EEE Canadian Review

La revue canadienne de l'IEEE

Spring/Printemps 2021 - No. 86

Spring Forward to 2021

Data Analytics and Edge-Computing

Cybersecurity and Power Grids

Fox Hunt Demonstration



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Jason Gu Ph.D., P.Eng., FEIC, FCAE

2020-2021 IEEE Canada President and Region 7 Director Président de l'IEEE Canada et directeur de la région 7, 2020-2021

ear friends and IEEE Canada members, As the Region 7 director and IEEE Canada president, I am excited to work with all of the volunteers and members of our Region. It has also provided me with the great opportunity to learn about the achievements of our dedicated volunteers all across the Region.

The COVID-19 pandemic has impacted our daily lives since early spring 2020. Unfortunately, it appears that the situation may still be in effect for most of 2021. I want to emphasize that our continuous support is with the professional community during the pandemic. IEEE Canada is fully operational despite the current challenges. While the COVID-19 pandemic has constrained us with many challenges, it has also brought along many new opportunities. We now have many more online meetings than ever, and I have attended as many Section annual general meetings (AGMs) as possible. In particular, I have attended the following Sections' AGMs: the Canada Atlantic, Montréal, Ottawa, Victoria, London, Windsor, Hamilton, Toronto, Northern Saskatchewan, and Newfoundland Sections.

(Continued on p. 2)

hers amis et membres de l'IEEE Canada, En tant que directeur de la région 7 et président d'IEEE Canada, je suis heureux de travailler avec tous les bénévoles et les membres de notre région. Cela m'a également donné l'excellente occasion d'en apprendre davantage sur les réalisations de nos bénévoles dévoués dans toute la région.

La pandémie de COVID-19 a eu un impact sur notre vie quotidienne depuis le début du printemps 2020. Malheureusement, il semble que la situation soit encore en vigueur pendant la majeure partie de 2021. Je tiens à souligner que notre soutien continu est avec la communauté professionnelle pendant la pandémie. L'IEEE Canada est pleinement opérationnel malgré les défis actuels. Alors que la pandémie COVID-19 nous a contraint avec de nombreux défis, elle a également apporté de nombreuses nouvelles opportunités. Nous avons maintenant beaucoup plus de réunions en ligne que jamais et j'ai assisté à autant d'assemblées générales annuelles (AGA) de section que possible. En particulier, j'ai assisté aux AGA des sections suivantes: les sections Canada Atlantique, Montréal, Ottawa,

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President's Message/Message du Président

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Last October, IEEE Canada successfully organized its board meeting with help from IEEE staff. Before the board meeting, three group committee meetings, three area meetings, and the conference advisory committee, they all had their meetings online.

We successfully held our CCECE 2020 and EPEC 2020 conferences online. We also recognized the IEEE Canada award recipients online. In addition, we successfully celebrated IEEE Canada's 25th anniversary on IEEE Day. On that day, IEEE Canada hosted many events together with students, Young Professionals groups, Women in Engineering, Life Members, and a number of Chapters and Sections.

Due to COVID-19, we have seen a decline in membership in 2020, particularly with the student membership. IEEE has implemented discounts for students to mitigate the situation and is helping students to overcome the financial stress. IEEE Canada has also set up an ad hoc committee to investigate this issue and is exploring strategies to handle it.

In 2021, working together with our dedicated volunteers, I would also like to focus on the relationship with industry, government sectors, and other professional societies. In addition, I intend to work on addressing the challenges faced by the small Sections, bringing more transparency to the nominations process, and elections, finances, awards, and recognitions.

> In 2021, working together with our dedicated volunteers, I would also like to focus on the relationship with industry, government sectors, and other professional societies.

As in 2020, the CCECE 2021 conference is going virtual. I would like to invite all of the Sections to work together to cosponsor and organize this conference. Together, we will celebrate the achievements of our award recipients at the IEEE Canada Gala online. We will also keep monitoring the COVID-19 situation and determine the format of the EPEC 2021 conference as soon as we get more clarity.

IEEE Canada has revised its operation manual and bylaws, and five committee groups were created, as of 1 January 2021. These committees are

- External Relations
- Member Services
- Publications and Communications
- Educational Services
- Operational Support.

With this new structure, there will be better group alignment, and operational efficiency will be improved.

By the time of writing this column, in 2021, we have already conducted three volunteer training session on the following topics:

- introduction to IEEE organization and governance
- introduction to IEEE Canada organization and governance
- introduction to IEEE Canada conferences

(Message du Président suite de p. 1)

Victoria, London, Windsor, Hamilton, Toronto, le Nord de la Saskatchewan et Terre-Neuve.

En octobre dernier, L'IEEE Canada a organisé avec succès sa réunion du conseil d'administration avec l'aide du personnel de l'IEEE. Avant la réunion du conseil d'administration, trois réunions de comité de groupe, trois réunions régionales et le comité consultatif de la conférence, ils avaient tous leurs réunions en ligne.

Nous avons organisé avec succès nos conférences CCECE 2020 et EPEC 2020 en ligne. Nous avons également reconnu les lauréats du prix L'IEEE Canada en ligne. De plus, nous avons célébré avec succès le 25e anniversaire de l'IEEE Canada le jour de l'IEEE. Ce jour-là, L'IEEE Canada a organisé de nombreux événements en collaboration avec des étudiants, des groupes de jeunes professionnels, des femmes en génie, des membres de la vie et un certain nombre de branches et de sections.

En raison du COVID-19, nous avons constaté une baisse du nombre de membres en 2020, en particulier avec le nombre d'étudiants. L'IEEE a mis en place des réductions pour les étudiants afin d'atténuer la situation et aide les étudiants à surmonter le stress financier. L'IEEE Canada a également mis sur place un comité ad hoc chargé d'enquêter sur cette question et étudie des stratégies pour y faire face.

En 2021, en collaboration avec nos bénévoles dévoués, je voudrais également me concentrer sur les relations avec l'industrie, les secteurs gouvernementaux et d'autres sociétés professionnelles. De plus, j'ai l'intention de travailler à relever les défis auxquels sont confrontées les petites sections, en apportant plus de transparence au processus de mise en candidature, aux élections, aux finances, aux récompenses et aux reconnaissances.

Comme en 2020, la conférence CCECE 2021 devient virtuelle. Je voudrais inviter toutes les sections à travailler ensemble pour coparrainer et organiser cette conférence. Ensemble, nous célébrerons les réalisations de nos lauréats lors du Gala IEEE Canada en ligne. Nous continuerons également à surveiller la situation du COVID-19 et à déterminer le format de la conférence EPEC 2021 dès que nous aurons plus de clarté.

L'IEEE Canada a révisé son manuel d'exploitation et ses règlements administratifs, et cinq groupes de comités ont été créés au 1er janvier 2021. Ces comités sont:

- Relations extérieures
- Services aux membres
- Publications et communications
- Services éducatifs
- Support opérationnel.

Avec cette nouvelle structure, il y aura un meilleur alignement des groupes et l'efficacité opérationnelle sera améliorée.

Au moment de la rédaction de cette chronique, en 2021, nous avons déjà organisé trois sessions de formation de bénévoles sur les sujets suivants:

- introduction à l'organisation et à la gouvernance de l'IEEE
- introduction à l'organisation et à la gouvernance de l'IEEE Canada
- introduction aux conférences de l'IEEE Canada
- ce qui est disponible pour les ressources bénévoles
- où trouver des outils et de la formation bénévoles de l'IEEE
- exigences opérationnelles financières

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(President's Message cont'd from p. 2)

- what is available for volunteer resources
- where to find IEEE volunteer tools and training
- financial operational requirements
- how to prepare a budget
- how to prepare an expense report
- what financial tools and resources are available for volunteers
- where to find financial tools.

Special thanks to the organizing committee lead by IEEE Canada President-Elect Robert Anderson—these orientation sessions will provide all of the returning and new volunteers with a renewed overview of IEEE, IEEE Canada, and MGA. We had our spring board meeting on 27 and 28 February 2021 and prepared a strategic plan for the rest of the year.

I wish everyone a safe, healthy, and happy 2021. With this spring edition of IEEE Canadian Review, I thank everyone for the continued support and understanding. Please contact me at jason .gu@ieee.org with your comments, questions, or concerns. I look forward to hearing from you.

> Jason Gu, Ph.D., P.Eng., FEIC, FCAE 2020-2021 IEEE Canada President 2020-2021 IEEE Region 7 Director

(Message du Président suite de p. 2)

- comment préparer un budget
- comment préparer un rapport de dépenses
- quels outils et ressources financiers sont disponibles pour les bénévoles
- où trouver des outils financiers.

Un grand merci au comité organisateur dirigé par le président élu de l'IEEE Canada, Robert Anderson, ces séances d'orientation offriront à tous les bénévoles de retour et aux nouveaux bénévoles un apercu renouvelé de l'IEEE, de l'IEEE Canada et de MGA. Nous avons réuni notre conseil d'administration de printemps les 27 et 28 février 2021 et préparé un plan stratégique pour le reste

Je souhaite à tous une année 2021 sûre, saine et heureuse. Avec cette édition du printemps de la Revue canadienne de l'IEEE, je remercie tout le monde pour son soutien et sa compréhension continus. Veuillez me contacter à jason.gu@ieee.org avec vos commentaires, questions ou préoccupations. Je suis dans l'attente de votre réponse.

> Jason Gu, Ph.D., P.Eng., FEIC, FCAE Président de l'IEEE Canada 2020-2021 Directeur de la Région 7 de l'IEEE 2020-2021

IEEE Canadian Review

La revue canadienne de l'IEEE

IEEE Canadian Review is published three times per year: Spring, Summer, and Fall.

Its principal objectives are:

To inform Canadian members of IEEE on issues related to the impacts of technology and its role in supporting economic development and societal benefits within Canada. To foster growth in the size and quality of Canada's pool of technology professionals to serve our increasingly knowledge-based economy.

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The circulation of IEEE Canadian Review is the entire membership of IEEE Canada, plus external subscribers.

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Authors are invited to contribute . submissions in electronic form to IEEE • Tel 1 (800) 678-4333 Canadian Review. Please contact one of • the editors. Responsibility for the content rests upon the authors and not the IEEE, nor its members, nor the editors of the publication.

Annual Subscription Price

Free of charge to all IEEE members in Canada.

For IEEE members outside Canada: \$20.00/year. Nonmembers: \$35.00/year. Corporations and libraries: \$37.50/year. Additional copies may be ordered at a cost of \$7.50 each from the administrator.

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Gautam Srivastava, Ph.D., SMIEEE srivastavag@brandonu.ca

s 2021 begins, we finally can see some light at the end of the tunnel. With vaccine rollouts happening globally at different speeds, I think Canadians, in general, are optimistic that some level of normalcy to life is just over the horizon.

In academia, as instructors, we saw a change almost overnight in how we delivered content. Online teaching at some institutions was regular before COVID-19, so those professors, teachers, and instructors were ahead of the curve as lors que 2021 commence, nous pouvons enfin voir un peu de lumière au bout du tunnel. Étant donné que les déploiements de vaccins se déroulent à des rythmes différents dans le monde, je pense que les Canadiens, en général, sont optimistes quant au fait qu'un certain niveau de normalité de la vie se profile à l'horizon.

Dans le milieu universitaire, en tant qu'instructeurs, nous avons constaté un changement presque du jour au lendemain dans la

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A Few Words From the Associate Editor / Quelques mots de l'éditeur associé

(A Few Words From the Associate Editor cont'd from p. 4)

(Quelques mots de l'éditeur associé suite de p. 4)

far as being able to deliver online content to their students. For many, however, it was a fast turnaround to learn how to successfully deliver courses in a manner without much, if any, face-to-face contact. I embraced it. I learned quickly how to write on the screen and deliver courses I would have previously delivered using a whiteboard due to a strong need for a mathematical background. Nonetheless, both students and instructors alike can say . . . we adjusted . . . and . . . we made it.

As a researcher, there were changes as well. Conferences were now virtual, and so, pending on presentation times, I saw myself waking up at odd hours to give "live" presentations on Zoom/Google Meet/WebEx or other platforms and fielding questions all online. It was different. I used to love traveling to conferences, getting acclimated to my surroundings, sight-seeing, eating wonderful food, and, most of all, meeting new potential friends and future collaborators. This was all, for the most part, nonexistent for virtual conferences. But life goes on. I think all researchers are looking forward to attending conferences again, and I appreciate all of the hard work many conference organizers have had to put in to make these virtual events work.

I think all researchers are looking forward to attending conferences again, and I appreciate all of the hard work many conference organizers have had to put in to make these virtual events work.

I had the privilege of attending, chairing, and presenting at the IEEE International Conference on Systems, Man, and Cybernetics, originally slated to be held in Toronto in the middle of October. This is a massive event! Hats off to all of the organizers for quickly being able to switch to an online platform to host such a large event.

One concern that I think all Canadians have realized is a paramount issue: data security and data privacy. All of a sudden, whether people like it or not, we are doing a lot more things online—from ordering nonessential items from stores to paying your house taxes—that we used to be able to do in person at a counter. There has been talk amongst people in the security and privacy research community that North America is planning to follow suit with something similar to the General Data Protection Regulation (GDPR), which was adopted in Europe a few years ago. This would be something that would at least give some level of consistency to our continent, which has not been able to agree on much in the form of data privacy regulations.

This edition of *IEEE Canadian Review (ICR)* features cybersecurity in the context of electric power grids—authored by Yanan's team at BC Hydro. In addition, a thought-provoking article by Darshika G. Perera puts the spotlight on data analytics in next-generation edge computing. In this edition, we

façon dont nous avons fourni du contenu. L'enseignement en ligne dans certains établissements était régulier avant COVID-19, de sorte que ces professeurs, enseignants et instructeurs étaient en avance sur la courbe dans la mesure où être en mesure de fournir du contenu en ligne à leurs étudiants. Pour beaucoup, cependant, c'était un revirement rapide d'apprendre à donner des cours avec succès d'une manière sans grand-chose, voire aucun, contact en face-à-face. Je l'ai embrassé. J'ai appris rapidement à écrire à l'écran et à offrir des cours que j'aurais déjà dispensés à l'aide d'un tableau blanc en raison d'un fort besoin d'un fond mathématique. Néanmoins, tant les étudiants que les instructeurs peuvent dire . . . nous nous sommes ajustés . . . Et . . . On a réussi.

En tant que chercheur, il y a eu également des changements. Les conférences étaient désormais virtuelles, et donc, en attendant les heures de présentation, je me suis vu me réveiller à des heures impaires pour donner des présentations «en direct» sur Zoom / Google Meet / WebEx ou d'autres plates-formes et répondre à des questions en ligne. C'était différent. J'adorais voyager à des conférences, m'acclimater à mon environnement, faire du tourisme, manger de la bonne nourriture et, surtout, rencontrer de nouveaux amis potentiels et de futurs collaborateurs. Tout cela était, pour la plupart, inexistant pour les conférences virtuelles. Mais la vie continue. Je pense que tous les chercheurs ont hâte d'assister à nouveau à des conférences, et j'apprécie tout le travail acharné que de nombreux organisateurs de conférences ont dû faire pour que ces événements virtuels fonctionnent.

J'ai eu le privilège d'assister, de présider et de présenter la Conférence internationale de l'IEEE sur les systèmes, l'homme et la cybernétique, qui devait initialement se tenir à Toronto à la mi-octobre. C'est un événement énorme! Chapeau à tous les organisateurs pour être rapidement en mesure de passer à une plate-forme en ligne pour accueillir un événement d'une telle taille.

Je pense que tous les Canadiens se sont rendu compte d'une question primordiale: la sécurité des données et la confidentialité des données. Tout à coup que les gens le veuillent ou non, nous faisons beaucoup plus de choses en ligne—de la commande d'articles non essentiels dans les magasins au paiement de vos taxes d'habitation—que nous étions en mesure de faire en personne à un comptoir. Les gens du milieu de la recherche sur la sécurité et la protection de la vie privée ont dit que l'Amérique du Nord avait l'intention de faire de même avec quelque chose de semblable au Règlement général sur la protection des données (GDPR), adopté en Europe il y a quelques années. Ce serait quelque chose qui donnerait au moins un certain niveau de cohérence à notre continent, qui n'a pas été en mesure de s'entendre sur beaucoup sous la forme de règlements sur la protection des données.

Cette édition de la revue canadienne l'IEEE (RCI) présente la cybersécurité dans le contexte des réseaux électriques, rédigée par l'équipe de Yanan de BC Hydro. En outre, un article stimulant de Darshika G. Perera met en lumière l'analyse de données dans l'informatique de pointe de nouvelle génération. Dans cette édition, nous récompensons plusieurs prix et distinctions externes reçus par nos membres. Les chroniques régulières de Dario Schor et Terrance Malkinson

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A Few Words From the Associate Editor / Quelques mots de l'éditeur associé

(A Few Words From the Associate Editor cont'd from p. 5)

(Quelques mots de l'éditeur associé suite de p. 5)

recognize several external awards and accolades received by our members. Regular columns by Dario Schor and Terrance Malkinson focus on contemporary matters in diverse fields of engineering and society. Wolfram Lunscher and Rob Haddow write an interesting article on "fox hunting," for which I don't want to spoil the suspense just yet. We have updated the roster to reflect the recent reorganization that took place at IEEE Canada. Last but not the least, we want to bring back good jokes and humor to our readers. David Green's "We Just Couldn't Resist . . ." is aimed just for that.

If you have enjoyed reading this issue of ICR and are interested in getting involved with our ongoing efforts, please reach out to me personally, any of our editors, or Editor-in-Chief Jahangir Khan, who has taken the lead in transforming ICR. As an IEEE volunteer myself, it is very rewarding to work with our team at ICR, and I hope that you as an IEEE Canada member can also connect with ICR in some way as well. All the best to you in 2021! ■

se concentrent sur des questions contemporaines dans divers domaines de l'ingénierie et de la société. Wolfram Lunscher et Rob Haddow écrivent un article intéressant sur la «chasse au renard», pour lequel je ne veux pas encore gâcher le suspense. Nous avons mis à jour la liste pour refléter la récente réorganisation qui a eu lieu à l'IEEE Canada. Dernier point mais non le moindre, nous voulons ramener de bonnes blagues et de l'humour à nos lecteurs. «Nous ne pouvions tout simplement pas resister. . . » est destiné juste à cela...

Si vous avez aimé lire ce numéro de la RCI et que vous êtes intéressé à vous impliquer dans nos efforts continus, veuillez me joindre personnellement, joindre l'un de nos rédacteurs en chef, ou au rédacteur en chef Jahangir Khan, qui a pris la tête dans la transformation de la RCI. En tant que bénévole de l'IEEE moimême, il est très gratifiant de travailler avec notre équipe de la RCI, et j'espère qu'en tant que membre de l'IEEE Canada, vous pourrez également communiquer avec la RCI d'une manière ou d'une autre. Tout le meilleur pour vous en 2021! ■

IMPORTANT UPDATES

IEEE Canadian Review (ICR) is now a "default-digital" publication.

What does this mean?

- All IEEE Canada members will receive *ICR* in digital formats, either through the website or through the
- Members who have explicitly requested not to receive electronic communication will not receive the digital copies. Default mail delivery of print copies will be discontinued to those members in the future. Members are encouraged to opt in for print copies, or modify their electronic communication preferences to receive digital copies.
- A print copy will be delivered only to those full-grade members who request it. This will be provided free of additional costs (included in the annual membership fee).
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IEEE Canadian Foundation

Creating an Endowed Scholarship Via the **IEEE Canadian Foundation**

You don't have to be a millionaire or a business holding a substantial surplus to create a lasting legacy that benefits Canadian students studying in IEEE fields of interest. By endowing a scholarship, you can achieve this goal, see the immediate benefits of your gift, and receive an income tax benefit.

Benefits for You or Your Organization

- Recognition: Receive acknowledgement from peers and IEEE colleagues.
- *Tax benefits*: Gifts to the IEEE Canadian Foundation may be income tax deductible.
- Brand building: Corporate philanthropic gifts are not commercial sponsorships but are recognized in keeping with the level
- Longevity: You can continue making a difference far into the
- Engagement: Meet with the recipients, when it is geographically convenient.
- Appreciation: Express your gratitude for a career that has treated you well.
- *Honour*: Show respect to a family member or mentor who has supported you along the way.
- Philanthropic spirit: Nourish a spirit of philanthropy in your family.

Several endowed scholarships have been established with the IEEE Canadian Foundation, including the most recent, the Gargantini-Strybosch Scholarship, for which the inaugural recipient is announced here.

How to Begin

With an endowed scholarship, you donate to the IEEE Canadian Foundation for a specific purpose. The fund is established to be enduring so that the principal is retained to achieve investment income as a consistent source of aid to students.

The IEEE Canadian Foundation will assist you in developing a directed gift memorandum, which records the details. You can choose the name for your scholarship and set the criteria for selection, consistent with overall IEEE aims and good scholarship practices. The criteria will outline the attributes and outcomes that are important to you. (Practical tip: Don't be too narrowly focused so that students feel daunted by high, overly specific requirements.)

How to Fund

An endowed scholarship need not be funded immediately. Pledges over time and gifts from family, friends, colleagues, past students and mentees, employers, and home Sections and Societies can all help build the endowment.

The larger your endowment is the more it will earn when invested and the greater good it will do. As a planning rule of thumb: each \$20,000 endowed will support an enduring annual scholarship of \$1,000. Most of the gifts are received as cash and receipted as such for Canadian tax purposes. However, you can also donate appreciated assets with additional tax benefits to you while the IEEE Canadian Foundation receives the full amount. Consult your financial advisor for details.

If you would like assistance or more information regarding an endowed scholarship, please contact Treasurer Luc Matteau (l.matteau@ieee.org), Vice President of Development Anader Benyamin-Seeyar (anader.benyamin@ieee.org), or President David Whyte (d.whyte@ieee.org) to help guide you through this process, in confidence. It helps to consider in advance what you hope to achieve, the amount and options for funding, the tax benefit to you, and the satisfaction you'll receive from your gift.

2020 IEEE Canadian Foundation Gargantini-Strybosch Scholarship Inaugural Award Given to Omer Abubaker, University of Ottawa



Irene Gargantini-Strybosch, **IEEE Life Member, London** Section.

This scholarship realizes the vision of Irene Gargantini-Strybosch, an IEEE Life Member, London Section, and professor emeritus at Western University. She is the first woman in Canada to chair a computer science department.

Students in good academic standing in fields of interest to IEEE and who are entering their second year of an undergraduate program at a Canadian university are eligible. Nominees must also be the first generation in their immediate family to attend a university (siblings excepted).

Selection criteria includes the following. Nominees should

- be bright, in a broad well-rounded sense, not just academic course marks
- show integrity, the fundamental values of which are honesty, trust, fairness, respect, responsibility, courage, as well as trustworthiness; these values are central to the development and sharing of knowledge
- be engaged with their community, e.g., electrical and computer engineering, the humanitarian use of technology, campus life, on local, national or international levels
- show ommitment and enthusiasm for undergraduate study in fields of interest to IEEE.

Ms. Gargantini-Strybosch shares her vision for this scholarship. "I was born in a family that highly valued education and in a country where access to a university was based on qualifications—the annual fee being only a token amount," said Ms. Gargantini-Strybosch.

"I believe in the just-mentioned approach regarding the admission to postsecondary studies; peripheral tasks not essentially related to the acquisition, development, or dissemination of knowledge should be left to the private sectors, which may be eager to establish and maintain extra curriculum activities in exchange for a visible promotion," she continued.

"I was given the opportunity—thanks to my family and my country-to enjoy learning at the highest level; I would like to help extending this wonderful gift to some meritorious people. IEEE embeds disciplines that can most directly and fairly quickly benefit humanity; this is the reason why I chose IEEE for my modest contribution," Ms. Gargantini-Strybosch said.

Inaugural recipient Omer Abubaker expresses his appreciation for receiving the scholarship: "I would like to thank the Canadian Foundation Board of Directors for accepting my nomination. I would also like to thank Ms. Irene Gargantini-Strybosch for initiating this scholarship and recognize her efforts for empowering first-generation university students to excel in their studies," he said. "Being the recipient of the inaugural award comes with great pride and motivation, in addition to support for achieving my educational and career goals. I am also proud to call myself an IEEE Member; being a part of IEEE has given me access to various resources and a community to strengthen my love with this field. I look forward to further being involved within the IEEE community during my studies and professional career."

Prof. Miguel Garzon, LTA Faculty of Engineering, University of Ottawa, nominated Abubaker for the scholarship. "Omer



Omer Abubaker, IEEE Student Member, Ottawa Section.

is, without question, one of the most motivated and hardworking students I have taught at the University of Ottawa," he wrote in his nomination. "On a personal level, Omer is a well-disciplined student with a pleasant personality. Throughout his academic career, Omer demonstrated great motivation and initiative. I must also make note of Omer's involvement in the Computer Science Student Association, seeking to create an environment where the students can help each other and enjoy their time."

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Reconfigurable **Architectures for Data Analytics on Next-Generation Edge-Computing Platforms**

by Darshika G. Perera, University of Colorado, Colorado Springs, USA

n the Internet of Things (IoT) era, there will be an enormous amount of data generated from various sensors and other similar devices physically distributed throughout networks and systems, such as smart grids, smart homes, and autonomous vehicles [1], [2]. Today, most of these networks (or systems) often collect and send these data directly to the cloud infrastructure, which comprises centralized data centers for processing, analyzing, and storing the data. However, traditional cloud infrastructures face serious challenges when transmitting, processing, and analyzing this massive amount of data. As illustrated in Figure 1, these challenges include insufficient bandwidth, high latency, unsatisfactory real-time response, high power consumption, and privacy-protection issues [3]. Edge-centric computing is emerging as a complementary solution to address the aforementioned issues of the cloud infrastructure [4], thus reducing (or eliminating) the overall communication overhead and response latency of the corresponding networks and systems and enhancing

the performance (i.e., processing power) and the scalability of systems [5].

Edge Computing

With edge computing, data processing and analysis can be done closer to the source of the data (i.e., at the edge of the networks, as shown in Figure 2), which, in turn, enables real-time, in situ data analytics and processing [1], [2]. Furthermore, preprocessing the data at the edge, prior to sending these data to the cloud, addresses the insufficient bandwidth issues [4]. Processing and analyzing the data at the edge can also enhance the privacy and security of the data compared to that of the cloud infrastructure because the raw data are not transmitted through unsecured networks of the cloud [4]. In addition, wireless communication modules utilized to transmit the data from the edge devices to the cloud are often power hungry, whereas the edge devices are typically energy constrained; hence, performing some data analytics

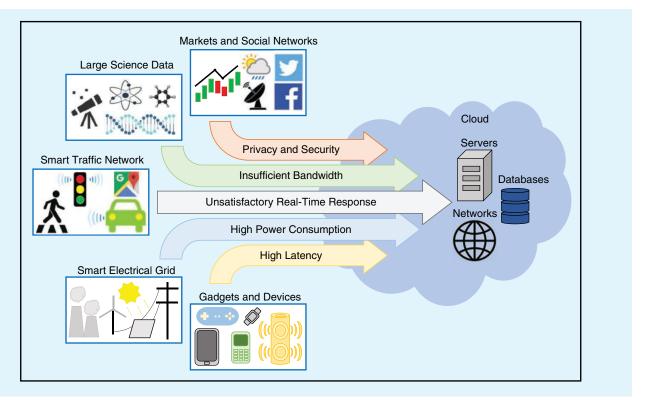


Figure 1: A conventional cloud infrastructure faces serious challenges when transmitting, processing, and analyzing massive amounts of data generated from variety of sources. These challenges include insufficient bandwidth, high latency, unsatisfactory real-time response, high power consumption, and privacy-protection issues.

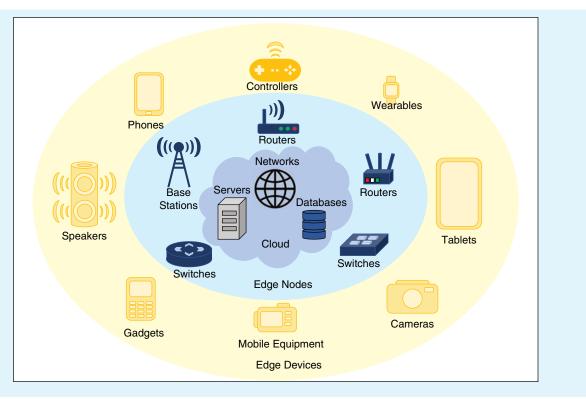


Figure 2: The concept of edge computing. The cloud infrastructure often consists of large data centers, server farms, and data storage. The cloud infrastructure can be used as the final stage for processing, analyzing, and storing big data. The edge nodes typically consist of routers, base stations, and switches. The edge nodes can be used as the intermediate stage for certain types of data analysis/mining prior to sending the data to the cloud. The edge devices usually consist of wearables, smartphones, cameras, and many other smart devices. The edge devices can be used as the initial stage for real-time data processing, including data preprocessing, data filtering, optimization, on-the-fly decision making, and so on. The edge devices comprise various sensors for real-time data collections. The edge devices can be used to connect to the cloud, either via edge nodes or directly.

and processing at the edge would be more energy efficient [1].

Real-Time Data Analytics

In many scenarios and often in experimental setups, data scientists and data analysts process enormous amounts of data without considering the real-time constraints. In these cases, the data are typically being processed offline (not in real time) for days, or even months, depending on the processing power of the computing platforms utilized. However, for many real-world scenarios, the data need to be processed in situ with real-time constraints, and the results must be available within strict time limits, for the subsequent analysis or actions to reap the actual benefits [6]. Real-time and in situ data analysis and processing are imperative in many edge-computing applications, including smart energy grid management and autonomous vehicles. For instance, autonomous vehicles typically produce gigabytes of data per second, and these data need to be processed in real time for these vehicles to make correct, split-second decisions on the fly [1]. In this case, the high (round-trip) latency associated with sending the data to the cloud and processing and receiving a response can lead to catastrophic scenarios [1].

Issues of Processor-Based Systems

Most of the existing algorithms and techniques for data mining/analytics are typically processor-based, software-only designs [7], [8]. They are designed for general-purpose computers (such as desktops and servers) and consist of CPUs; thus, they are often incapable of analyzing and processing enormous amounts of data efficiently and effectively. As a result, these software algorithms and techniques might be incapable of being executed directly on next-generation edge-computing platforms in their current form. These processor-based designs have high execution overhead because each instruction has to be fetched from the memory, decoded, and then executed [9]. Furthermore, due to this instruction fetch-decode-execute cycle overhead and because of general-purpose circuits, the power consumption of a processor-based design is much higher than special-purpose (or customized) hardware [9]. A survey done in [10] demonstrated that pure processor-based, software-only computing platforms, including multiprocessor, multicore, general-purpose GPUs, are

simply not sufficient to handle this enormous amount of data.

As stated in [11] and [12], at the edge, the processing power needed to analyze and process such an enormous amount of data will soon exceed the growth rate of Moore's law. As a result, edge-computing frameworks and solutions, which currently solely consist of CPUs, will be inadequate to meet the required processing power. Although they could potentially meet the processing power requirements, GPUs are extremely power hungry and have limited energy efficiency [13].

Need for Novel Solutions

All of the aforementioned facts illustrate that the existing algorithms and techniques used for data mining/analytics and the conventional computing platforms utilized for current edge-computing platforms will not suffice to process and analyze this ever-increasing data as well as to

tion, high-performance processors often consume high power [9]. Also, customized circuits are usually function specific and occupy less hardware space on a chip compared to the circuitry of a generalpurpose processor. As a result, they are more suitable for resource-constrained edge-computing platforms.

Reconfigurable Architectures

To provide the flexibility required in an ever-changing application environment, it is also crucial to incorporate reconfigurable (adaptive) hardware (and/or software) architectures into next-generation edge-computing platforms. Reconfigurable hardware has advantages similar to those of special-purpose hardware: providing efficient and customized circuits and avoiding the instruction fetch-decodeexecute cycle overhead as in a processor, thus leading to low power and high perfor-

Real-time and in situ data analysis and processing are imperative in many edge-computing applications, including smart energy grid management and autonomous vehicles.

handle the associated complex computational problems efficiently and effectively.

Consequently, novel, unique, and innovative architectures, methodologies, and techniques are required to propel edge computing from its infancy to support and accelerate real-time, in situ data mining/ analytics on next-generation edge-computing platforms that are heterogeneous in nature, considering the constraints associated with the computing platforms and requirements of the edge applications.

Special-Purpose Architectures

In this case, apart from algorithmic development, it is imperative to incorporate some special-purpose (or customized) hardware (and/or software) architectures and techniques into next-generation edge-computing platforms. Unlike general-purpose, process-based designs, customized hardware architectures are optimized for specific applications and avoid the instruction fetch-decodeexecute cycle overhead. Furthermore, special-purpose hardware provides superior speed performance and consumes less power than equivalent software running on a general-purpose processor [9]. As operating frequency is directly proportional to dynamic power consump-

mance [9]. Apart from having advantages similar to those of customized hardware, reconfigurable computing systems, such as field-programmable gate arrays (FPGAs), have added advantages, including reusing the on-chip hardware circuitry to perform variety of tasks and reducing the time to market and design time due to their flexibility and programmability postfabrication. Our analysis [9] demonstrated that FPGA-based reconfigurable hardware provides numerous advantages, including flexibility, durability, upgradeability, compact circuits, reduced time to market, and relatively low cost, which are important to support real-time, in situ data analytics/mining on next-generation edge-computing platforms. In this case, multiple applications and tasks can be executed on a single FPGA by dynamically reconfiguring the hardware on chip from one application/task to another as needed.

FPGA-Based Edge Computing

Several studies illustrate that FPGA-based systems are being considered as viable solutions for future edge-computing platforms and devices [14], [15]. There are several key advantages to adopting FPGAs for edge computing over other computing systems. For instance, FPGAs provide superior performance because

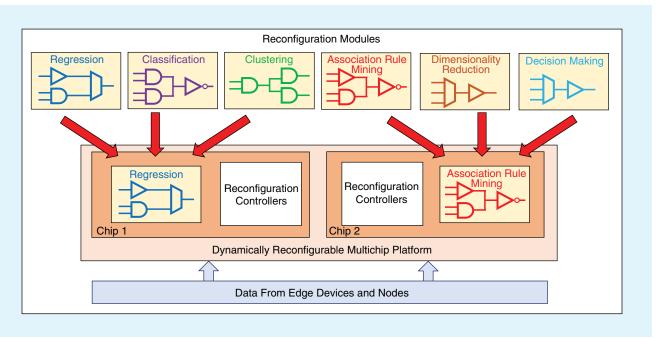


Figure 3: An overview of the next-generation edge-computing platform. As shown, this platform will comprise multiple FPGAs. Also, architectures and techniques will be created to dynamically reconfigure the whole platform globally, and to dynamically reconfigure some systems (e.g., individual chips) locally, to provide the necessary self-adaptive, self-healing, and self-correcting traits as well as the postdesign and postdeployment optimizations and upgrades required for edge applications. Based on the requirements of the edge application, different data analytic/mining algorithms (shown in the reconfiguration modules) will be dynamically swapped in and out of the multichip platform to perform a variety of applications/tasks.

they leverage spatial and temporal parallelism and fine- and coarse-grain parallelism in computations and in massive scale [16]-[18], which, in turn, would accelerate high-concurrency, high-dependency algorithms and applications at the mize the features and resources as needed, and adapt to any algorithmic characteristics, which is important for edge workloads and applications [21]-[23]. The aforementioned facts illustrate that FPGA-based systems comprise numerous traits and

As operating frequency is directly proportional to dynamic power consumption, high-performance processors often consume high power.

edge [12]. In addition, FPGAs typically provide a steady throughput to the application's workload size (unlike GPUs) and also with a reduced latency, which is imperative for integrating and addressing requests from various IoT sensors (or devices) in the network [19]. Furthermore, FPGAs consume significantly less power than that of CPUs and GPUs to execute the same edge applications, which is crucial for small-footprint edge devices/platforms [20]. Most importantly, FPGAs provide hardware flexibility (i.e., reconfigurable postfabrication); hence, with FPGA-based edge computing, we can dynamically upgrade processing power, enable scalability, modify and opti-

advantages that are important for realizing next-generation edge-computing platforms.

Envisioning Next-Generation Edge-Computing Platforms

We envision that next-generation, heterogeneous edge-computing platforms will ultimately consist of multiple computing systems, especially including multiple FPGAs that provide the required reconfigurability, and also GPUs, applicationspecified integrated circuits, and CPUs. These multiple systems will be distributed throughout the platform with distributed and shared memory systems and connected by a network of interconnections. Furthermore, we envision that novel and innovative techniques and methodologies will be introduced and incorporated to make next-generation edge-computing platforms smart and autonomous enough to seamlessly and independently process and analyze data in real time, with minimal or no human intervention. As illustrated in Figure 3, the architectures and techniques will be created to dynamically reconfigure the whole platform globally, and to dynamically reconfigure some systems locally, to provide the necessary selfadaptive, self-healing, and self-correcting traits required for edge applications. The global and local reconfigurations (as in Figure 3) will be performed dynamically without interrupting the system operations. The interconnection network will also be reconfigurable. We also envision that machine and deep learning techniques will be created and incorporated to further enhance the smart, autonomous, and adaptive features of the next-generation edge-computing platforms.

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About the Author



Darshika G. Perera (darshika.perera@uccs.edu) is a fellow Canadian. She received her Ph.D. degree in electrical and computer engineering from the University of Victoria, Canada, and her M.Sc. and B.Sc. degrees in electrical engineering from the Royal Institute of Technology, Sweden, and the University of Peradeniya, Sri Lanka, respectively. She is currently an assistant

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Ottawa ARDF Group Fox Hunt Demonstration

by Wolfram Lunscher, LSMIEEE, and Rob Haddow, **Ottawa Valley Mobile Radio Club**

aturday, 19 September 2020, found the Ottawa Amateur Radio Direction Finding (ARDF) Group setting up in Walter Baker Park in Kanata for the first official ARDF demonstration event, alongside the Ottawa Amateur Radio Club (OARC) "Radio in the Park" event. ARDF is also known as fox hunting, transmitter hunting, bunny hunting, and radio-orienteering. Please note that none of these activities actually involve the hunting of animals!

The Ottawa ARDF Group displayed new equipment that they had purchased and built with IEEE funding, allowing key sponsors, target audience groups, and local area hams to try it out by searching for five minitransmitters hidden in the park area. Though a bit chilly in the morning, it was a beautiful, sunny day dominated by a blue sky. The demonstration event was attended by 18 representatives from a diverse range of interested parties, including the IEEE Ottawa Section, adult leaders and Scouts from local Scouts Canada troops, organizers from the Christie Lake Kids youth outreach organization, and Orienteering Ottawa leadership. Local amateur radio operators also took part.

A short introductory brief was given to each group of fox hunters; the introduction included an emphasis on the science,

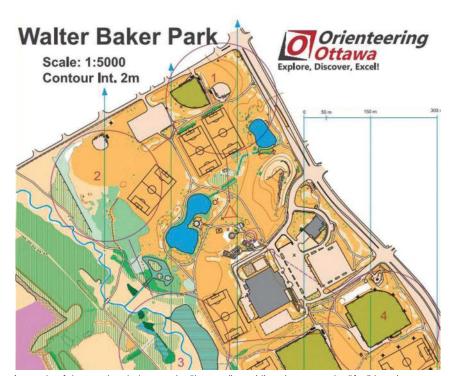
technology, engineering, and mathematics (STEM) aspects of radio direction finding and an explanation on using the equipment to find the "fox." The five hidden transmitters were spaced widely throughout the park, making for an exciting, energetic adventure in the crisp outdoors. It was a novel experience clearly enjoyed by all participants, making for a 100% successful demonstration of transmitter finding for the target audience. There were immediate requests for setting up more events!

All current COVID-19 measures were maintained, and the equipment was cleaned between uses. Masks were worn by all attendees when at the registration and briefing area. All participants returned, having successfully found the hidden transmitters.

The purchase of the transmitters, receivers, and antennas used to deliver this program was largely funded by the IEEE Life Member Fund through a special project grant of \$2,916, requested and administered by the Ottawa Section. IEEE was interested in promoting this program because it will expose young people (ages 11 and up) to technology that will increase their awareness of STEM and possibly lead them to explore STEM careers in their future. This also provides a multigenerational opportunity for IEEE Members, including Life Members, to mentor the community in radio technology.



(From left) Roger Egan, OVMRC/OARC (VA3EGY); Emily Panter, OARC (VE3EMI); Wolfram Lunscher, IEEE Ottawa Section, holding the three-element Yagi receiver; and Harrie Jones, OARC (VE3HYS).



A sample of the map handed out to the "hunters" providing clues as to the "fox" location.

As the day's activity has successfully shown, this outreach included Scouts Canada, Guides Canada, Cadets, and school-sponsored activities. Interest was also expressed by the Orienteering Ottawa Club, whose members run with maps and compasses to locate hidden targets. Of course, since transmitter hunting is an outdoor activity, it also encourages a healthy, active lifestyle.

The Ottawa ARDF Group was formed by Roger Egan (VA3EGY), special events coordinator for the Ottawa Valley Mobile Radio Club (OVMRC), in the fall of 2019 and is made up of Ottawa amateur radio operators, mainly from the OVMRC and OARC, with an interest in ARDF. Since its formation, the group has been building a collection of world-class ARDF equipment, such as three-element flexible Yagis and the purchase of 12 Sniffer mk4 receivers specifically designed and built for ARDF. The group also arranged for the bulk purchase of KC9ON offset attenuators and held a build session at the University of Ottawa Makerspace in early spring.

The direction-finding receivers incorporated the new Kerberos four-channel software-defined radio. This made for a very compact and easy-to-use portable



The (a) mini Byonics transmitter and (b) small orange-and-white flag with "Q" code used to identify the transmitter's location.

system that anyone without transmitter hunting experience could successfully use to find the target. Roger made the tubes to safely store the mini transmitter, easily allowing it to be secured to a tree or fence. The transmitters are Byonics with a mini antenna to lower the effective radiated power.

Transmitter locations were discreetly concealed but not too hidden. Small orangeand-white orienteering flags marked the transmitter location along with a "O" code label that participants had to copy down to confirm they had found each "fox."

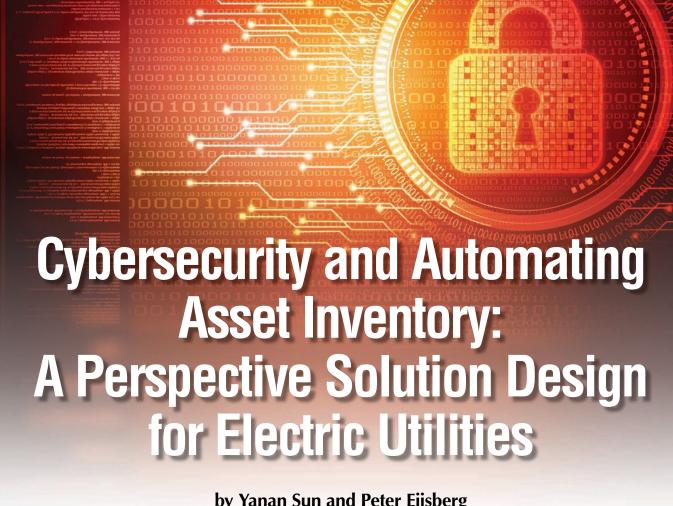
For further information on ARDF and for details of upcoming local events, check out ARDF Ottawa's brand-new website at https://www.ARDFOttawa.ca.

About the Author



Wolfram Lunscher is a retired spacecraft instrumentation engineer with a B.Sc. degree in physics (1974) from the University of

Toronto and B.A.Sc. (1980) and M.A.Sc. (1983) degrees in electrical engineering from the University of British Columbia. He is an associate fellow of the American Institute of Aeronautics and Astronautics and a Life Senior Member of IEEE. As an active member of the IEEE Ottawa Section, he chairs the local Teacher-in-Service Program Committee and the Life Member Affinity Group.



by Yanan Sun and Peter Eijsberg

his article investigates the design of an automated asset management solution that is applicable in industrial control systems (ICSs) for electric utilities, with a primary focus on cybersecurity. The design is a part of a research study at BC Hydro to investigate asset inventory solutions for operational technology (OT) cybersecurity.

Background: What Is a Typical Electric Power Grid Structure? How Does It Work?

The electric power grid is used by electric utilities to deliver energy to their customers (e.g., residential and industrial customers). As illustrated in Figure 1, a power grid consists of generation systems, transmission systems, distribution systems, and customers. The generation systems refer to the energy production facilities, including conventional power plants and renewable resources. The transmission systems transport the bulk electric energy from the production facilities over long distances and high voltages to consumption areas. The distribution systems step down the voltage and allow the electric energy from the transmission system to be delivered to the actual customers. The power grid is generally managed by operation centers, where they depend on various ICSs, such as supervisory control and data acquisition (SCADA) systems as well as the use of communication technologies for centralized monitoring and operational decision-making. For example, the use of SCADA enables the operation center to remotely monitor and control substation operations through remote terminal units and intelligent electronic devices to guarantee reliable energy dispatch to the customers.

Why Do We Need an Asset **Management Solution? What Does the Solution Provide?**

Cybersecurity is fundamental to guaranteeing the reliable operation of electric power systems. Driven by the need to increase business processes and operational performance, electric utilities' ICSs are increasingly adopting IT solutions to improve remote access capabilities [1]. However, the convergence of OT and IT has significantly changed the cybersecurity landscape of ICSs. This is further complicated by legacy control systems and the unique device characteristics

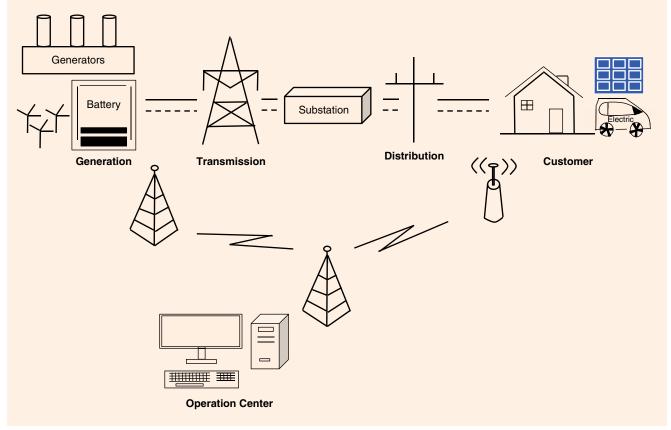


Figure 1: A typical electric power grid structure.

that have made ICSs more vulnerable to cyberthreats. Various incidents (e.g., the attack on Ukraine's power grid) have demonstrated the vulnerability of ICSs to cyberattacks and the potential severe consequences associated with those successful attacks [2], [3]. Taking into consideration the evolving threats and emerging vulnerabilities, electric utilities need to employ effective security mechanisms to protect ICSs from cybersecurity breaches.

Maintaining accurate asset inventory is a primary building block for electric utilities to achieve OT/ICS security. It is necessary for electric utilities to be equipped with knowledge about their OT assets before they can protect these assets from cyberthreats. With the recent alert from the National Security Agency and Cybersecurity and Infrastructure Security Agency, it is highly recommended that electric utilities look into automating their asset inventory to identify, monitor, and control ICS devices in real time [4]. The need for electric utilities to increase visibility into their OT assets and configurations requires an OT asset management solution with the following capabilities:

■ Asset discovery: identifies ICS devices to establish an asset inventory, along with characteristics such as the manufacturer, model, physical and logical

- addresses, and software and firmware versions.
- Asset management: detects and manages any changes in ICS devices and configurations for operational decision making.

The importance of such an OT asset management solution for ICS cybersecurity can be highlighted through mapping to the National Institute of Standards and Technology Cybersecurity Framework [5]:

- *Identify (ID)*: asset management (ID. AM), governance (ID.GV), and risk assessment (ID.RA)
- Protect (PR): data security (PR.DS) and protective technology (PR.PT)
- Detect (DE): anomalies and events (DE.AE) and security-continuous monitoring (DE.CM).

This OT asset management solution can be further leveraged to provide respond (RS) and recover (RC) functions.

How to Design the Asset Management Solution? What Are the Challenges?

Asset discovery techniques and intrusion detection systems (IDSs) are relatively mature for cybersecurity in the IT space. They cannot, however, be directly migrated to an OT environment for inventory management and anomaly detection. This is due largely to the fundamental differences in device functions and communication patterns as well as security-operation considerations among IT and OT environments, as summarized in Table 1. Automating OT asset management thus requires

Table 1: A comparison of IT and OT environments as well as security considerations.

	IT	OT
Environment	Dynamic	Deterministic
Characteristics	Focused on data	Focused on processes
Security Considerations	Confidentiality, integrity, and availability	Availability, integrity, and confidentiality
	Patch management on a regular basis (patch Tuesday)	Patching happens only occasionally and might not be supported by legacy devices

Table 2: A comparison of the passive and active approaches for device fingerprinting.

	Passive Approach	Active Approach
Pros	Nonintrusive; does not generate additional communication traffic/device overhead	High accuracy in device fingerprinting and capable of obtaining extensive device information
Cons	Information depends on the device's communication traffic; might obtain limited useful information	Generates additional traffic and device overhead; might interrupt the device's normal operation
Applicable to an ICS/OT environment	Preferred as it incurs no impact on the device's operations	Not preferred as it can potentially interfere with the device's operations

the development of techniques and solutions that are applicable in the electric utilities' ICS environment.

For OT asset discovery, devicefingerprinting methods that are commonly used in the IT domain for asset identification can be adapted to the ICS environment. Generally, device-fingerprinting methods can be classified into passive or active approaches [6]. A passive approach refers to fingerprinting a device through passively monitoring and analyzing network traffic, while an active approach refers to fingerprinting a device by actively probing with specially crafted queries (e.g., SNMP probes). A comparison between passive and active approaches as well as their relevance to ICS/OT environments is listed in Table 2. Considering that safety and availability are the first and foremost priority in OT environments, the passive fingerprinting approach is preferred for ICS device discovery. Moreover, several characteristics of ICSs, including device heterogeneity, proprietary protocols, and legacy technologies, need to be addressed when developing ICS-specific device-fingerprinting techniques for asset discovery.

For OT asset management, conventional IDS solutions implemented in the IT environment can be tailored for ICSs to detect potential attacks and threats. Based on the approaches used to detect intrusions, the IDS solutions developed for OT environments can be categorized into two groups: protocol- and trafficbased IDSs. Protocol-based IDSs detect intrusions by parsing industrial protocols such as DNP3 [7] and GOOSE [8] to analyze whether protocol specifications have been violated. Protocol-based IDSs belong to a class of signature-based IDSs, where detection relies largely on defining specific rule sets. Traffic-based IDSs detect intrusion by analyzing network traffic based on different data mining

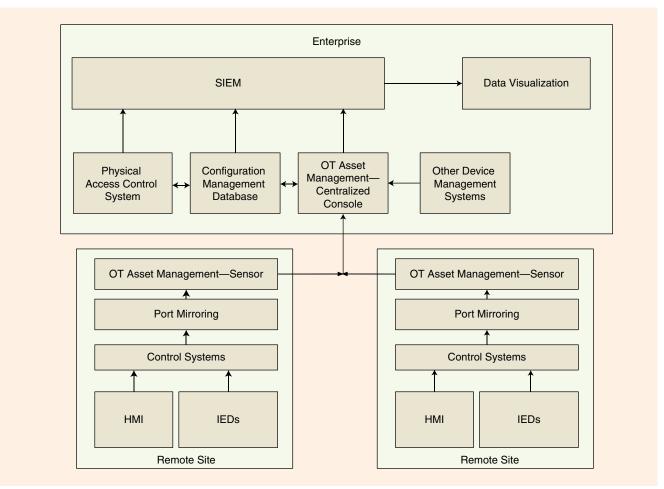


Figure 2: A high-level view of our proposed reference example solution. SIEM: security information and event management; HMI: human-machine interface; IEDs: intelligent electronic devices.

techniques [9], [10] to identify abnormal system behaviors. Traffic-based IDSs belong to a class of anomaly-based IDSs where traffic-based IDSs establish mapping between network traffic and system normal/abnormal behavior patterns. Protocol- and traffic-based IDSs can be integrated when used in practice to improve detection accuracy.

Overall, the successful design and implementation of an OT asset management solution for electric utilities requires knowledge about OT devices and processes as well as their cybersecurity implications for ICSs. It relies on the tight collaboration between the OT engineers and IT specialists to automate asset inventory in the ICS environment. Cross-functional coordination between OT and IT is critical to baseline ICS devices and monitor changes in the OT environment for real-time operational decisions.

What Is Our Proposed Solution?

Considering electric utilities' cybersecurity planning from a high level, any OT asset management solution needs to be integrated with existing IT security tools for centralized management. As illustrated in Figure 2, our proposed reference solution takes an integrated approach by consolidating information from OT, IT, and physical security tools to improve overall situational awareness for electric utilities. The OT asset data are collected and parsed from the remote ICS networks by the OT data monitoring/analysis sensor and then sent to the centralized OT asset management platform. The OT asset inventory and event logs are aggregated with the event logs from the physical and IT security systems in security information and event management for comprehensive situational awareness and centralized operational decision making.

To design the solution, we have identified key goals:

- Specify the objectives for OT asset information collection and solution integration. Some high-level design considerations, e.g., user requirements and technology gaps, should be addressed.
- Measure the effectiveness in terms of asset visibility and threat-detection efficiency. Some specific evaluation criteria, e.g., the accuracy of asset inventory, the detection rate, and the accuracy of the detection rate, should be quantified.

Addressing these goals can help establish and integrate an effective OT asset inventory solution to improve electric utilities' ICS cybersecurity.

Key Takeaways

Maintaining accurate asset inventory is the fundamental building block for electric utilities to establish an effective cybersecurity strategy. This requires an automated asset management solution where ICS devices can be identified, monitored, and managed in real time for OT security. Although asset discovery techniques and IDSs are relatively mature for cybersecurity in the IT space, they cannot be directly migrated to the

Cross-functional coordination between OT and IT is critical to baseline ICS devices and monitor changes in the OT environment for real-time operational decisions.

OT environment due to the fundamental differences in device functions and communication patterns as well as securityoperation considerations among IT and OT environments. The OT asset management solution requires the development of techniques and tools that are applicable in the electric utilities' ICS environment. Its successful implementation relies on the crossfunctional collaboration between OT and IT. Moreover, the OT asset management solution needs to be integrated with existing IT security tools for centralized monitoring and control to improve overall cybersecurity for electric utilities.

Acknowledgements

We would like to thank Dr. Sara Bavarian for providing guidance and feedback during the research study. We would like to thank Dr. Amir Rasti for giving comments and feedback on this work. This research study was supported by the Mitacs Accelerate Program.

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Yanan Sun received her B. Eng. degree in information engineering and her M.S. degree in systems engineering from Xi'an Jiaotong University, Xi'an, China, in 2011 and 2014, respectively. She received her Ph.D. degree in electrical and computer engineering from the University of British Columbia, Vancouver, British Columbia, Canada, in 2020. Currently, Yanan is a research intern at BC Hydro.



Peter Eijsberg received his master's degree in electrical engineering from Twente University, The Netherlands, and has been working for more than 25 years in the field of data communication and cybersecurity. He is currently a cybersecurity planner at BC Hydro.

Ashfaq (Kash) Husain

ike most engineering students, I was introduced to IEEE while attending electrical engineering classes at the Technical University of Nova Scotia, which is now a part of Dalhousie. Later on, when I worked for Nova Scotia Power, I became more familiar with IEEE when I got involved with design, research, and reading technical articles. Around 1989, I received a call from a friend who asked me to help with the IEEE Canadian Atlantic Section, based in Halifax. I agreed to come on board as the Section's secretary and continued in that role for a couple of years. I then moved into the treasurer's role, followed by vice chair and eventually chair. Little did I know that this introduction would lead to almost 30 continuous years of volunteerism with IEEE.

In 1995 I moved to London, Ontario, and joined the executive committee of the London Section. Unfortunately, at that time the London Section was inactive, and so I reached out to my contacts within the region and worked with people like Dave Kemp to rejuvenate the Section. While working in collaboration with other Sections in the Central Area, we ran the IEEE Canada Conference on Electrical and Computer Engineering for a number of years and held joint events.

In the late 1990s, I started to experience issues with my eyesight. I was diagnosed with retinitis pigmentosa, a degenerative disease of the retina; the symptoms include night blindness and loss of peripheral vision, acuity, and colour. The prognosis was eventual blindness. As a result of this diagnosis, in 2000, I left my position as senior electrical engineer with Dillon Consulting Limited and went on long-term disability. They say that when one door closes, another one opens, and in my case, that door was called volunteerism, which had already been opened by IEEE. With the support of my colleagues and friends within IEEE, I was able to continue to volunteer. For the next 18 years, I served



as treasurer for many IEEE conferences, took on the role of Central Area chair and then conference advisory committee chair, followed by treasurer for IEEE Canada and, finally, administrator for IEEE Canada until May 2019.

As a person newly diagnosed with a disability, I wanted to learn more, so I searched for answers about my diagnosis.

Working with Londoners with disabilities and city staff members, we established the City of **London's Accessibility Advisory Committee,** and I became its chair for the first four years.

I became aware of not only my own challenges but also of those faced by others in the disabled community. I realized that things had to change, so I began to volunteer with local organizations to improve the quality of life for my new community. Working with Londoners with disabilities and city staff members, we estabAshfaq (Kash) Husain a.husain@ieee.org

lished the City of London's Accessibility Advisory Committee, and I became its chair for the first four years. I still serve on that committee. Together, we raised awareness and educated our politicians, organized seminars and conferences, and accumulated funds for the nonprofit sector. None of this work would have been possible without the knowledge and experience I gained through volunteering with IEEE. Volunteering is a great way to learn not only technical knowledge but also behaviours and traits. You learn how to manage a situation, find your way through problems, and adapt yourself to unique circumstances, including issues about racism, disability, gender diversity, and minorities.

Sometimes I ask myself, why do I volunteer? The answer is not as simple as one would think. It's not just a calling or an obligation; there is more to it than that. When I feel something is wrong, I want to put it right. When I see someone who is oppressed, I want to elevate that person. When I see challenges, I want to overcome them and find solutions. Volunteering lays the foundation for learning; it takes you on a journey down a winding path, acquiring many skills along the way if you choose to seek them. Each journey is unique to the individual and promises to give back as much as you put in. It's much bigger than yourself and indeed heightens your strive for self-worth. It creates a bond with fellow engineers and draws you in to a larger community. It asks of you in abundance without asking for more than you can give, and in return, it wheels its magic and transforms you into better engineers. I highly recommend it.

Updates on COVID-19: What We Have **Learned and Where** We Might Be Going

by Terrance Malkinson

n 31 December 2019, Chinese health-care workers first announced to the World Health Organization (WHO) that a cluster of pneumonia cases had emerged in Wuhan, China. Gene sequencing revealed the agent to be a novel coronavirus related to the 2002-2003 SARS outbreak. In January 2020, it was determined that this new virus spreads through the air before symptoms appear. Wuhan was locked down, and new cases were reported in 21 countries. February saw outbreaks on cruise ships and an escalating spread around the world. The disease officially became COVID-19. In March, the WHO declared the outbreak a pandemic, which led to lockdowns throughout the world. The world became acquainted with the terms social distancing, flattening the curve, and masking.

Using an unprecedented multi-disciplinary global approach, scientists are working to determine how this virus spreads, how it causes disease, who is most vulnerable to disease, and its strengths and weaknesses. At the time of this report (January 2021), a number of vaccines have been created, tested, and approved by government health authorities. The initial limited supply of vaccine is being administered on a priority basis starting with health-care professionals, who are in close proximity their patients, and the elderly, who are the most vulnerable to infection and death. Other vaccines are entering the final stages of clinical trials and will soon be distributed. National governments are funding the purchase of vaccines and setting up logistics systems for distribution to their citizens.

Of concern is that poorer and lessdeveloped nations will be challenged in their ability to both purchase and distribute the vaccine to their people. Philanthropic organizations and some wealthier nations are stepping up to provide assistance to these nations. The COVAX plan (www.weforum.org/agenda/2020/09/ what-is-covax), coordinated by the WHO and other agencies, strives to procure and deliver doses of safe, effective, and approved vaccines for equitable distribution throughout the world. Currently, 156 economies representing nearly two-thirds of the global population have signed up. Countries will have guaranteed access to the world's largest portfolio of vaccine candidates. Canada is investing \$440 million into COVAX. This is the secondlargest contribution any country has made thus far.

In late December 2020, the WHO (www.who.int) issued a warning that future pandemics could be much worse than COVID-19. Despite its severity, this pandemic is not necessarily the big one. Dr. Mark Ryan, head of the WHO emergencies program, said an important lesson from this pandemic is that "we need to get ready for something which may be more severe in the future." Ryan also said that "there is a possibility of never eradicating COVID-19. The existence of a vaccine, even at high efficacy, is no guarantee of eliminating or eradicating this infectious disease." The likely scenario is that the virus will become another endemic virus that will forever remain a low-level threat. The WHO strongly believes that attempts to improve human health are doomed without tackling climate change and animal welfare. We are unprepared for future devastating pandemics, and we must learn from the COVID-19 pandemic. We need to understand and communicate the links among the health of humans, animals, and the planet. The science is clear that without real change, many more zoonotic diseases (diseases that jump from animals to humans) will occur and occur more frequently.

We have a long journey ahead, and there will be setbacks. Vaccine producers are trying to hit a moving target because viruses mutate as a natural biological mechanism used to survive. Indeed, at the time of this writing, a COVID-19 variant has emerged in the United Kingdom, which could be up to 70% more infectious than the current virus. There are now reports of variants emerging in other countries, and scientists are investigating whether the current vaccine will be effective against these variants.

There is good evidence that the vaccines will be both safe and effective. Even with the protection provided by the vaccine, it is likely we will be required to wear masks and will need to be diligent about personal hygiene and social distancing for months and perhaps years. One failure has been the marketing of ineffective masks and the improper use of masks by the public. To provide protection, masks must be of high quality, handled using sterile techniques, and used only once. Additionally, eyes should be covered by glasses or face shields.

Frequent showers are also recommended, particularly when returning from public spaces. Vaccinated people could be healthy but may still carry and spread the virus without displaying any symptoms. As COVID-19 vaccines are new, scientists do not know how long the protection will last. We have no long-term information on unexpected, adverse side effects.

COVID-19 has been particularly devastating to the elderly and to those of all ages who have pre-existing medical conditions. A most important lesson is the inadequacy of extended care accommodation for this group. COVID-19 and other infections have spread rapidly in care facilities because of overcrowding and well-meaning but under-paid and inadequately trained staff. All residents in these facilities should have their own room, bathroom facilities, and professional staff.

The public health-care system has also been devastated by COVID-19 because administrators and government have failed for many years to plan for an increasingly aging population. For many years, we have not had the capacity to meet current hospital care or surgical needs. Now we realize that we also do not have the elasticity of hospital space to deal with the significant health-care demands of this pandemic. Current politicians blame previous governments for underfunding but offer no solutions themselves. The reality is that some non-essential, high-cost, planned publicly funded infrastructure projects, such as professional sports arenas, convention centers, and new roadways and bridges may need to be cancelled or delayed. Public funds need to be used for supporting the more important urgent needs in health care, elder care, and education. Our strategy must be to increase health-care capacity quickly, starting with new state-of-the-art facilities and hiring skilled doctors, nurses, and support staff. We need to attract top talent into health-care professions and fewer, but more effective, managers of health care.

Borders may or may not open to travellers later in the year. Aircraft travel will be particularly complex, time-consuming, and expensive with multiple infection-mitigation procedures in place. Mandatory face coverings, pre-flight health testing, proof of vaccination (vaccination passport), less cabin baggage, lower levels of inflight service, and restricting unnecessary movements within the aircraft are all possibilities. Travel health and tripcancellation insurance is strongly encouraged. Governments have learned the importance of quickly closing borders and cancelling flights to areas where there is evidence of a large outbreak. International travel may never fully return or be 100% safe again. Until we defeat COVID-19 and its variants everywhere in the world, we defeat it nowhere.

Small businesses have been casualties of government restrictions during the pandemic. Many small businesses have closed, never to re-open because of owner fatigue, stress, and in many cases bankruptcy. Large box stores remained open and many expanded their offerings to include those which were previously the domain of small businesses. Many small business owners believe and correctly so that this was very unfair. New business models based on technology have and will likely continue to emerge, taking the place of brick-and-mortar stores. Consumers can search the web for any product or service, compare vendors and prices, make a selection, and have their needs met by next-day delivery to their doorstep. Government, business, and employee COVID-19 support programs and concessions by landlords and suppliers have, in most cases, simply delayed the inevitable.

Many workers have transitioned to the home office. It will be interesting if this will be the new normal. What will happen to the concept of teamwork and the sense of employee belonging and commitment to an organization? What emerges will significantly impact commercial real estate. Will the office tower be financially viable? Will building ventilation systems need to be upgraded? Will sealed window units need to be replaced with units that can be opened to the outdoors? The science is clear: Breathing the same air as others while indoors presents a real risk of virus infection. What will happen with crowded elevators and escalators? Will it be necessary to continue expanding roadways and public transit if commuting to work or shopping is reduced?

Urban planning will need to be reexamined along with uncontrolled world population growth. In recent years, large families and increasing density in urban centers has been the norm. Large numbers of people in close proximity facilitates the spread, as experienced in New York City and California. Large areas of the earth are being de-vegetated as land is annexed for development, and many animal species are extinct while many others face extinction. As vegetation is removed, land is paved/cemented over, and forest fires increase in frequency, how will carbon dioxide be removed and the oxygen necessary for our life be produced? Humans are but one form of life on the planet, and if we do not respect the importance of the planet's ecosystem and protect it, life will soon not be sustainable on this planet.

We have learned during COVID-19 that many citizens are very angry about the mandatory government and health authority restrictions that have been imposed upon them. This is new to many, particularly our youth and young adult cohorts. All they have known is freedom and the right to do as they wish. Perhaps it is time to now revisit the Canadian Charter of Rights and Freedoms. Rights and freedoms are important; however, they must be coupled with citizen responsibilities. An improved document could be the Canadian Charter of Rights, Freedoms, and Responsibilities. This would detail the responsibilities that citizens have to their country and to the well-being of their fellow citizens.

Renowned economist Klaus Schwab. founder and executive chairman of the World Economic Forum, discusses his vision of the future in his 2017 book The Fourth Industrial Revolution. COVID-19 may accelerate the reality of his visions. He believes that this revolution will be more significant and its ramifications more profound than previous industrial revolutions. New technologies that are joining the physical, digital, and biological entities are affecting all disciplines, economies, industries, and governments. He outlines the key technologies driving this revolution and discusses their impacts on individuals. Schwab also offers bold ideas on how to harness these changes and shape a better future. In his words: "one in which technology empowers people rather than replaces them."

History will be the judge of whether the enormous multiple and far-ranging economic and other costs associated with fighting the pandemic were justified. For many who were at no or little risk, this is very personal, with jobs lost, business closures, careers damaged, primary and secondary education interrupted, personal finances devastated, the deterioration of mental health, increased non-prescription drug use, and lives changed and lost. This virus has affected everyone of us in many ways and in ways that may have been unnecessary collateral damage.

Concluding Remarks

It has been an amazing year, a demonstration of the power of good science and the emergence of the best in our professionals and support staff in the healthcare sector who are risking their health every day helping others. The citizens of all countries will need to adapt and change deeply ingrained behaviors to

mitigate this pandemic and future threats. The lessons we learned from this pandemic will give us important insights to adapt and change our behaviours. Most importantly, COVID-19 has provided many examples for opening our minds to the nature of humanity: the preciousness of life, the importance of a healthy lifestyle, the realization that nature is unpredictable, and facing our personal mortality. COVID-19 has brought out the best of human nature and demonstrated the power of working together for a common cause. COVID-19 will become part of the history of humanity joining learnings from previous pandemics and devastating World Wars.

Acknowledgement

The opinions expressed are those of the author and not necessarily those of IEEE.

For Further Reading

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About the Author



Terrance Malkinson is a long-term contributor to IEEE and the author of more than 500 peer- and editorial-reviewed publications and is now retired. However, in retirement, he vigorously continues research and journalism, with an extensive portfolio of basic and applied research projects, journalism, philanthropy, and mentorship. His diverse career path includes 26 years in medical research as

a founding member of the Faculty of Medicine at the University of Calgary as well as a threeyear appointment as a manager with the General Electric Company followed by a one-year applied research appointment with SAIT Polytechnic. During his long career, he has advanced both basic and applied medical, health and wellness, scientific, and engineering knowledge. He has trained and mentored undergraduate, graduate, and postdoctoral students as well as staff in the business sector and government. He is a 45-year, long-term Member of IEEE and, over the years, served in many IEEE governance and publication roles. His current research interest in health and wellness extends to being an accomplished multisport triathlete including, among other events, the completion of 11 long-distance Ironman triathlons. He is a Senior Life Member of IEEE.

Congratulations to Anis Ben Arfi

ongratulations to Anis Ben Arfi for winning the 2020 EAB Meritorious Achievement Award in Outreach and Informal Education. IEEE Educational Activities Board (EAB) awards recognize and honor major contributions to engineering and technical education.

As an international graduate student at the University of Calgary, Anis's foray into IEEE volunteering started with Young Professionals events and local student branch activities. Starting with rather smaller tasks, he joined the Southern Alberta Executive Committee as the IEEE SIGHT chair. Soon after, he became engaged in IEEE's educational activities through a STEM outreach program. Among many other entities, Anis is grateful to the IEEE EAB for the 2020 EAB Meritorious Achievement Award.

Watch more at IEEEtv (https://ieeetv.ieee.org/channels/communities/ meritorious-achievement-in-outreach-informal-education-anis-ben -arfi-2020-eab-awards).





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The Breakthrough Prize Foundation (https://www.break throughprize.org) announced on 3 December 2020 that Maryam Tsegaye, 17, of Fort McMurray, Canada, was the winner of the sixth annual Breakthrough Junior Challenge. She triumphed over more than 5,600 applicants aged 13 to 18 from 123 countries. The challenge, founded in 2015, is a global science video competition aiming to develop and demonstrate a young person's knowledge of science and scientific principles; generate excitement in these fields; support science, technology, engineering, and mathematics career choices; and engage the imagination and interest of the public in the key concepts of fundamental science. Maryam used her 3-min video submission to explain the concept of quantum tunneling and how this phenomenon makes many aspects of our world possible. She will receive a total of \$400,000 in educational prizes for herself; her teacher; and her school, École McTavish Public High School.

The Arecibo radio telescope was the first to send a signal to alien civilizations. Completed in November 1963 and after almost six decades of cutting-edge research, the world's most famous radio telescope is to be decommissioned and disassembled. Two cable breaks, one in August 2020 and a second in November 2020, threatened the structural integrity of the telescope (https://www.cbc .ca/news/technology/arecibo-telescope -collapse-1.5823391). Built into a natural sinkhole located near Arecibo, Puerto Rico, the 305-m-diameter dish of Arecibo was the largest radio telescope in the world for 53 years. It was surpassed in July 2016 by the 500-m Aperture Spherical Telescope in Guizhou, China. The telescope was primarily used for research in radio astronomy, atmospheric science, and radar astronomy, as well as for programs that searched for extraterrestrial intelligence. The Arecibo telescope made numerous discoveries, detecting planets in other solar systems, spotting neutron stars and pulsars, and observing molecular clouds in other galaxies. It was also a powerful radio transmitter, able to send out 2.5-MW radio beams that could be bounced off asteroids passing close to



by Terrance Malkinson

Earth, detailing their shape and orbital motion. The telescope was listed on the U.S. National Register of Historic Places in 2008, and the center was named an IEEE Milestone in 2001.

The Alberta foothills are the setting for a pilot project using drones to deliver medical supplies and personal protective equipment to remote communities. Researchers at the University of Calgary, Southern Alberta Institute of Technology (SAIT), Alberta Health Services, and Alberta Precision Laboratories partnered with the three reserves that are part of the Stoney Nakoda First Nation. A drone capable of carrying up to 45 kg delivered equipment and COVID-19 test kits on its first trip to the Morley reserve west of Calgary. The CEO of the Stoney Nakoda said the First Nation is thrilled to be on the ground floor of testing new technology.

The goal is to prove this technology locally and then expand through-The Arecibo telescope out Canada and then made numerous discovto developing couneries, detecting planets in tries. The World other solar systems, spotting Health Organizaneutron stars and pulsars, tion is interested in and observing molecular the potential benefits clouds in other galaxies. of this and is one of several funding agencies supporting the project. Delivering vaccines to remote villages for self-inoculation and sending medical equipment directly to patients so a doctor could do remote diagnosis are but two applications. More information is available on the applied research and innovation page of the SAIT website (https:// www.sait.ca, "Researchers Investigate Drone Delivery of Medical Supplies to Remote Communities During Pandemic,"

22 October 2020).

A Canadian astronaut will fly around the moon as early as 2023 in NASA's first crewed mission back to the moon in half a century (https://www.nasa.gov/specials/ artemis). This is one part of a larger agreement between the U.S. and Canadian space agencies. A lunar orbiting space station is to be assembled later this decade. Canada has committed to supplying a pair of robotic arms for the Lunar Gateway (https:// www.asc-csa.gc.ca/eng/astronomy/ moon-exploration/lunar-gateway .asp). In exchange, a Canadian will join Artemis II, a NASA-led mission that is set to launch a capsule carrying four astronauts around the moon and back. The flight will serve as a setup for Artemis III, a mission whose goal is to land people on the moon. The deal solidifies a Canadian role in furthering human spaceflight beyond the International Space Station.

> The agreement with NASA also includes a second

lunar flight for a Canadian crew member to the orbiting Gateway. The Canadian Space Agency has awarded a \$22.8 million federal contract to space technology company MDA of Brampton, Ontario, to develop a robotic system for

the Lunar Gateway. The system, dubbed Canadarm 3, is an advanced and more autonomous version of the robotic arms previously built for the space shuttles and space station. The package that MDA is developing will include a large arm that will assist with docking spacecraft among other tasks and a smaller arm that will be used as a tool for maintenance and science experiments. It will employ artificial

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intelligence algorithms to move itself around as it accomplishes assignments without human guidance.

sleeper trains across Europe. COVID

Recently, there has been a

resurgence of cross-border night

has caused stressful and time-consuming complexity in air travel. The night trains of Europe have been an adventure-filled experience and immortalized by writers such as Agatha Christie. In December, four European national rail providers teamed up to announce new routes between 13 European cities. Austria's OBB, in conjunction with Germany's Deutsche Quantum algorithms have been developed that are Bahn, France's SNCF, thought to be unbreakable. and Swiss Federal It is these cryptographic Railways—this capabilities that interest both collaboration will see nations and corporations new Nightjet (https:// involved in e-commerce. www.nightjet.com) routes over the next four years. These include Vienna-Munich-Paris, Zurich-Cologne-Amsterdam, Vienna/ Berlin to Brussels/Paris, and Zurich and Barcelona. Night trains are cost-effective, saving you hotel costs while still getting a good night's sleep. You can book an entire sleeping compartment for yourself. Trains leave and transport you to the heart of the city. Passengers have freedom to get up, walk around, breathe fresh air, get food, change seats, work, and engage in conversation with fellow passengers. Trains are more environmentally friendly. For the author, European night trains have a special meaning. During his university years, he spent three summers traveling the rails in Europe as a vagabond, limitedfinances youth, questing for adventure. It was an incredible personal growth and confidence-building experience and the best time of my life, setting the stage for

An asteroid between 92 and 210 m in size traveled past Earth at a speed of 10 km/s at 8:20 p.m. GMT on Christmas Day, according to data from NASA's Center for Near-Earth Studies (https://www.cneos.jpl.nasa.gov). This asteroid came within 1.9 million mi from Earth's surface. Despite being around eight times farther out than the moon, this is considered close in astronomical terms. Earth is hit by a football pitchsized rock every 5,000 years and a civilisation-ending asteroid every 1 million years, according to NASA's near-Earth object program. Scientists have inventoried more than 95% of the large asteroids (1 km and larger) and know that none of them has any chance of impacting over the next century.

England is discouraging unhealthy eating to reduce and eliminate the rate of obesity, which is among the highest in the world. Almost two-thirds of adults and one in three children are overweight or obese. The new rules are scheduled to start by

April 2022 (https://www.gov.uk/ government/organisations/

> department-of-health-and -social-care). New measures will ensure that the healthy choice is the easy choice. Restrictions extend well beyond the usual culprits: chocolates, soft drinks, sweets, and potato chips. Discount offers for unhealthy foods will be prohibited in stores

and online. Unhealthy promotions will no longer be allowed in high-visibility locations. Free refills of sugary soft drinks in restaurants will also be banned.

Chuck Yeager (https://www .chuckyeager.com), famed as the pilot who broke the sound barrier, died 7 December 2020 at age 97. He published his story in an authorized autobiography called Yeager (Bantam, 1986). It not only tells the story of breaking the sound barrier on 14 October 1947 but covers his entire flying career. He recounted his experiences as a fighter ace in World War II and the decades after when he served as a test pilot, flying experimental aircraft through and past the sound barrier, as well as his military service at postings around the world. He has also been immortalized in the best-selling book The Right Stuff, by Tom Wolfe, which also inspired the Oscar-winning 1983 movie. Both the book and film presented Yeager as the ultimate test pilot, glorifying his courage and boldness.

The Diefenbunker (https:// www.diefenbunker.ca), located a short distance from Ottawa and commissioned by Prime Minister John Diefenbaker in 1959, was purposed to house members of the government and military in the event of a nuclear attack on Canada. The underground site was completed and began operation in 1961. It

was active as the Canadian Forces Station Carp until 1994. Today, it operates as a not-for-profit, charitable museum with award-winning tours and programs. Designed and engineered by the Foundation Company of Canada, the entire construction process took fewer than 18 months and was the first recorded use of critical path construction methodology in Canada. Its 100,000 ft² over four levels consisted of 32,000 yd3 of hand-poured concrete and 5,000 tons of steel. It is an extraordinary marvel of engineering and built to withstand a 5-megaton nuclear blast. It was the site of some of Canada's most top-secret communications throughout the Cold War. The Diefenbunker was given National Historic Site status in 1994. Recently, it underwent a restoration to upgrade its electrical, plumbing, and other systems, improving tourism services, youth programs, signage, and other services to meet the needs of 80,000 visitors a year.

A CNN online opinion article by Don Lincoln describes how physicists, engineers, and computer scientists are trying to harness the counterintuitive behavior of quantum mechanics to build quantum computers, leading, eventually, to a quantum Internet ("The unhackable computers that could revolutionize the future," 29 December 2020, https://www.cnn .com/2020/12/29/opinions/quantum -internet-opinion-lincoln/index.html). Quantum physics has been identified by the U.S. government as an important national initiative. Federal agencies are designing the framework for an American quantum infrastructure. Universities, national laboratories, and private industry have formed a consortium to develop the capabilities necessary to make a quantum Internet. A quantum Internet is unique because it is unhackable. Quantum algorithms have been developed that are thought to be unbreakable. It is these cryptographic capabilities that interest both nations and corporations involved in e-commerce. In the article's conclusion, Don Lincoln states that "it is still very early in the history of quantum computing and it is unclear exactly where it is going. ... Quantum computing is still in its infancy, but one day it may change the world."

Nearly 6 million people in the United States and roughly 30 million worldwide have Alzheimer's, and

future success.

this number is expected to more than double by 2050 as the population ages. Alzheimer's diagnoses are often inaccurate, and there is difficulty with distinguishing Alzheimer's from other dementias. Elevated levels of amyloid protein alone are not enough. Teams of scientists around the world are seeking a rapid and accurate test for diagnosis, make diagnosis simpler, more affordable, and widely available. The results of one research project were recently published in Journal of the American Medical Association [vol. 324, no. 8, pp. 772-781, 2020; open access; https:// www.jama.com]. The test, which measures a form of the tau protein found in tangles that spread throughout the brain in Alzheimer's patients, proved accurate in a study of 1,402 people from three different groups in Sweden, Colombia, and the United States. Importantly, the test

can identify signs of the degenerative,

About the Author



Terrance Malkinson is a long-term contributor to IEEE and the author of more than 500 peer- and editorial-reviewed publications and is now retired. However, in retirement, he vigorously continues research and journalism, with an extensive portfolio of basic and applied research projects, journalism, philanthropy, and mentorship. His diverse career path includes

26 years in medical research as a founding member of the Faculty of Medicine at the University of Calgary as well as a three-year appointment as a manager with the General Electric Company followed by a one-year applied research appointment with SAIT Polytechnic. During his long career, he has advanced both basic and applied medical, health and wellness, scientific, and engineering knowledge. He has trained and mentored undergraduate, graduate, and postdoctoral students as well as staff in the business sector and government. He is a 45-year, long-term Member of IEEE and, over the years, served in many IEEE governance and publication roles. His current research interest in health and wellness extends to being an accomplished multisport triathlete including, among other events, the completion of 11 long-distance Ironman triathlons. He is a Senior Life Member of IEEE.

deadly disease 20 years before memory and thinking problems emerge. Results need to be replicated in continuing clinical trials. It is hoped that a test could be available for clinical use in as few as two to three years.

Congratulations to **Prof. Jing (Jin) Jiang**

ongratulations to Prof. Jing (Jin) Jiang on being inducted into the Royal Society of Canada (RSC). Prof. Jiang has been with the Department of Electrical and Computer Engineering, Western University, since 1991, where he is a distinguished university professor and an NSERC Senior Industrial Research chair. He is an expert in fault-tolerant control, instrumentation/control systems for nuclear power plants, and renewable energy microgrids. He is a fellow of the Engineering Institute of Canada, Canadian Academy of Engineering, and a registered Professional Engineer in Ontario. Prof. Jiang is an IEEE Fellow and the winner of IEEE Canada's 2020 P.D. Ziogas Electric Power Medal.

The RSC recognizes the country's top talents in the fields of arts, humanities, and sciences. Being elected into the RSC is a crowning achievement for Canadian scholars.

For more information, please visit https://news.westernu.ca/2020/09/ royal-society-celebrates-5-western-scholars/.



We Just Couldn't Resist ...

David Green St. John's NL davidgreen@ieee.org

anice is a hardworking electrical engineering student. Her neighbours are the very wealthy Kappa family. One Saturday, the mother of the family asks Janice to look after their kids, Mia and Emily, while they went out for a fancy dinner, offering to pay her \$100 for the night. Figuring that this is a great way to pay down her debt while going to school, she agrees to do so.

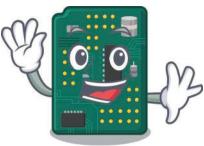
She shows up to look after Mia and Emily. They are very well behaved through-

out the night and in bed by 9:00 p.m., as they are supposed to be. Their parents return from dinner and are delighted at the job



Janice has done. They ask her to look after Mia and Emily for the remaining Saturdays of the semester. Janice agrees.

Each Saturday, Janice shows up to look after Mia and Emily; however, she notices that they are becoming more dif-



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ficult to deal with. They refuse to go to bed on time. They run around screaming for three hours. One time, they knocked over a lamp and broke it.

Janice decides that \$100 is not enough for an increasingly stressful night of work, so she asks the parents for a raise. They refuse, insisting that \$100 for a night is a very generous wage. Janice is annoyed because she knows that Mr. and Mrs. Kappa could easily afford to pay her more. And so it became a pattern. Each Satur-

day, Janice would look after Mia and Emily, and after a hard night's work, she would ask Mr. and Mrs. Kappa for a raise, only to be refused.

Finally, after one particularly long Saturday night, during which Mia and Emily threw a two-hour tantrum, Janice had had enough. When she finally got them to bed, Janice decides to sneak into Mr. and Mrs. Kappa's bedroom and survey their vast jewelry collection. She is disgusted at their opulence combined with their unwillingness to pay her more. She is tempted to steal and thinks: "They're exceedingly rich, they wouldn't miss it!" So she swipes a pair of emerald earrings, a pair of diamond cufflinks, and a sapphire ring.

Unfortunately for Janice, the police appear at her door the very next day. She confesses and returns the emeralds, diamonds, and sapphire and pleads her case. However, the police are having none of it. The officer says, "You're the Kappa's sitter—if you had that many jewels, you must be charged!"

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hile there are still some technological challenges to overcome, the biggest hurdles for the space mining industry are not necessarily going to be solved by engineers. In this issue, we look at some current events to understand what is holding us back from extracting and benefiting from space resources.

> Ad astra, Dario Schor; schor@ieee.org

What we once thought of as science fiction could easily become the next space race. Space mining has the potential to be a trillion-dollar industry, so it is no wonder that nations and corporations are developing technologies to extract raw resources from celestial bodies. These materials could be used in situ to further space exploration or be returned to Earth for manufacturing purposes. For instance, a lunar habitat could take advantage of water found on the polar regions of the Moon to reduce the expenses associated with transporting water from Earth. Moreover, extracting solar wind deposits of Helium-3 from the Moon's surface could power nuclear fusion reactors for such a habitat and even serve as a gas station for nuclear fusion rockets enabling future interplanetary missions. Longer term, minerals and rare metals from asteroids could be brought back to Earth and disrupt global markets. Needless to say, there is great potential for new ventures based on space mining.

As a natural first step, interested parties began planning prospecting and sample-return missions. In fact, last year alone there were three such missions helping to advance necessary technologies while also cultivating our scientific understanding of the evolution of the Solar System. The Japanese Hayabusa2 mission returned from asteroid Ryugu with a sample collected at the surface. NASA's OSIRIS-REx captivated audiences with stunning video footage of its Touch-and-Go Sample Acquisition Mechanism, collecting carbonaceous asteroid regolith from Bennu to be returned to Earth in 2023. Not to be outdone, China's Chang'e 5 mission brought back a 1.7-kg sample from the Moon's northwestern volcanic region. Not surprisingly, these destinations include the most likely first target due to proximity, the Moon, as well as two of the top-five most cost-effective asteroids, according to Asterank [1]. This ranking takes into account both the spectral composition and the orbital parameters of the asteroid to estimate the value as well as the approximate fuel costs from the ΔV needed for the mission.

Although the sample-return missions are encouraging, there are many who believe that the legal uncertainty surrounding extra-terrestrial mining is holding back the industry. This controversy originates from ambiguities in the wording of the 1967 Outer Space Treaty (OST) and its shunned counterpart, the 1979 Moon Agreement [2]. The OST proclaims outer space to be a "province of all mankind" that all nations are free to explore and use. One could argue that mining is a "use" of space; however, there are other parts of the treaty that may throw a wrench into that interpretation. Most notably, a large mining operation would need to abide by Article II, which forbids claims of sovereignty to set up a mine, and Article IX, which requires nations to avoid harmful contamination of the environment.

In contrast, Article XI of the Moon Agreement explicitly states that celestial bodies are "the common heritage of mankind" and, with the exception of small scientific samples (like the afore-

mentioned missions), neither the surface, subsurface, nor resource shall become property of any entity. Instead, the parties to this agreement have agreed to establish an international regime that ensures the equitable sharing of resources amongst all countries (giving special consideration to those who finance the mission). The intent from this provision was to ensure that the developing nations unable to afford their own expedition would not be left behind in a colonial mining-grab operation. Unfortunately, the righteous nature of the treaty did not resonate with most governments, so only 18 nation states have ratified the Moon Agreement as of February 2021.

On a more philosophical level, many legal scholars argue that the phrase "province of all mankind" aligns with the res communis principle, Latin for "a thing of the entire community" or "subject to a common regime" [3]. Moreover, they view space as a global commons because it is not owned by anyone in particular, yet it is crucial to the future of all humankind. For comparison, this is the same language used to describe the High Seas, where no one can claim they own the waters, yet everyone is allowed to fish there. The key difference is that fish can be considered a renewable resource whereas space resources from celestial bodies are finite. An argument could be made that there is a vast number of celestial bodies in the universe; however, practically speaking, there is only a limited number of these that are accessible using state-of-the-art rocket engines. Consequently, some form of international cooperation is needed to avoid Hardin's infamous "tragedy of the commons."

Undoubtedly, readers might be asking themselves, why does this matter? It turns out that many space entrepreneurs are eager to mine for extra-terrestrial resources but are struggling to finance their missions. It is difficult for investors to accept both the technical and legal risks associated with this emerging industry. Accepting that not all mining sites are equal, there is also an incentive for some space-faring nations to address these legal questions to call "dibs" on the most cost-effective sites and beat the space equivalent of the 19th century gold rush.

As an initial step, both the United States and Luxembourg passed national laws granting all citizens rights over the resources extracted from celestial bodies in 2015 and 2017, respectively. More international support, however, is needed to make this possible. Thus, in April 2020, U.S. President Trump issued an executive

order stating that "outer space is legally and physically a unique domain of human activity, and the United States does not view it as a global commons" [4]. He further instructed the U.S. Secretary of State to boost support for safe and sustainable space-resource extraction through new international agreements.

Within days, a group of prominent Canadian space leaders wrote an open letter to the Honourable François-Philippe Champagne, minister of foreign affairs, urging the Canadian government to not endorse the policy. Instead, they proposed that Canada should "seek a widely-supported international agreement on how space resources should be recovered and used" [5]. In addition, they emphasized the view that the adoption of national legislation should not replace broadly supported international agreements. Although it is unclear whether the U.S. Biden administration will continue to push for space mining, the topic is bound to re-emerge in the near future.

Thus, immediate action is needed. Before another Sputnik-like sequence where laws are playing catch up with worldwide events, nations must reach a consensus and establish an international agreement with regard to space-resource extraction. Canada needs to acknowledge that space mining will become a reality, learn from the flaws of the Moon Agreement, and take a leading role in the negotiations. The sooner such an agreement is established, the sooner Canadians' aerospace and mining expertise can join forces to bring benefits to all in a safe and sustainable manner.

Acknowledgements

Special thanks to Prof. Michael Dodge at the University of North Dakota for many engaging discussions and recommended readings on space law and the commons.

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About the Author



Dario Schor is a software engineer at Magellan Aerospace and is currently in a two-year Interchange Canada position supporting sat-

ellite operations at the Canadian Space Agency. He is also pursuing a space studies Ph.D. at the University of North Dakota. He obtained his B.Sc. and M.Sc. degrees in computer engineering from the University of Manitoba in 2008 and 2013, respectively, before attending the 2013 Space Studies Program from the International Space University in Strasbourg, France. He has served in various roles within IEEE Canada and the Winnipeg Section. He can be reached by email at schor@ieee.org.



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he International Union of Radio Science (abbreviated URSI, after its French name, Union Radio-Scientifique Internationale) has a long history of cooperating with IEEE to advance international cooperation in the study of electromagnetics. In this regular column, we explore how IEEE Canada members can both contribute to and benefit from URSI's mission.

In the following, we look back at the partnership between the Canadian National Committee of URSI (CNC-URSI) and IEEE in supporting the International Symposium on Antenna Technology and Applied Electromagnetics (ANTEM). ANTEM was begun in 1986 as a direct response to the success of the IEEE AP-S/URSI symposium that had been held in Vancouver during the previous year. Over the years, CNC-URSI has played a key and integral role in ANTEM's success.

> David G. Michelson dmichelson@ieee.org president@ursi.ca

From 8 to 11 August 2021, the 19th edition of the International Symposium on Antenna Technology and Applied Electromagnetics (ANTEM) will be hosted virtually from Winnipeg, Manitoba, with co-sponsorship from IEEE Canada, the IEEE Winnipeg Section, and the Canadian National Committee of URSI (CNC-URSI).

As the name suggests, ANTEM serves Canadian researchers active in antennas, propagation, and other aspects of applied electromagnetics. As the only Canadian conference in this area, ANTEM has played a key role in

building a sense of community among Canadian antennas and propagation researchers and promoting cooperation and collaboration amongst antennas and propagation research groups across the country for 35 years.

In a world increasingly reliant on the steady advance of wireless technology, ANTEM has helped to grow and retain Canadian expertise in a strategically important area. In size and scope, ANTEM has been compared to the annual National Radio Science Meeting, which is held each January in Boulder, Colorado, under the auspices of the U.S. National Committee of URSI and the U.S. National Academies of Sciences, Engineering and Medicine.

The 2021 edition of ANTEM is the first to be co-sponsored by IEEE Canada as the newest part of its conference portfolio, which includes the Canadian Conference on Electrical and Computer Engineering (CCECE), the Canadian Electrical Power and Energy Conference (EPEC), and the International Humanitarian Technology Conference (IHTC). Accordingly, now is a good time to reflect upon the history and future of ANTEM and CNC-URSI's contributions to the ANTEM success story.

ANTEM ORIGINS

The formation of ANTEM as a Canadian antennas and electromagnetics conference was inspired by several factors. The immediate motivation was the very positive experience that the 1985 IEEE Antennas and Propagation Society (AP-S)/URSI Symposium in Vancouver had provided to Canadian students. Although large international conferences come to Canada at only long intervals, Prof. Lot Shafai and his team from the University of Manitoba realized that the Canadian community, in this area, was now large enough to support a biennial regional conference with international participation. The National Research Council's 1986 decision to shut down their Division of Radio and Electrical Engineering reinforced the need to promote cooperation and collaboration among antenna and electromagnetics researchers across the country. The AP-S and URSI were approached, and both offered their support.

There was another factor: The antenna and electromagnetics communities were also aware that Canada's first regional conference in this area was actually the Electromagnetic Theory Symposium (EMTS), organized by George Sinclair and James R. Wait at the University of Toronto in 1959. It did not stay in Canada,

In a world increasingly reliant on the steady advance of wireless technology, ANTEM has helped to grow and retain Canadian expertise in a strategically important area.

however, and instead became the first of the triennial EMTS series organized by URSI Commission B—Electromagnetic Fields and Waves. By late 1985, a consensus had quickly formed that it was indeed time to start an antennas and electromagnetics conference that would remain in Canada. Thus, ANTEM began.

The first ANTEM conference was held in Winnipeg in early August 1986 with roughly 75 attendees. George Sinclair gave a keynote presentation on engineering education and established the continuity between EMTS and ANTEM. Yahia Antar, who is currently serving as the 2021 president of the AP-S, also gave a keynote presentation and chaired the first technical session. From the start, ANTEM established its focus on emerging topics, with an emphasis on community building and a strong commitment to the student experience. The event was designed to provide maximum opportunities for students to interact with both leading researchers and other students.

ANTEM GROWS AND PROSPERS

Like other regional conferences of its type, ANTEM was conceived as a biennial event. The Communications Research Centre in Ottawa was a key patron and

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The IEEE Power & Energy Society (PES) Scholarship Plus Initiative supports the most promising future engineers in power and energy. Recipients are high-achieving undergraduate students in electrical engineering programs who have committed to exploring the power and energy engineering field. Established by Sahazizian's children through their generous donation to IEEE's PES Scholarship Plus Initiative, the Anne-Marie Sahazizian Scholarship Fund celebrates Anne-Marie's outstanding contributions. The 2020 Anne-Marie Sahazizian Scholarship recipients from Canada are

- Maisha Nasim, University of Saskatchewan
- Samia Sami, University of Saskatchewan.

Canadians may choose to donate to the IEEE PES Canadian Scholarship Fund to support this initiative in Canada via the IEEE Canadian Foundation.

For more information please visit: https://www.ee-scholarship.org/about-thescholarship/sahazizian-scholars.

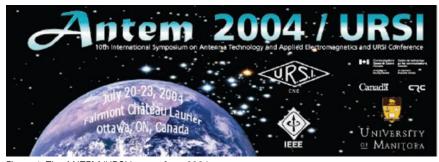


Figure 1: The ANTEM/URSI banner from 2004.



Figure 2: A student presentation at ANTEM 2018 in Waterloo, Ontario.

supporter, especially during the event's formative years. CNC-URSI contributed greatly to the technical program, and, for a time in the mid-2000s, the conference was known as ANTEM/URSI, as shown in Figure 1. Attendance quickly grew to between 150 and 200 attendees, of which up to a third were international. The guidance provided by Shafai and the support offered by Shelly Girardin, ANTEM's conference administrator, ensured the conference's success during its entire initial 35-year run.

The first few editions of ANTEM were held in Winnipeg, but later events were hosted in either Ottawa or Montréal to be closer to the majority of participants. ANTEM returned to the West in 2000 as the homecoming event to celebrate the start of the new millennium and was also held in Banff in 2009 and in Victoria in 2014. In 2010, ANTEM and AMEREM joined forces to host a joint event in Ottawa. Special editions of ANTEM were held in St. Malo, France in 2005 and Toulouse, France in 2012. In 2018, the most recent and best-attended ANTEM conference was held in Waterloo, with more than 200 participants. A student presentation at the 2018 event is shown in Figure 2.

During this period, ANTEM benefited greatly from the steadily increasing demand for wireless technology, including advances in satellite and terrestrial communications, the introduction and development of cellular wireless technology, the introduction and development of personal wireless technology, and the growing applications of wireless technology in medicine and biology. A persistent theme has been the move to higher frequencies and the miniaturization of antennas to accommodate evershrinking device form factors.

THE NEXT PHASE

In 2019, IEEE Canada brought ANTEM into its conference portfolio. Because the IEEE AP-S/URSI 2020 Symposium was held in Montréal, it was decided to delay the next ANTEM conference until 2021. The global pandemic has necessitated holding the event as a virtual conference, but ANTEM's role in building a sense of community amongst Canadian antennas and propagation researchers, and promoting cooperation and collaboration between antennas and propagation research groups across the country continues undiminished.

The 2021 ANTEM conference theme is "Making Space." Several specialized topical sessions have been introduced to the conference under this theme, including

- the design and application of antennas and radiating systems to eliminate touch requirements
- antenna miniaturization to reduce antenna dimensions
- antennas designed for space applications (e.g., satellites and CubeSats).

CNC-URSI looks forward to supporting and contributing to ANTEM, both this year and in the years to come. See "Call for Papers" elsewhere in this issue or visit the ANTEM website at https:// antem2021.ieee.ca/.

The National Research Council of Canada is the adhering body for Canadian membership in URSI and appoints the members of CNC-URSI. For more information about URSI International, please visit http://www.ursi.org/.

For more information about URSI Canada, please visit http://www.ursi.ca/.

About the Author



David G. Michelson is president of the Canadian National Committee of the International Union of Radio Science (2018–2021). He has led the Radio Science Lab at the Department of Electrical and Computer Engineering, University of British Columbia (UBC), since 2003. His current research focuses on shortrange/low-power wireless networks for smart transportation, smart utility, and

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Call for Papers: ANTEM 2021

19th International Symposium on Antenna Technology & Applied Electromagnetics

8-11 August 2021 Held Virtually https://antem2021.ieee.ca/



Important Dates

Final Paper Submission: March 1, 2021

Notification of Acceptance: May 1, 2021

Registration Deadline: July 1, 2021

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ANTEM 2021

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Scope of the Conference

IEEE ANTEM 2021 will be held from 8-11 August 2021 and hosted virtually from Winnipeg, Canada. The symposium is co-sponsored by IEEE Canada, the IEEE Winnipeg Section, and CNC-URSI. ANTEM is a premier event in antennas and applied electromagnetics. It provides an ideal forum and venue for networking, exchanging ideas, and identifying future trends and developments. The well-balanced, comprehensive technical program will include a broad range of presentations on antennas, propagation, and electromagnetics. Accepted papers will be submitted to IEEE Xplore. There will be distinguished lectures and special sessions on contemporary topics at the leading edge of antenna and electromagnetics technology. The language of the symposium is English.

Conference Theme: "Making Space"

The world has experienced major changes in the last year as a result of the COVID-19 pandemic. The conference will be hosted virtually to maintain continuity. The theme, "Making Space," can be interpreted in many ways. Several specialized topical sessions will be introduced to the conference under this theme:

- Design & application of antennas & radiating systems to eliminate touch requirements
- Antenna miniaturization to reduce antenna dimensions
- Antennas designed for space applications (e.g., satellites & CubeSats)

List of Topics

Antennas

- · Antenna Theory
- Dielectric, Planar & Conformal Antennas
- Antenna Miniaturization & Integration
- Intelligent Reconfigurable Antennas
- Phased Arrays, Reflect-Arrays, and Lenses
- Reflector Antennas
- Wearable & Wireless Sensor Antennas
- On-Chip/In-Package Antennas
- Terahertz & Optical Antennas
- · UWB Antennas & Systems

Field Theory & Computation

- Analytic & Numerical Methods
- Modelling & EM-CAD Tools
- Scattering & Diffraction
- · Inverse Scattering & Remote Sensing
- · Guided Waves
- Transients & Time Domain Electromagnetics

New Phenomena & Engineered Media

- · Bio-electromagnetics
- · Nano-electromagnetics
- EBG/Metamaterial Structures
- · Frequency Selective Surfaces

Electromagnetic Systems, Devices & Applications

- · Propagation & Channel Modelling
- Next Generation Mobile Communication & Sensing
- Machine Learning
- Satellite Radio Communication Systems
- · Terrestrial & Ionospheric Radio Communication
- Automotive Radar & Imaging Systems
- Software Defined Radio
- MEMS & Micromachining for RF Systems
- Microwave-to-THz Devices, Circuits & Imaging Applications
- MIMO Systems
- Photonic Devices & Circuits
- Vehicular Electromagnetics
- Wireless Power Transmission
- Electromagnetic Energy Harvesting
- · Biomedical Imaging & Sensing
- Electromagnetic Field Measurement
- Electromagnetic Properties & Material Characterization
- EMI/EMC
- Spectrum Management
- · Spectrum Policy





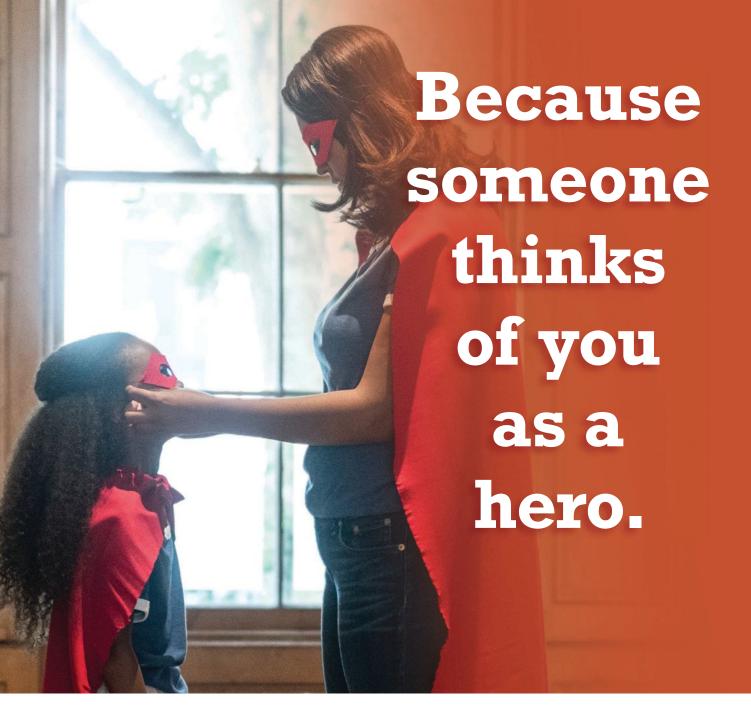












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