPU or graphical processing unit was initially developed for faster processing of computer graphics, but these and similar chips are now being applied to

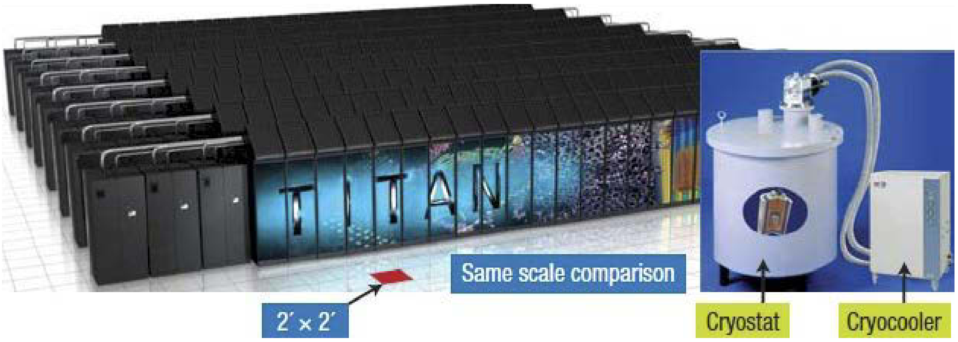


Fig. 6. Conceptual representation of actual conventional supercomputer vs. alternative planned superconducting computer with a similar computing power. From ref. [6], courtesy of IARPA.

a wider variety of computing applications, where they can be much more energy efficient. In the most recent LPIRC, the winning competitors used commercial GPUs for image recognition with both high speed and low power. New neuromorphic processors may be particularly efficient for pattern recognition applications, as discussed below.

IV. Superconducting Computing

Superconductors are metals that have the ability to carry very large currents without resistance, but only at cryogenic temperatures. While some superconductors can operate at temperatures up to about 100 K (=– 173 °C), most practical superconductors for digital electronic applications operate at temperatures less than 10 K. Niobium (Nb) is the “silicon of the superconducting world” and dominates electronic applications; Nb circuits typically operate at about 4 K. While such temperatures are impractical for mobile computing, they are quite feasible for large-scale applications to supercomputers and data centers. Cryogenic refrigerators (sometimes called cryocoolers) are reliable and commercially available. The majority of power for operating a superconducting computer is actually refrigeration power, so that proper packaging and input/output are critical.

The basic element in a superconducting circuit is known as a Josephson junction, and it represents two superconducting layers with an insulator between them of thickness on the order of a nanometer (nm). A superconducting loop with a Josephson junction can support a lossless circulating current, and acts as an ideal storage element for magnetic flux. But due to the quantum nature of the superconducting state, the value of magnetic flux in the loop must be an integer multiple of a fundamental quantity called the flux quantum $\Phi_0 = h/2e = 2 \times 10^{-15}$ Wb. A Josephson junction acts as a switch for magnetic flux, transferring a single flux quantum at a time, and generating a voltage pulse with time-integrated value $\int Vdt = \Phi_0 = 2$ mV-ps. As shown in Fig. 7, this pulse is typically about 1 mV high and 2 ps wide.

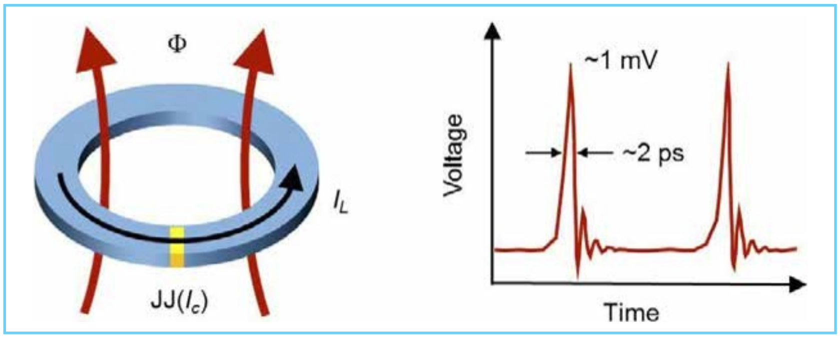


Fig. 7. Superconducting storage loop and single-flux-quantum voltage pulse. From ref. [6].

The SFQ pulse is the basis for modern superconducting logic circuits [6], which are both very fast and very low power. Clock speeds up to 100 GHz should be feasible, and the switching energy is ~ 10^{-18} J/bit, orders of magnitude smaller than that for CMOS transistors. The higher speed is responsible for the smaller footprint in Fig. 6, since fewer parallel processors would be necessary for the same performance. This also contributes to the sharply reduced power requirements. However, we should note that the superconducting results in Fig. 5 are projected; no full-scale superconducting processor has yet been demonstrated.

FIt is important to appreciate that a single-flux-quantum circuit is NOT the same as a quantum computer, which has recently been getting much attention in the news. The superconducting computer of Fig. 6 is based on classical bits and logic. However, there are also major research and development projects (and even one commercial system) on quantum computing based on Josephson junctions and superconducting circuits similar to that in Fig. 7. Unlike a classical bit in Fig. 7, which might correspond to current circulating either clockwise or counterclockwise, in a quantum bit (“qubit”) one might have a superposition of circulating currents in both directions at the same time! See ref. [6] for more information.

V. Neuromorphic Computing

FSince the earliest computers with vacuum tubes in the 1940s, computer hardware has been based on the von Neumann architecture of a digital logic unit linked to memory and a control program, as shown in Fig. 8 on the left. Modern computers are much more complicated, but still have the same basic structure. People have long spoken of computers as electronic brains, but they are really quite different. Brains have dramatically different structures from von Neumann computers, as well as dramatically different capabilities. The right-hand diagram in Fig. 8 illustrates one type of structure known as a neural network (or neural net), which represents a simplified version of the interconnections in

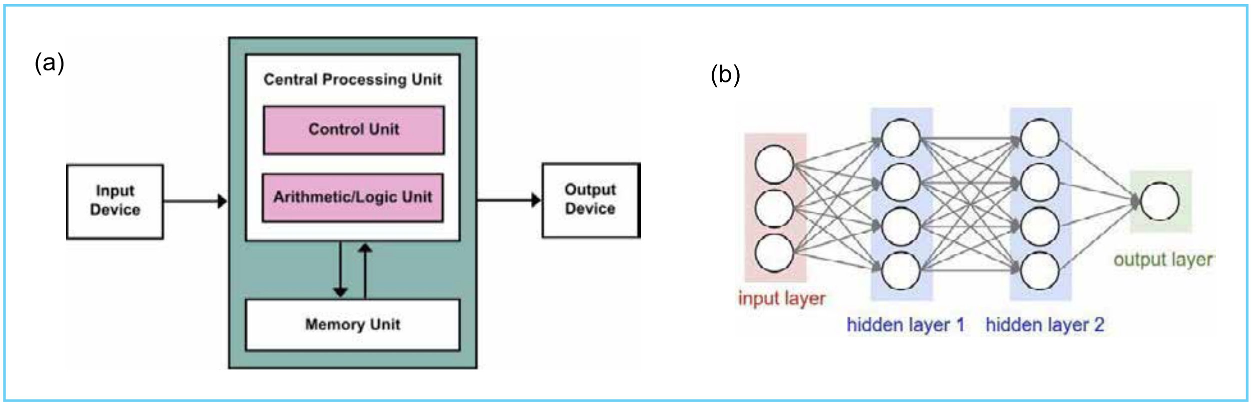


Fig. 8. (a) Orthodox von Neumann computer architecture vs. (b) neural net. From Wikipedia.

a network of biological neurons. The circles represent neurons, and the arrows represent the synapses interconnecting the neurons. A neural network is particularly good at matching patterns, based on a set of training data. This strengthens certain synapses and weakens others, creating a network that can learn by example, without having to be specifically programmed. This is an example of a neuromorphic or "brain-inspired" computer architecture.

The neural net is not remotely similar to the von Neumann architecture. Where are the logic, program control, and memory? Both the logic and memory are distributed among the synapses. While the von Neumann architecture is a universal computer that can simulate any other computer, even including a neural network, such a simulation is not guaranteed to be either fast or energy-efficient. Recent developments in artificial intelligence, such as IBM Watson, have simulated neural nets with many "hidden layers" of neurons between the input and output, and have demonstrated "deep learning" using supercomputers. This "cognitive computing" has shown impressive results, but maybe there is a better way to implement it.

Biological neurons are slow, noisy, and unreliable. The characteristic switching time is of order ms, over a million times slower than modern transistors. The power consumption of the human brain is of order 10 W, which is a million times less than that of a supercomputer. Despite this, the human brain can be much faster than a supercomputer at certain tasks related to matching and recognizing patterns. For this reason, major research efforts have been made into developing chips that can emulate one or more aspects of brain structure. For example, the True North chip of IBM and the Zeroth chip of Qualcomm use conventional transistor technology, where many transistors are needed to simulate a single neuron. Other research efforts have focused on novel device technologies such as memristors or spintronic devices, which might emulate neurons more efficiently.

The field of neuromorphic computing is making major gains [8], and will lead to a class of special-purpose processors chips that are fast and energy-efficient for certain types of problems. However, this does not mean that we are actually designing or simulating biological brains. We still don't quite know how brains work, and ongoing research is showing complex structure on multiple levels. But biology will continue to provide inspiration to engineers in the future.

VI. Conclusions

As the classical approach of simply increasing transistor count seems to be ending, the door opens to a wide range of new opportunities, from new devices to new architectures, from new applications to new types of artificial intelligence. A central theme will need to be energy efficiency. Several new approaches, including neuromorphic and superconducting computing, are discussed in this article, but other novel approaches are also being actively developed.

The IEEE will be at the center of this endeavor, and we at the IEEE Rebooting Computing Initiative are encouraging both students and senior engineers to participate – we need your enthusiasm and new ideas. Participating ventures include the new industry-oriented International Roadmap for Devices and Systems (IRDS), and the student-oriented Low-Power Image Recognition Challenge (LPIRC). The exact configurations of future computing systems remain to be determined, but continued growth in computer performance and productivity is inevitable. The next twenty years will be an exciting time for computer engineering and related fields.

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TAB Resource Center Portals Create Value for Societies and Technical Committees

By Ed Rezek, IEEE-HKN Board of Governors

The Technical Activities Board (TAB) of the IEEE is the governing body of IEEE Technical Activities and is the largest of six major boards within IEEE. The TAB mission is to foster the development and facilitate the exchange of scientific and technological knowledge that benefits members, the profession, and humanity. It comprises 39 IEEE Societies, 6 IEEE technical Councils, 7 IEEE technical communities, and the Technical Activities Board (TAB). An IEEE TAB Society is a membership community within IEEE representing a specific field of interest, while technical Councils consist of a group of societies that share similar fields of interest. A technical community is a group of IEEE volunteers with a specific interest in a technical activity that is within the Field of Interest of the IEEE, but has not yet matured to the level of a Society of a technical Council.

IEEE TAB Societies and technical Councils produce over 160 publications and sponsor, co-sponsor, and technically sponsor over 900 conferences each year all around the world. Most Societies generate a large amount of valuable intellectual property each year beyond the traditional articles and papers that get published in IEEE Xplore or are presented at IEEE conferences. These non-traditional materials may include:

- Recorded conferences presentations
- Recorded technical panel sessions
- Presentation slides
- Technical committee reports
- Webinars
- Tutorials
- Results of surveys

These materials have proven to be of extremely high value for society members. This content may be found on society web pages, which can make discovery challenging due to the number of societies.

In 2015, IEEE TAB developed a portal where society materials can be stored and made readily available to society members and the global technical community. This is the IEEE TAB Resource Center Portal. Nearly half of the IEEE TAB Societies and technical councils and technical committees have links to the TAB Resource Center portal. The societies, councils and committees determine what content is linked in its Resource Center, and whether content may be acquired at no cost, or mustbe purchased.

The IEEE TAB Resource Centers serve the following needs:

- Store and distribute valuable non-traditional society content
- Consolidate and make non-traditional society content available thereby complementing Xplore which holds the traditional content
- Enable access to society content through an easy-to-use global portal
- Enable society members to secure content at little or no cost and enable non-society members to secure valuable content at low cost
- Increase value of society membership and encourage membership in TA societies and IEEE

The current links to content in the IEEE TAB Resource Center are as follows:

IEEE TAB Resource Center Links

Power and Energy Society
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Robotics and Automation Society
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Dielectrics and Electrical Insulation Society
Reliability Society
Geoscience and Remote Sensing Society
Ultrasonics, Ferroelectrics and Frequency Control Society
Antennas and Propagation Society
Electron Devices Society
Circuits and Systems Society
Technology and Engineering Management Society
Sensors Council
Future Directions Community
Transportation Electrification Community
Smart Grid Community

Tax Reform Presents Opportunity for IEEE and Eta Kappa Nu

By Stan Retif, IEEE Foundation

With change comes opportunity. As lawmakers in Washington, D.C., move closer to a comprehensive overhaul of the tax code, they have an opportunity to preserve and expand a provision that is proven to increase charitable giving. That's why nearly 200 representatives of nonprofits from across the country, including the IEEE Foundation, fanned out recently on Capitol Hill to encourage lawmakers to enact a universal charitable deduction.

It is undeniable that the current tax deduction for charitable contributions works. It's good tax policy. Study after study confirms that this tax incentive encourages Americans to give more to the charitable causes that are important to them. Individual giving is the single largest source of contributions to America's charities. In 2015, donors gave nearly $265 billion to charities, supporting the broad, diverse and vital network of nonprofit organizations that are the backbone of communities across our country.

With tax reform, Congress can take good tax policy and make it great. The current charitable deduction is available only to taxpayers who itemize their tax returns. Many of the proposals to simplify the tax code include reconfiguring the standard deduction so that more taxpayers won't need to itemize. This could be welcome relief from complex tax returns – but it takes away from many taxpayers the charitable giving incentive.

Instead of offering a charitable giving incentive to fewer people, we should strive to make it available to all Americans, regardless of income level or how they file their taxes. A universal charitable deduction would increase giving, in terms of both dollars and donors, increase fairness by treating all taxpayers' contributions equally, and provide modest tax relief to middle- and lower-income taxpayers.

Imagine what that could look like for IEEE. IEEE-HKN, the honor society of IEEE, is dedicated to encouraging and recognizing individual excellence in education and meritorious work, in professional practice, and in any of the areas within the IEEE-designated fields of interest. Through individual chapters on campuses to gatherings such as the Student Leadership Conference, HKN is making its mark. HKN Members who lend charitable support should have continued access to the charitable tax deduction.

Americans support charitable tax incentives because they work. A 2016 national survey of voters commissioned by Independent Sector found that 88 percent of respondents believed Congress should make it easier to deduct charitable contributions from taxes. The research also found that 79 percent believe that all taxpayers should be able to take advantage of the charitable deduction.

This year, 2017, marks the 100th anniversary of the charitable tax deduction. Congress should recognize this important milestone by doing something great for America's charities - enact a universal charitable deduction.

Babbage and His Analytical Engine

The Analytical Engine was designed by Charles Babbage, an English mathematician, during the 1830s. Although his plans for the device are extensive, it was not constructed due to lack of funding. The functioning of the Analytical Engine was mechanical and used decimal arithmetic. Original features included programmable operations and an internal memory. Inspired by punch-card control of silk-weaving looms, Babbage provided for programming of the machine using punch cards. The device was a significance advance in computing technology and can be considered the first general-purpose computer design. His work predated the modern general-purpose computers by more than a century. For this contribution, Babbage is often credited as the father of computing.

FIGURE 1 Charles Babbage. Image courtesy of the Engineering and Technology History Wiki

Charles Babbage (1791-1871) became interested in better means of computing due to difficulties in generating mathematical tables. The manually-generated tables of the time were prone to human errors. He proposed a mechanical design to compute values polynominal functions using the finite differences method. Preliminary work on his first Difference Engine was funded by the British government, but the device was never finished. This Difference Engine design led to his work on the programmable, general-purpose Analytical Engine. He returned to the basic computing problem later in life and designed an improved device, called the Difference Engine No. 2. A complete difference engine using Babbage's plans was built in 1991 to confirm that the design was feasible even with the tolerances possible with 19th-century technology.

For further study.

Biography of Charles Babbage at the Engineering and Technology History Wiki "Charles Babbage," http://ethw.org/Charles_Babbage

Discussion of the life and contributions of Charles Babbage see *IEEE Annals of the History of Computing*, notable examples are A. G. Bromley, "Charles Babbage's Analytical Engine, 1838," *IEEE Annals of the History of Computing*, 4(3) 196-217 (1982). D. D. Swade, "The Construction of Charles Babbage's Difference Engine No. 2," *IEEE Annals of the History of Computing*, 27(3) 70-88 (2005).

Overview of Babbage's Engines at the Computer History Museum "The Babbage Engine," http://www.computerhistory.org/babbage/

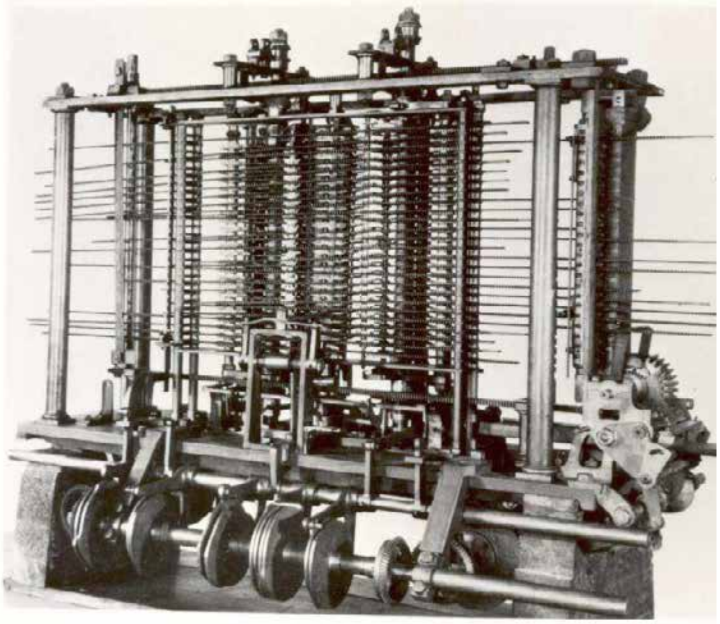


FIGURE 2 Analytical Machine. Image courtesy of the Engineering and Technology History Wiki

Students' Voice: On WISE Internships

By Nikhil Garg
Reprinted from IEEE-USA Insight

It isn't often that engineering students influence policy and policymakers at the highest levels, while being treated as experts. This summer, I was one of 14 engineering students who did just that, in Washington, D.C. We participated in the Washington Internship for Students of Engineering (WISE)—and each student works on a technology policy issue of their choice, with the end goal a published policy paper. IEEE-USA, along with AICHE, ANS, ASHRAE, ASME, ASTM, and SAE, sponsors the program. WISE challenges students to think beyond the technical aspects of their work, and to consider the global context of engineering, preparing us for long-lasting careers.

This internship stands out—from among both technical and policy internships—because it is open-ended. The intern chose their own policy areas. We were then responsible for setting up individual meetings with policymakers, and people in the appropriate agencies and industries for our topics. We customized our internships, based on our interests and prior experiences.

As an undergraduate, I studied models for wireless networks. During WISE, I applied that knowledge to argue that a paradigm shift is needed to understand how unlicensed wireless spectrum is managed. I met with senior officials at the FCC, executives at such companies as Qualcomm, and high-level volunteers on the IEEE 802 LAN-MAN Committee. IEEE-USA also connected me with mentors who have played large roles at the FCC, and in wireless policy, who provided me with invaluable insights. I then submitted a filing at the FCC, applying my research to a current matter regarding the unlicensed bands. My filing was one of only a few giving independent analysis in a politically charged debate. The experience taught me some realities of wireless policy, and allowed me to contribute in a meaningful way.

In addition to furnishing an avenue to explore our policy interests, the WISE program advisors helped us arrange meetings with top policy influencers, both in and out of government. As a group, we met with leaders in the Senate, White House Office of Science and Technology Policy, Nuclear Regulatory Commission, Department of Homeland Security, State Department, National Science Foundation, and several interest groups. Each meeting gave us an opportunity to discuss critical technology policy issues with the experts. We also attended bill markups, congressional receptions, numerous think-tank events, and were in the center of D.C. during one of the most momentous summers in government in recent history.

One of the strongest realizations we reached was that though engineers are a tiny minority in D.C., we have an important role to play in policy. We have insights not available to even the extremely intelligent lawyers who work on these issues every day. As science and technology problems on such issues as automation, energy, cybersecurity and climate change increasingly dominate public debate, it is critical that those with technical backgrounds engage with policymakers to design effective solutions. Many of us had meetings where we were treated as the experts, due to our backgrounds. For example, I met with a congressional legislative director who had just held a meeting with all the primary stakeholders surrounding my issue. Instead of asking questions, I spent much of the meeting sharing my views, and explaining some of the technical components of the debate--from an independent perspective.

Finally, what made the program invaluable was that the intern class was diverse. D.C. is said to be the only place in the United States where you will find at least one person from every district, nook, and cranny in the country. This year's intern class was a microcosm of D.C., in more ways than just geographic. The intern class included those about to start engineering jobs and grad school; those with patents and their own startups; and those who are well-travelled, who have much work experience. It included different engineering majors, and people from all over the political spectrum. These differences led to numerous engaging discussions about policy. In surroundings where it is likely to spend time only with those like you, this WISE intern program proved to us the benefits of discussing issues with those who are not.

Though coming from disparate backgrounds, all of us left with an indelible belief in the value of seeking opportunities that will provide a greater context to our engineering educations—whether in business, policy, or the arts. I encourage anyone interested in the WISE program to apply at www.wise-intern.org/applications.

Nikhil Garg is IEEE-USA's Student's Voice columnist. He is working towards an MS/Ph.D. in electrical engineering at Stanford University. He graduated from the University of Texas at Austin, with a B.S. in Electrical & Computer Engineering, and a B.A. in Plan II in 2015. Nikhil can be reached at nkgarg@stanford.edu or gargnikhil.com.

Your Personal Brand Says a Lot about You

By Chris McManes, IEEE- USA

Two recent TV appearances. Two vastly different reactions.

Mariah Carey, singing on New Year's Eve, had a meltdown and proceeded to blame others for her flawed performance. Lady Gaga, during halftime of Super Bowl LI, soared to (and from) new heights.

The impression they left on viewers were at polar opposites. Carey was generally lambasted by traditional and social media. Gaga scored high marks and saw downloads of her songs soar nearly 1,000 percent.

Both performances affected the singers' personal brands. Carey has a lot of work to do to repair her damaged reputation. Gaga used her stunning Super Bowl appearance to launch her world tour.

Branding is not limited to celebrities and business entities. A personal brand is what people think of first when someone comes to mind. Each of us draws out a favorable or unfavorable response.

"We all have a personal brand," leadership expert and business strategist Carolyn Andrews said. "Managing it and making sure it's the brand you want it to be is really important. Because after all, your brand is how you appear to the world."

Andrews was speaking at the 2017 IEEE Rising Stars Conference in Las Vegas. She and business life coach Jennifer Johnson presented "Creating and Marketing Your Personal Brand." The session was well-attended by IEEE student members and young professionals.

In today's social media age, personal branding for many children begins the moment they're born. Parents and grandparents flood their Twitter, Facebook, Instagram and YouTube accounts with photos and stories of everything baby is doing.

"Sixty to eighty percent of two-year-olds have a personal brand," Andrews said, "because mom has put them on Facebook or they've been involved in something else, or people are seeing them now.

"So it's really important to understand that we all have a personal brand."

Be Who You Are

A key to developing a positive personal brand is to be yourself. We are all uniquely created and shaped individuals. Make the best of who you are.

Johnson told a story about how hard it was for former ESPN sportscaster Robin Roberts to land a job at ESPN. At the time, few African-American women worked there.

Johnson said Roberts' advice is to "make your mess your message."

"Your mess is what you want to hide, right?" Johnson said. "She says, 'no, make that your message.' Her mom always preached that to her … [telling her] to bring 'you' forward. And guess what, she ended doing that, and now she's on Good Morning America."

Johnson offers similar advice when she says to turn "your scars into stars." While some people have physical scars, almost all of us have emotional roadblocks that hold us back, that fill us with fear.

"Usually it's an internal scar, something that we tell ourselves, that we're not OK. Or that we can't raise our hand for that promotion. Or we can't give that talk. Or we can't get that project," Johnson said. "Turn your scar into a star. The scar that you think is so negative can be one of your best assets."

The tagline to Johnson's company, 3P Coaching, is "You don't have to be a size 6 to make 6 figures."

"I can't tell you when I came up with that tagline how much it propelled my business," she said. "It was unbelievable. And it was exciting. … Whether you're a size 2 or 22, it's all what's in your head. Something like this could have held me back. Instead I get to go out into the world, have fun, share my message and inspire others to do the same.

"I didn't let my weight, my size hold me back. I took what was my perceived scar and turned it into a shining star."

So yes, put your best foot forward. But if you have something you perceive to be negative, don't try to hide it. Make light of it if you have to. Talk about how it inspires you to work harder, to overcome, to reach your potential. What's in your heart is much more important.

Is the Online You On- or Off-Message?

Another area that strongly shapes how people perceive you is your online presence. The stories, photos and text you post all have a bearing on this.

Employers today comb the Internet to see what job seekers post and what others say about them. While you have to possess the skills they're looking for, who you are as a person carries more weight. The good or bad inside of you will eventually come out.

At DeMatha Catholic High School in Hyattsville, Md., teachers, coaches and staff are cautioned to make sure sites they have their name attached to feature acceptable photos, text and graphics. If not, they are urged to sanitize them.

"The words we speak and the things we post reveal what's inside of us," DeMatha President Father James Day says.

So make sure what you share is appropriate for all age levels and reflects positively on you. It will help you gain a job or keep one.

When you do well and people generally have a positive opinion of you, it also reflects well on your employer. The products and services companies sell are important. Their employees are more valuable. They are the brand ambassadors.

"You should always give all that you can give to the company you work for," Andrews said. "But you also need to build your own brand, your own expertise within that company. Not just the company's expertise."

Andrews also suggests securing your first and last name as your domain name. This can be difficult for people with common names. Sometimes adding a little wrinkle like a middle initial or numeral will do the trick.

"If you have not gotten your own name, please do," she said. "You never know what you're going to do with your life, and that is part of your brand."

Branding is Dynamic

Mariah Carey might still be paying the price for her forgettable performance on New Year's Eve. She is preparing to open up for Lionel Richie on a 35-city concert tour. Ticket sales are not good.

The good news for Carey and others whose personal brands have been tarnished is that they can be repaired.

"Sometimes you have to reinvent your brand if you make a mistake," Andrews said. Likewise, "if you switch careers, you might reinvent your brand then. Your personal brand is not static."

Chris McManes is IEEE-USA's public relations manager. This story originally appeared on IEEE-USA InSight.

IEEE-HKN Awards News

Congratulations to all 21 of our Outstanding Chapters this year, these chapters exemplify the core principles of Scholarship, Attitude and Character that all members of IEEE-HKN strive for. Photos taken at the 2017 ECEDHA Conference

Emily Hernandez received the Oustanding Student award for outstanding scholastic excellence and high moral character, coupled with demonstrated exemplary service to classmates, university, community, and country.

David Soldan received the Distinguished Service Award for exceptional leadership and life-long support and service to Eta Kappa Nu and IEEE-Eta Kappa Nu members, chapters, and volunteers.

Student Leadership Conference

IEEE-HKN held their annual Student Leadership conference at Purdue University over the weekend of 31 March – 2 April.

Beta Chapter hosted this fantastic event, with more than 150 chapter members, officers and faculty attending from chapters across the world.

Students were treated to talks by industry experts, as well as fantastic sessions on Chapter best practices and academic standards. Officers were able to meet and exchange ideas in a lively forum, gaining new insights into running their chapters and an appreciation of the wider IEEE-HKN community.

With multiple Board Governors in attendance, the SLC also presented a unique opportunity for students to meet the leadership of IEEE-HKN and understand the guiding vision of the future of the society.

Beta Chapter were excellent hosts, opening their legendary HKN coffee lounge and facilities to all the travelling chapters, as well as showing them the sights and sounds of Purdue.

◀ The group photo of attending chapters, taken on the Engineering Mall after an enlightening campus tour.

▶ Nadra Guizani (Conference Chair) and Kelsie Larson (Conference committee member) leaping for joy at the IEEE-HKN Photo Booth.

HKN chapters from across the globe enjoying the new HKN Photo booth!

Proud HKN members with the Beta Chapters HKN Monument. For more photos, visit us on facebook at IEEE- Eta Kappa Nu

HKN Beta Tau Chapter Northwestern University Freshmen Mentoring Program

By Prof. Allen Taflove, Beta Tau Faculty Adviser

Beginning with the 2010-11 academic year, the Beta Tau Chapter of HKN at Northwestern University has annually conducted a Freshmen Mentoring Program as its primary service activity. The goal of this program is for Beta Tau members to provide freshmen at Northwestern's McCormick School of Engineering with one-on-one mentoring.

Experience has shown that many freshmen are unsure as to their choice of engineering courses and professors, or even more broadly (and critically), their choice of an engineering major!

Electrical and computer engineering (ECE) is quite often thought of as requiring a more difficult academic path than other majors, causing ECE enrollments to stagnate while more popular majors receive more attention (i.e., more resources) from the school. Mentorship by Beta Tau members shows McCormick freshmen that it's not only possible, but in fact extremely desirable to major in ECE.

Each freshman joining the Mentorship Program is paired with an HKN member who serves as his/her mentor. During winter and spring quarters, each mentor/mentee pair meets and enjoys a couple of off-campus lunches or dinners per month (at the expense of the EECS Department) to talk about courses, professors, majors, careers, and life in general. It's sort of like a big brother/big sister thing!

The kickoff event for the Mentorship Program is held annually, one week before Thanksgiving break (see attached 2016 flyer). After an upscale catered buffet dinner funded by the EECS Department, mentor-mentee pairing is conducted and the year's program is launched.

During the 2016-17 academic year, 19 Beta Tau members mentored 25 freshmen. More freshmen had applied, but with the entire membership of Beta Tau already involved, we simply ran out of mentors!

P.S. The visibility and perceived merit of the Mentoring Program is such that there has been a significant increase in the yield of acceptances by our HKN invitees to join our Chapter. This is definitely a side benefit of the Mentorship Program!

Beta Mu Chapter Spotlight

By: Grayson Noah | Annual Report Chair and Bridge Correspondent

The Beta Mu Chapter of IEEE-HKN at Georgia Tech maintains a multitude of programs to provide benefits to members, to the School of Electrical and Computer Engineering, to Georgia Tech, and to the community. One of the most prominent programs run by the Beta Mu Chapter is a comprehensive lab supplies sale every semester for three major labs in the core undergraduate ECE curriculum. To prepare for sales, the officers contact professors each semester to obtain a list of parts required and then proceed to order the parts from several suppliers. At the beginning of each semester, to further sales, all officers take shifts selling parts in the ECE building lobby and visiting labs during open hours. The sales provide students with a significantly less expensive alternative. Estimated total savings passed on to students since the program was started has reached over $140,000 and continues to grow. The sales also serve as a sizeable source of revenue for the Beta Mu Chapter, allowing the organization to award scholarships to deserving students in the ECE School. The Chapter sponsors scholarships for early innovation by an ECE student and a deserving junior. In addition, the Beta Mu Chapter provides awards for an outstanding junior in ECE, an outstanding senior in Electrical Engineering, and an outstanding senior in Computer Engineering.

Service to the community is something the Georgia Tech branch of IEEE-HKN takes very seriously, as it is representative of the character traits and values of IEEE-HKN. In an effort to foster more community service through the organization, the Beta Mu Chapter of IEEE-HKN developed a partnering relationship with the Georgia Tech chapter of the honor and service organization Gamma Beta Phi that is expected to last into the foreseeable future. Every semester, IEEE-HKN members and prospective initiates tackle a service project together, in addition to the individual service many members complete. In fall semesters, this takes the form of Georgia Tech's annual "Team Buzz" student-organized community service day. This year, volunteers were split into groups which helped landscape worn cemetery lots, replace flower beds, and plant new flowers at Oakland Historic Cemetery. Another Georgia Tech student-organized community service project, Tech Beautification Day which happens each spring, is focused on helping Georgia Tech's facilities department in maintaining and improving the campus and its immediate surroundings. This year's HKN Tech Beautification Day project involved planting new trees and spreading mulch around Georgia Tech's central campus transit hub over the span of four hours in an effort to help Georgia Tech secure its recently acquired arboretum status.

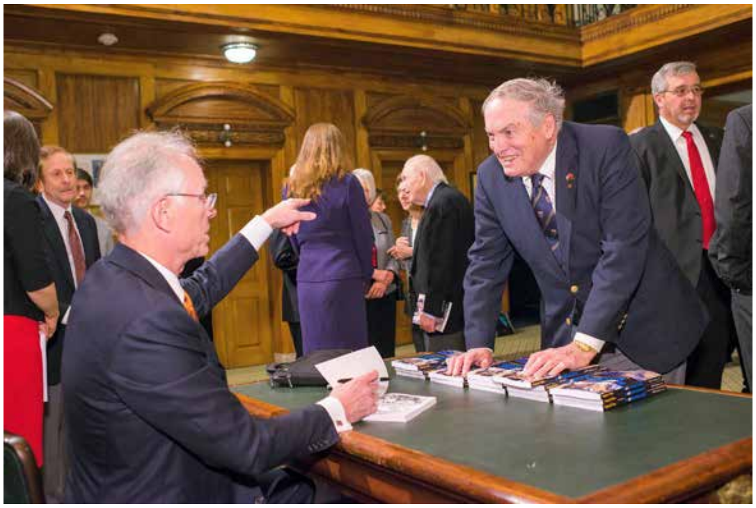
ECE Spring Picnic sponsored by Beta Mu Chapter of IEEE-HKN
April 8, 2016

In this past year, a push was made to improve the publicity for the chapter. This was to improve internal cohesiveness, external relations, and overall involvement of IEEE-HKN on campus. Representatives of the chapter attended more campus events to network with other organizations and campus leadership. In addition, a dedicated publicity chair position was appointed for the first time in Spring 2016 and continues to play an important role in furthering these objectives. The Beta Mu Chapter's biggest event of the year, the annual ECE spring picnic, has been greatly aided by these improvements. A large multimodal publicity campaign of posters, flyers, emails, and social media outreach preceded this year's picnic, and the results were visible in the impressive attendance at the final event. Nearly 400 students and faculty members were present for some duration of the event, greater attendance than at any prior picnic. A delicious menu including barbecue was provided, and a few of the chapter's corporate sponsors were invited as guest speakers for the event.

In summary, the Beta Mu Chapter is working to embrace and amplify, through tangible actions, the principles for which IEEE-HKN stands.

Kent R. Martin, Beta Zeta Chapter

Kent Martin is currently retired for the past thirteen years. His field encompassed electronic engineering with experience in space, military and aviation control electronics. Before his retirement in 2004 his was senior vice president and general manager of Servo Corporation, which was located in Long Island, New York. Prior to Servo he was president of Republic Electronics Corporation, a wholly owned subsidiary of Esterline Technologies Corporation. Republic was an engineering and manufacturing company that supplied radar simulators, navigation test equipment, space equipment, and electronic warfare simulators to worldwide customers. Esterline is a NYSE Corporation. Martin has a BSEE and MSEE from New York University College of Engineering and Science. He is also is a graduate of The Harvard Business School Advanced Management Program. It was an honor to be elected to Eta Kappa Nu and Tau Beta Pi. Martin has held a professional engineer license in the state of New York. His military service included a tour in the United States Marine Corps where he was first exposed to electronics. The great thing about engineering is that you are able create products that advance the state of the art which gives you a large amount of personal satisfaction. My advice to engineering students is study hard a do not neglect the humanities, speech, English and all the other non-technical subjects. If you cannot communicate through writing and speech you will never get very far. Engineering is a great profession that will provide a challenging and rewarding career.



Greg Olsen - Inventor, Entrepreneur and Private Space Pioneer and Kent Martin at the Global Leaders Meeting, 3 February 2017 New York City.

If you cannot communicate through writing and speech you will never get very far. Engineering is a great profession that will provide a challenging and rewarding career.

Kent and Eleanor Martin with Karen Kaufman (IEEE-Foundation) at the Global Leaders Meeting, 3 February 2017 New York City

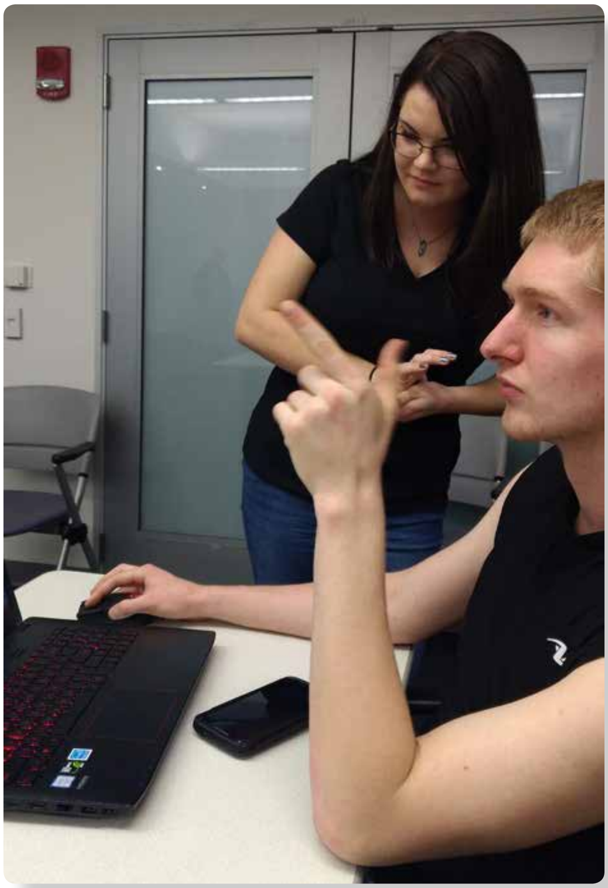
Nu Chapter at Iowa State University awarded "Outstanding K-12 Outreach Program"

During the annual E-week celebration at Iowa State University, the Nu chapter was awarded for having an outstanding k-12 outreach program. This award was presented to one club out of all the engineering related clubs on campus who has done the most to promote STEM within the community.

The Nu chapter would like to emphasize that winning this award was only made possible due to the collaboration of the Nu chapter and the IEEE student chapter. Both of these chapters are very active and wish to promote STEM throughout the Ames community. In order to achieve this, the two chapters banded together in order to pursue their common goal.

Together, on the Iowa State University campus and the broader Ames community, these two organizations constantly help to promote the development of young students and educate them on possible careers in STEM related majors. The Nu Chapter president, Matthew Lee, commented that "it's clear to me that our members really see the value in these outreach events because they know they are helping to inspire the future. "

Over the past year, these two chapters have been responsible for organizing and volunteering for multiple K-12 outreach including STEM nights at local middle and elementary schools, Science Fairs, Science Expo nights, and FIRST Lego League.



At the STEM nights and Science Fair events, a popular activity is always teaching kids about fundamental electronics through Snap Circuits. Snap Circuits are a puzzle type game that use easy-to-connect blocks to teach kids basic electrical concepts.

Additionally, the clubs have put on demonstration for K-12 students to showcase what ISU Students have created in the past. The clubs are happy to note this not only helps its member gain presentation and communication skills it also gets future generations excited to pursue engineering careers.

The vice president of the Nu Chapter, Stephanie Engelhardt, said "We are definitely honored to receive such a prestigious award, but at the end of the day, what matters the most to us is that we help k-12 students see their full potential."

University of Pittsburgh – Beta Delta Chapter

On Saturday, March 25, 2017, the University of Pittsburgh Beta Delta chapter of IEEE-Eta Kappa Nu held their annual Hands On Science event. The Eta Kappa Nu volunteers mentored 19 high school students on building miniature traffic lights using integrated circuits on breadboards. The high school students, most of whom had never seen a breadboard, learned the basics of using oscilloscopes and wiring resistors and capacitors, and they successfully completed the project in one afternoon!

If you are interested in volunteering with the University of Pittsburgh chapter of IEEE-Eta Kappa Nu for this and/or other mentoring events, please email us at pitt.ieee.hkn@gmail.com .

The high school students represented 12 schools in the Greater Pittsburgh Area and are part of the University of Pittsburgh's Excel and Investing Now programs. Please see the following links for more information about how your high school student can join the fun!

http://www.engineering.pitt.edu/EXCEL/

http://www.engineering.pitt.edu/InvestingNow/

Welcome and Welcome Back!

IEEE-HKN is proud to welcome five new chapters into our growing community:

Mu Kappa Chapter at the University of Queensland

Mu Lambda Chapter at East Carolina University

Mu Mu Chapter at Wentworth Institute of Technology

Mu Nu Chapter at Politecnico di Torino

Mu Xi Chapter at the Indian Institute of Science- Bangalore

In the October 2016 issue of The Bridge on page 47, the University of Colorado-Denver: Theta Zeta Chapter had a small asterisk by it. On March 4, 2017, that asterisk was removed. With Noel Hess as president, Julia Redmond as Vice President, and Dr. Dan Connors as the faculty advisor, Theta Zeta Chapter is active once again and its members are excited to renew the traditions of excellence begun in 1978.

A total of 14 new members were inducted in Theta Zeta's first ceremony in over a decade with a speech from special guest speaker, President-Elect and The Bridge's Editor in Chief Steve E. Watkins. Mr. Watkins spoke of the history of IEEE-Eta Kappa Nu and ways the re-established chapter could enrich its community and members. Theta Zeta Chapter is back to show our dedication to scholarship, volunteer service, and distinguished accomplishments.

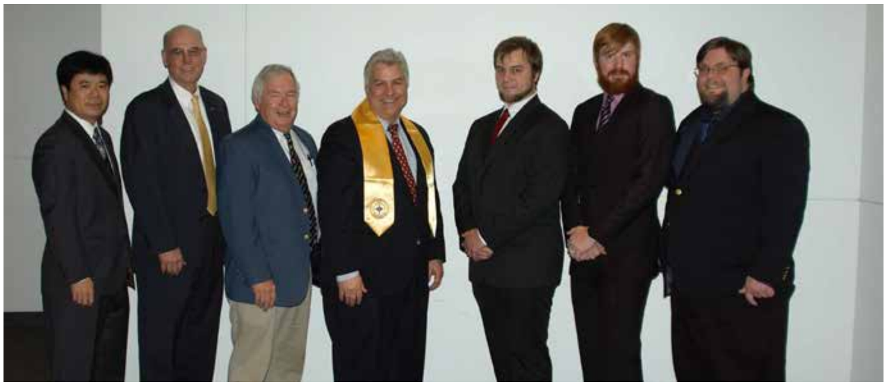
Thank you to the faculty advisors, department chairs, and student members of all of these new and reactivated chapters for all their hard work now and in the years to come!

If you know of a chapter that would like to resume active status, we are eager to work with you. Please contact Nancy Ostin, Director, IEEE-HKN.

Mu Mu Chapter installation, at the Wentworth Institute of Technology

Mu Kappa Chapter Installation, at the University of Queensland

Mu Nu Chapter Installation, at the Politecnico di Torino



Mu Lambda Chapter Installation, at the East Carolina University

STUDENT PROFILE

Christina Segerholm

Gamma Epsilon Chapter

Christina Segerholm is a senior at Rutgers University in New Brunswick majoring in Electrical and Computer Engineering (ECE) and Computer Science, with a minor in Economics. In 2015, she received the Rutgers Academic Excellence Award. Christina also became the Event Coordinator for Eta Kappa Nu. As a junior, she was the proud recipient of the Petrucelli Scholarship, and was elected Vice President of Eta Kappa Nu. Currently, she is ranked fourth overall and is the top female in Rutgers ECE class of 2017. Outside of the classroom, Christina spends her time at the rink playing left wing for the Rutgers Women's Ice Hockey Club team where she is vice president. Christina interned twice at TD Ameritrade doing Application Development and once during the summer of 2016 at AT&T as a software engineer. This fall, Christina is super excited to start her career at Google.

Why did you choose to study the engineering field (or the particular field you are studying)?

My high school chemistry teacher was the first one who made me consider engineering. I liked calculus and physics, so I thought it was a good fit for me. It wasn't until I took my first computer science class at Rutgers that I found my true passion. After one class with my professor, I was hooked. I was mesmerized by the idea that you could create almost anything through Java: a calculator, a course registration system, or even a battleship game. I still remember how thrilled I was after finishing my first Connect Four game on the command line. For the first time, I actually felt like I was doing something I loved. After that, I decided to go into computer engineering, and it's one of the best decisions I've ever made.

What do you love about engineering?

The innovation. I think engineers have the best jobs in the world. Engineers get to solve problems every day. We have the opportunity to change the future; we decide what gets created or improved. Sure, not all of us are going to be working on life saving technologies, but most of us do work that improves some aspect of human life. Whether it be increasing the fuel efficiency of hybrid cars or decreasing the amount of cycles per instruction on a processor, engineers are making a positive difference everywhere.

What don't you like about engineering?

The course load. It's a love hate relationship. I love learning all of the new things, but sometimes keeping a healthy work life balance is tough, especially in college. I don't think I will ever forget my junior year. At that time, I was taking five different classes…this meant five different weekly homework assignments, five different exams, and five different subjects to learn. Try throwing in a part time job, a club sport, and some kind of social life and it becomes quite hectic. However, at the end of the day, I did enjoy the challenge of balancing all of the classes at once.

What is your dream job?

My dream job is not a specific company or position. My dream job is one where I can continually learn. I want a job where I can always improve not only what I'm working on but also my own abilities. I want a job where I can feel like I'm making a difference in the world and am productive; one that does not consume me. I want a job where I can still play hockey on the weekends and spend time with my family and friends. At the end of the day, a fancy job title is not going to make you happy. You have to like what you do in order to like who you are. My dream job is a position in which I can be proud to tell people what I do.

Whom do you admire (professionally and/or personally) and why?

I have come to admire quite a few people in my life. They range from teachers and professors, to managers and mentors, to colleagues and friends. I appreciate confidence, but not cockiness. I admire honesty, especially during hard situations. I treasure random acts of kindness and am a huge believer of hard work, especially in groups. I believe managers who recognize and promote hard work are the best type of leaders.

In what direction do you think that the engineering and other IEEE fields of interest are headed in the next 10 years?

Towards cloud computing. The idea that you can spin up and take down instances of programs when their request frequency changes is very attractive. It's interesting because cloud hardware is pretty basic; it feels like we are taking a step backwards. Instead of making a special high performance computer, we can just put a few cheap machines together. We are drifting away from specializing hardware for one specific task. Now, we are focusing on how to make hardware generic enough to run any type of program. To achieve this, there must be a software layer that controls the program's position within the cloud, and what data it has access to. With that said, I also think security will have to grow since the data in the cloud will be easier to grab if you are sharing a piece of hardware with another program.

What is the most important thing you've learned in school?

How to learn. Sure, engineering teaches you how to find the pH level of a solution, how to find the acceleration of a box sliding down a ramp, and even how to find the magnetic field induced by a current. However, to be completely honest, none of these stands even close to the most important lesson: learning how to learn. It sounds silly, but everyone learns differently and figuring out how to grasp a new concept is an essential skill to have. Even when we leave school, we still learn, whether we want to admit it or not. Getting yourself to understand a certain subject can really make a difference, not just on the job, but also in life.

What advice would you give to other students entering college and considering studying your major?

Engineering and coding are both very similar to playing an instrument. You don't become Mozart overnight; it takes practice…lots of practice. Even if you think you have it, sometimes you need to go over it that one extra time to be sure. I also found that teaching other students or explaining problems to peers really helps me better understand the subject.

If you have a question, ask it. Chances are, many other students will be thinking the same thing

Also, don't be afraid to ask questions. Do not be afraid will look stupid or that the professor is going to get annoyed with you. If you have a question, ask it. Chances are, many other students will be thinking the same thing and the professor will know you are paying attention! This goes for working as well; never be afraid to ask your manager or mentor questions.

Finish this sentence. "If I had more time, I would …"

Build my own version of Dr. Mario for the iPhone. Volunteer more with Habitat for Humanity. Travel the world. Learn how to do a backflip. Talk to the younger generation about how awesome coding is. Learn how to fence. Train for American Ninja Warrior. Learn the guitar. Learn how to surf. Run a marathon. Train for a triathlon. Grow my own tomatoes. Make a pizza from scratch.


PHOTO CREDIT: PAULA BRONSTEIN