IEEE Information Theory Society Newsletter

Vol. 64, No. 1, March 2014 Editor: Tara Javidi ISSN 1059-2362

President's Column

Abbas El Gamal

Why is information theory such a special field? This is the first question that occurred to me when I started writing this column. There is of course the beauty of the theory itself, which is why many of us dedicate most if not all our careers to it. There is also the fact that information theory has had a profound impact on practice, from providing a foundation for the information age to practical codes that achieve the limits predicted by the theory. Equally important is the exceptional quality of the people who worked in this field early on. Founded by Shannon, one of the real giants of the 20th century, information theory has attracted some of the best and brightest engineers and mathematician, including several we have recently lost (Ahlswede, Wolf, Cover, and Massey). But what makes information theory truly special is the culture of intellectual honesty, openness, generosity, and collegiality fostered by its exceptional membership.

The stated mission of the IT society is "to support the open exchange of ideas in information theory, broadly construed, through publications, communications, meetings, outreach, education, mentoring, and recognition of excellence." I think you will agree that our society through the active participation of its members has stayed true to its mission. The *Transactions* remains the premier publication in the field, ranking among the top IEEE publications. The society supports communications and education through annual conferences, workshops, schools, and a Distinguished Lecturers program. The Newsletter provides quarterly updates on the activities of the society. My predecessors (Goldsmith and Medard) have started standing committees on student and outreach, as well as a mentoring program for junior faculty and students. We recently created the Cover outstanding dissertation award, which together with existing awards further recognizes excellence in the society.

As for any organization, our society faces several challenges that if properly addressed can make it stronger. The most significant of these is identifying future research directions to maintain the vitality of the field. Our research in the past 15 years has been driven mainly by physical layer wireless communication, which is becoming mature and commoditized. What will the next major driver(s) of research in IT be? An ad hoc committee chaired by Jeff Andrews set out to explore answers to this question, and will be reporting on its findings at the February BoG meeting. I look forward to sharing highlights of their report with you in my next column. In addition (and in some ways related) to this challenge, I would like to outline the following pressing issues.

Increasing Transactions size. The *Transactions* has steadily increased in size from around 2800 pages in 2000 to 8400 in 2013 and this trend is expected to continue albeit at a slower rate. While a sign of the vitality of our field, this dramatic increase has several potential adverse effects, including the difficulty of maintaining high quality with tens of associate editors handling hundreds of submissions, the possibility of losing some important work to other more targeted journals, the increasing load on the EiC in the current flat structure of the editorial board, and the increase in the production costs beyond our income. To explore ways to mitigate these effects, there have been many discussions over several years in two focused ad hoc committees and among the officers. The proposals from these discussions have included imposing overlength page charges or page limits with online supplementary material (IEEE accepts posting supplements on Xplore), moving toward a hierarchical editorial board with Senior Editors, and reducing the per page editing cost (we have already moved to moderate editing, but the charges

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From the Editor

Tara Javidi

Dear IT Society members,

The first issue of 2014, naturally, contains Abbas El Gamal's first column as the IT society president. Please join me in welcoming Abbas and wishing him the best for continuing the tradition of excellence and growth. This issue contains a summary of Katalin Marton's 2013 Shannon Lecture which was delivered in Istanbul.

In addition to our popular and regular contributions by historian Ephremides and puzzle- master Golomb, we congratulate A.J. Paulraj who has been awarded this year's Marconi Society Prize for his pioneering contributions to developing the theory and applications of MIMO antennas. We also congratulate those members of our society who were among the 2014 newly elected IEEE Fellows. This year, we are providing short bios on those members who were nominated by the IT Society, i.e. Guang Gon, Syed Ali Jafar, Emina Soljanin, and Wei Yu. This issue also has a contribution from Stark Draper and Emina Soljanin reporting on two meetings on green data storage at DIMACS. I would like to thank all the contributors sincerely.

As a reminder, announcements, news and events intended for both the printed newsletter and the website, such as award announcements, calls for nominations and upcoming conferences, can be submitted jointly at the IT Society website http://www.itsoc.org/, using the quick links "Share News" and "Announce an Event." Articles and columns also can be e-mailed to me at ITsocietynewsletter@ece.ucsd.edu with a subject line that includes the words "IT newsletter." The next few deadlines are:

Issue	Deadline
June 2014!	April 10, 2014
September 2014	July 10, 2014
December 2014	October 10, 2014

Please submit plain text, LaTeX or Word source files; do not worry about fonts or layout as this will be taken care of by IEEE layout specialists. Electronic photos and graphics should be in high resolution and sent as separate files. I look forward to hear your suggestions (especially regarding the new column) and contributions.

IEEE Information Theory Society Newsletter

IEEE Information Theory Society Newsletter (USPS 360-350) is published quarterly by the Information Theory Society of the Institute of Electrical and Electronics Engineers, Inc.

Headquarters: 3 Park Avenue, 17th Floor, New York, NY 10016-5997.

Cost is $1.00 per member per year (included in Society fee) for each member of the Information Theory Society. Printed in the U.S.A. Periodicals postage paid at New York, NY and at additional mailing offices.

Postmaster: Send address changes to IEEE Information Theory Society Newsletter, IEEE, 445 Hoes Lane, Piscataway, NJ 08854.

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2014 IEEE Medals and Recognitions Recipients and Citations

1. IEEE MEDAL OF HONOR, for an exceptional contribution or an extraordinary career in IEEE fields of interest, sponsored by the *IEEE Foundation*, to BANTVAL JAYANT BALIGA (LFIEEE)—Distinguished University Professor, North Carolina State University, Raleigh, North Carolina, USA

"For the invention, implementation, and commercialization of power semiconductor devices with widespread benefits to society."

2. IEEE ALEXANDER GRAHAM BELL MEDAL, for exceptional contributions to the advancement of communications sciences and engineering, sponsored by *Bell Labs, Alcatel-Lucent*, to DARIUSH DIVSALAR (LFIEEE)—Senior Research Scientist, Jet Propulsion Laboratory, Pasadena, California, USA

"For fundamental contributions to the theory and practice of channel codes that transformed deep space and other forms of wireless communications."

3. IEEE EDISON MEDAL, for a career of meritorious achievement in electrical science, electrical engineering, or the electrical arts, sponsored by *Samsung Electronics Co., Ltd.*, to RALPH H. BAER (LFIEEE)—Owner, R.H. Baer Consultants, Manchester, New Hampshire, USA

"For pioneering and fundamental contributions to the video-game and interactive multimedia-content industries."

4. IEEE FOUNDERS MEDAL, for outstanding contributions in the leadership, planning, and administration of affairs of great value to the electrical and electronics engineering profession, sponsored by the *IEEE Foundation*, to ERIC SCHMIDT (MIEEE)—Chairman, Google, Inc., Mountain View, California, USA

"For transforming global access to information through his leadership and technological contributions."

5. IEEE RICHARD W. HAMMING MEDAL, for exceptional contributions to information sciences, systems, and technology, sponsored by *Qualcomm, Inc.*, to two co-recipients:

- THOMAS RICHARDSON (FIEEE)—Vice President, Engineering, Qualcomm, Bridgewater, New Jersey, USA
- RÜDIGER URBANKE (SMIEEE)—Professor, Ecole Polytechnique Federale de Lausanne, Lausanne, Switzerland

"For fundamental contributions to coding theory, iterative information processing, and applications."

6. IEEE MEDAL FOR INNOVATIONS IN HEALTHCARE TECHNOLOGY, for outstanding contributions and/or innovations in engineering within the fields of medicine, biology, and healthcare technology, sponsored by the *IEEE Engineering in Medicine and Biology Society*, to LEROY HOOD (Non-member)—President and Co-founder, Institute for Systems Biology, Seattle, Washington, USA

"For pioneering contributions to DNA sequencing technologies that revolutionized life and health sciences."

7. IEEE JACK S. KILBY SIGNAL PROCESSING MEDAL, for outstanding achievements in signal processing, sponsored by *Texas Instruments, Inc.*, to THOMAS P. BARNWELL, III (LFIEEE)—Professor Emeritus, Georgia Institute of Technology, Vinings, Georgia, USA

"For leadership in and contributions to speech processing, filter banks and wavelets, DSP hardware and architectures, and technology-enhanced education."

8. IEEE/RSE WOLFSON JAMES CLERK MAXWELL AWARD, for groundbreaking contributions that have had an exceptional impact on the development of electronics and electrical engineering or related fields, funded by *Wolfson Microelectronics plc*, to DAVID NEIL PAYNE (MIEEE)—Director, Optoelectronics Research Centre, Southampton, Hampshire, United Kingdom

"For ground-breaking contributions to optical fiber technologies and their application to optical communications."

9. IEEE JAMES H. MULLIGAN, JR. EDUCATION MEDAL, for a career of outstanding contributions to education in the fields of interest of IEEE, sponsored by *MathWorks; Pearson Education, Inc;.* and the *IEEE Life Members Committee*, to JOHN GEORGE PROAKIS (LFIEEE)—Professor Emeritus, Northeastern University, Winchester, Massachusetts, USA

"For contributions to electrical engineering education through influential textbooks and inspiring leadership in integrating research and education."

10. IEEE JUN-ICHI NISHIZAWA MEDAL, for outstanding contributions to material and device science and technology, including practical application, sponsored by *The Federation of Electric Power Companies, Japan*, to two co-recipients:

- FRANZ LAERMER (Non-member)—Vice President, Robert Bosch Corporate Research and Advanced Development, Stuttgart, Germany

  AND

- ANDREA URBAN (Non-member)—Senior Expert, Robert Bosch GmbH, Reutlingen, Germany

"For inventing and developing the Bosch deep reactive ion etching process that has impacted the micro-electro-mechanical systems (MEMS) field."

11. IEEE ROBERT N. NOYCE MEDAL, for exceptional contributions to the microelectronics industry, sponsored by *Intel Foundation*, to JOHN E. KELLY III (FIEEE)—Senior Vice President and Director of Research, IBM Corporation, Yorktown Heights, New York, USA

"For global executive leadership in semiconductor technology R&D."

12. IEEE DENNIS J. PICARD MEDAL FOR RADAR TECHNOLOGIES AND APPLICATIONS, for outstanding accomplishments in advancing the fields of radar technologies and their applications, sponsored by *Raytheon Company*, to YURI ABRAMOVICH (FIEEE)—Principal Research Scientist, WR Systems Ltd., Fairfax, Virginia, USA

"For seminal contributions to adaptive radar signal processing algorithms and Over-The- Horizon Radar."

13. IEEE MEDAL IN POWER ENGINEERING, for outstanding contributions to the technology associated with the generation, transmission, distribution, application, and utilization of electric power for the betterment of society, sponsored by the *IEEE Industry Applications, Industrial Electronics, Power Electronics,* and *Power & Energy Societies*, to THOMAS ANTHONY LIPO (LFIEEE)—Emeritus Professor, Department of Electrical & Computer Engineering, University of Wisconsin, Madison, Wisconsin, USA

"For contributions to electrical machine and drive topologies."

14. IEEE SIMON RAMO MEDAL, for exceptional achievement in systems engineering and systems science, sponsored by *Northrop Grumman Corporation*, to LYNDON EVANS (Non-member)—Director, Linear Collider Collaboration, European Centre for Particle Physics (CERN), Geneva, Switzerland

"For systems leadership of the Large Hadron Collider Project from conceptual design through completion of construction."

15. IEEE JOHN VON NEUMANN MEDAL, for outstanding achievements in computer-related science and technology, sponsored by *IBM Corporation*, to CLEVE MOLER (Non-member)—Chief Mathematician, MathWorks, Santa Fe, New Mexico, USA

"For fundamental and widely used contributions to numerical linear algebra and scientific and engineering software that transformed computational science."

16. IEEE CORPORATE INNOVATION AWARD, for an outstanding and exemplary innovation by an industrial entity, governmental or academic organization, or other corporate body, which have resulted in major advancement of electrotechnology, sponsored by *IEEE*, to DEFENSE ADVANCED RESEARCH PROJECTS (DARPA)—Arlington, Virginia, USA

"For many decades driving world-changing technological innovations."

17. IEEE ERNST WEBER MANAGERIAL LEADERSHIP AWARD, for exceptional managerial leadership in the fields of interest of IEEE, sponsored by *IEEE*, to PAUL E. JACOBS (MIEEE)—Chairman of the Board and Chief Executive Officer, Qualcomm, Inc., San Diego, California, USA

"For leadership in the development and commercialization of mobile technologies that contributed significantly to the growth of its global industry."

18. IEEE HARADEN PRATT AWARD, for outstanding service to IEEE, sponsored by the *IEEE Foundation*, to V. PRASAD KODALI (LFIEEE)—Retired, Adviser, Government of India, Department of Electronics, New Delhi, India

"For sustained contributions to IEEE, its Boards and Committees, and for pioneering the development of Region 10."

19. IEEE RICHARD M. EMBERSON AWARD, for distinguished service to the development, viability, advancement, and pursuit of the technical objectives of IEEE, sponsored by the *IEEE Technical Activities Board*, to WANDA K. REDER (FIEEE)—Vice President, S&C Electric Company, Chicago, Illinois, USA

"For leadership in the IEEE Smart Grid program and in the continued growth of the Power and Energy Society, including the creation of its Scholarship Fund."

20. IEEE HONORARY MEMBERSHIP, elected by the Board of Directors from among those individuals, not members of IEEE, who have rendered meritorious service to humanity in IEEE's designated fields of interest, sponsored by IEEE, to SHIRLEY M. TILGHMAN (Non-member)—President Emerita and Professor of Molecular Biology, Princeton University, Princeton, New Jersey, USA

"For leadership in bridging quantitative biology and engineering and for advancing higher education."

21. IEEE W.R. G. BAKER PAPER AWARD, for the most outstanding paper reporting original work published in any IEEE archival publications (such as TRANSACTIONS, JOURNALS and LETTERS), MAGAZINES, or PROCEEDINGS—sponsored by *IEEE Circuits and Systems, IEEE Communications, IEEE Control Systems, IEEE Information Theory, IEEE Power & Energy, IEEE Signal Processing*, and *IEEE Vehicular Technology Societies*, to three co-recipients:

- STEPHEN J. WRIGHT (MIEEE)—University of Wisconsin, Madison, Wisconsin, USA
- ROBERT NOWAK (FIEEE)—University of Wisconsin, Madison, Wisconsin, USA
- MÁRIO A. T. FIGUEIREDO (FIEEE)—Instituto de Telecomunicações, Instituto Superior Técnico, Torre Norte, Lisboa, Portugal

For their paper titled, "Sparse Reconstruction by Separable Approximation," *IEEE Transactions on Signal Processing*, Vol. 57, Issue 7, July 2009, pp. 2479–2493.

22. IEEE DONALD G. FINK PRIZE PAPER AWARD, for the outstanding survey, review, or tutorial paper in any of the IEEE Transactions, Journals, Magazines, or Proceedings, sponsored by the *IEEE Life Members Committee*—to two co-recipients:

- DIPANKAR RAYCHAUDHURI (FIEEE)—WINLAB, Tech Centre of NJ, North Brunswick, New Jersey, USA
- NARAYAN B. MANDAYAM (FIEEE)—WINLAB, Tech Centre of NJ, North Brunswick, New Jersey, USA

For their paper titled, "Frontiers of Wireless and Mobile Communications," *Proceedings of the IEEE,* Vol. 100, Issue 10, April 2012, pp. 824–840.

Professor A.J. Paulraj Wins the 2014 Marconi Prize

Honored for his pioneering contributions to developing the theory and applications of MIMO antennas

Palo Alto, CA, January 21, 2014—Professor (Emeritus) Arogyaswami Joseph Paulraj, Stanford University, has been awarded the prestigious 2014 Marconi Society Prize. His idea for using multiple antennas at both the transmitting and receiving stations—which is at the heart of the current high speed WiFi and 4G mobile systems—has revolutionized high speed wireless delivery of multimedia services for billions of people.

"Paul (as he is commonly known) has made profound contributions to wireless technology, and the resulting benefit to mankind is indisputable. Every wifi router and 4G phone today uses MIMO technology pioneered by him," says Professor Sir David Payne, Chairman of the Marconi Society and Director of the Optoelectronics Research Centre at the University of Southampton. "MIMO will soon be pervasive in all wireless devices. Moreover, Paulraj's work has provided fertile ground for thousands of researchers to explore and advance MIMO's potential to enhance wireless spectrum efficiency."

The Marconi Society, celebrating its 50th year in 2014, was founded by Gioia Marconi Braga. Each year it recognizes one or more scientists who—like her father, radio inventor Guglielmo Marconi—pursue advances in communications and information technology for the social, economic and cultural development of all humanity. Winners, who receive a $100,000 prize, have included scientists whose mathematical theories and inventions have shaped the Internet and broadband access, public key encryption, Web search, wired and wireless transmission, multimedia publishing, optical fiber and satellite communications.

Paul's story is a remarkable one. A native of India, a brilliant and always a top ranking student, he finished high school at 15 and having no career guidance, joined the Indian Navy. He opted for the electrical engineering branch, where his training focused on practical skills for maintaining weapons systems. But Paul wanted more and taught himself subjects like control theory, information theory and signal processing. He so impressed his superiors that in 1969 the Navy sent him to the Indian Institute of Technology (Delhi), one of India's top schools, for a MS program. His performance there quickly attracted the attention of Prof. P.V. Indiresan, an influential EE professor who urged the Navy to allow Paul to enroll in the Ph.D. program. Indiresan's persistence eventually overcame opposition both from the IIT Senate and from the Navy, allowing Paul to switch to the doctoral program with just two years to wind up his research.

That opportunity changed Paul's life. In 1970, Stanford Prof. Thomas Kailath, a brilliant and influential systems theorist, visited IIT Delhi to lecture on non-linear estimation. Inspired by Kailath's lectures, Paul went on to make fundamental advances in non-linear estimation of signals using advanced tools from Ito calculus and stochastic diffusion theory. The Navy also got a big payoff. In 1971, a brief war with Pakistan exposed the shortcomings of the Navy's (British origin) sonars leading to the loss of a Naval ship. Paul led a successful project to redesign the sonar adding many new signal processing concepts. Three years later the new technology was widely deployed in the fleet.

After a brief fellowship at Loughborough University U.K., the Navy assigned him to lead a much more ambitious project to design an advanced technology sonar not available to India because of military export restrictions. Overcoming difficult circumstances, his team developed a world-class sonar system (APSOH) that was inducted into fleet service in 1983, a stunning achievement in military electronics for India. APSOH to this day ranks among the best sonars in the world. Retired Admiral R. H. Tahiliani, former Chief of the Naval Staff, recalling APSOH says, "The Navy is enormously proud of Paul's many achievements and will remain always indebted for his landmark development of the APSOH sonar."

Following APSOH work, Paul was given a two-year sabbatical leave to explore new areas, and his scientific supervisor suggested he should try to work at Stanford University. Paul wrote to Prof. Tom Kailath, who despite initial skepticism, finally agreed to allow Paul to join his research group. Paul recalls "Coming to Stanford was one of the most fortunate breaks in my life, I am very grateful for the opportunity. Tom has an uncanny nose for choosing researchers and the people he attracted to his group helped make Stanford a top engineering school."

At Stanford, Paul worked on a multiple signals Directions of Arrival (DOA) estimation problem that had a long history of improvements using a spectrum approach. Paul proposed a totally new method called ESPRIT (Estimation of Signal Parameters via Rotational Invariance Techniques).This led to a mini-revolution spawning more than 1000 papers and over 50 doctoral dissertations; its applications now go far beyond array signal processing to spectral estimation and to system identification. "ESPRIT came from a physical rather than a mathematical, insight," says Paul. "I was trying to generalize my Indian sonar work, and as usual was thinking about it in a visual manner; the mathematics followed easily".

Paul returned to India in 1986 and served as the founding director for three major labs in India—CAIR (Center for Artificial Intelligence and Robotics), CDAC (Center for Development of Advanced Computing) and CRL (Central Research Labs of Bharat Electronics). But by 1991, bureaucratic battles began to take their toll and with the consent of the Indian Navy, he returned to the U.S. and Stanford University. Admiral Tahiliani, commenting on Paul's difficulties adds, "His departure for Stanford University was a major loss for our country and the circumstances that led to his move may explain why we have so few Nobel Laureates from India."

At Stanford, while awaiting a faculty appointment, Paul worked on signal separation experiments for airborne reconnaissance. He

noticed something surprising: in presence of scattering, co-channel wireless signals from closely spaced transmit sources were often separable by an adaptive receiver antenna array. A few days later, sitting in a barber shop, he had an idea for increasing throughput in wireless systems using multiple transmit and receive antennas (MIMO—Multiple Input, Multiple Output). Paul applied for an U.S, patent titled "Distributed Transmit—Directional Receive DTDR" (with his then supervisor Prof. Kailath as co-inventor) in Feb. 1992 and the patent was granted in Sep. 1994. Spatial Multiplexing, as this is now known, boosts spectral efficiency by creating "parallel spatial data streams" within the same frequency channel. Once again, it was visual thinking that sparked the idea. The rigorous, more mathematical details came from others, and indeed, many years later.

"When I stumbled upon the concept and potential of MIMO spatial multiplexing in 1991 I was troubled that such a simple idea might indeed not be original. Some years later, I discovered that Dr. Marconi had similar sentiments in 1895 when he first demonstrated wireless telegraphy," says Paul.

He need not have worried. The idea was indeed original. Moreover, his attempts to attract interest from the mobile technology companies and funding agencies were met with deep skepticism. His claim that a 1,000,000-QAM system could be built using MIMO when the state-of-art was then 4-QAM engendered disbelief. Now, 20 years later, the MIMO-based 802.11ac WiFi supports 16,000,000-QAM.

Following his appointment as Professor (Research) in 1993, Paul built a large research group around MIMO at Stanford that has since graduated over 50 doctoral and post-doctoral students, many of whom have gone on to become important leaders in their own right.

Undaunted by the skepticism about MIMO's practical feasibility, he took leave from Stanford in 1998 to found Iospan Wireless Inc. (initially known as Gigabit Wireless) and built a MIMO based commercial system. Venture firms finally paid attention after he demonstrated a 3×3 MIMO radio he built with his personal funds. While CDMA access technology was still the mainstay of the wireless industry, Paul pushed for OFDMA as the best access technology for incorporating MIMO. Iospan developed a MIMO-OFDMA based fixed wireless system to offer 4096-QAM with 2 spatial streams. By 2001, Iospan had firmly established that MIMO offers good value in typical cellular applications. Intel Corp. acquired Iospan's technology in 2003, and Paul worked with Intel to develop the WiMAX mobile standards.

In 2004, Paul co-founded Beceem Communications to develop semiconductor solutions and the company emerged as a world leader in WIMAX semiconductors with more than 65% market share. It was acquired by Broadcom Corp. In 2006 and the 3GPP standards group also adopted Iospan's MIMO-OFDMA as the core technology for the 4G mobile standards.

Stanford colleague and Marconi Fellow Prof. John Cioffi, the inventor of DSL technology, calls Paul's technical capability "almost unparalleled in the world. But what impresses me most is how Paul endured the tremendous, pressure, turmoil and stress of people saying his ideas weren't going to work, and persevered until he found success. Such people are pretty rare."

With characteristic modesty, Paul says, "MIMO technology is today embedded in 4G mobile and WiFi. It has taken the effort of thousands of engineers and researchers around the world, many of them truly eminent, to make this happen. My contribution, in comparison, is indeed small." And with characteristic optimism, he says, "The potential of MIMO to multiply the capacity of wireless spectrum is seemingly limitless. Use of milli-metric band frequencies can soon enable much larger numbers of MIMO antennas and the corresponding boost in wireless capacity."

Paul remains active, supervising Post-Doc students and serving as a Sr. Adviser to Broadcom Corp. He also maintains close ties to Indian IITs. Prof.Bhaskar Ramamurthi, Director IIT Madras, says, "Paul has enduring links with the entire IIT system. He has served on a variety of committees, mentored faculty members and even hosted some of them at his Stanford lab and his companies. He's been a marvelous asset for the IIT system over the past four decades."

Despite having received many awards and honors in the U.S. and India Paul says, "In telecom there are two top recognitions; the IEEE Alexander Graham Bell Medal which has a bias toward theoretical contributions, and the Marconi Prize, which honors contributions that convert breakthrough ideas into products benefiting billions of people. I am incredibly honored to have won both. The Marconi Prize emphasizes service to humanity. It is the highest recognition I can imagine."

Paul was elected to the U.S. National Academy of Engineering (NAE) in 2006, and to several national academies around the world. Notably, his election to U.S, NAE was just a dozen years after starting a career in wireless research in the U.S. He has also received recognition in India for his work, including the Padma Bhushan, a major national award.

"Paulraj's brilliance and perseverance have revolutionized wireless technology bringing a lasting benefit to mankind. He is a wonderful role model for researchers all over the world." says Mr. Narayana Murthy, Executive Chairman Infosys and a noted pioneer of IT Services.

Although Paul and his wife Nirmala live on the Stanford campus, they are frequent visitors to India, where Paul emphasizes the need for India to build its own telecom technology industry. He hopes to find more ways to contribute personally to that goal.

"I have two grown and married children and we're proud grandparents of four grandchildren," says Paul. "I love spending time with my family, but I'm not ready to stop work yet. My biggest challenge is finding time for all the things I want to do."

About the Marconi Society

The Marconi Society was established in 1974 through an endowment set up by Gioia Marconi Braga, daughter of Guglielmo Marconi, the Nobel laureate who invented radio (wireless telegraphy). It is best known for the Marconi Prize, awarded annually to an outstandingindividual/s whose scope of work and influence emulate the principle of "creativity in service to humanity" that inspired Marconi. Through symposia, conferences, forums and publications, the Marconi Society promotes awareness of major innovations in communication theory, technology and applications with particular attention to understanding how they change and benefit society.

Additional information about the Marconi Society and the Marconi Fellows can be found at www.marconisociety.org.

The Historian's Column

Anthony Ephremides

Not every member of our Society knows what the structure of our parent Institute (the IEEE) is. Not that it matters much but it provides additional sources of historical matter. Basically, the Societies of the IEEE (they number more than forty by now) are organized into ten technical Divisions, each having a Division Director who sits on the Board of IEEE, the supreme "Soviet", so to speak, of the Institute that is the upper-most authority in making decisions of all sorts. The term of each Director is two years (rarely renewable). So, like most volunteer organizations, the IEEE suffers from the fundamental weakness of having its top leaders quit their positions as soon as they "learn the ropes". Thus it is the Staff that holds much of the reins of power.

In any event, our Society belongs to the 10th Division along with several other Societies. Sometimes, the Board rearranges which Societies belong to which Division, especially since often there are new Societies that get created fairly regularly. The Director is elected by the members of the Societies that belong to the appropriate Division. I had the dubious privilege of serving as "your" Director during 1989 and 1990 (seems like really last century, doesn't it?). That experience provided me with a fair amount of insight into the workings of IEEE and also gave me a broader perspective as well as the opportunity to meet and associate with interesting people. And, of course, it provided a lot of material for historical musings. I was ruminating about those years the other day and decided that it might be interesting to many of our readers to highlight some vignettes of historical and entertainment value.

During my term the Societies of our Division included the Control Systems Society, the Society of Bio-engineering, the Society of Industrial Electronics, and perhaps one or two more that by now I forget. The "big" innovations during my term included the establishment of the so-called "International Colloquia", whereby the Technical Division Directors (because I forgot to mention that there are also ten, so-called, Regional Directors, who represent, regions and IEEE geographical sections) would travel extensively around the world and meet with the local IEEE leadership and run some sessions and seminars, exchanging information and fostering closer ties among the components of the Institute.

The first Colloquium that took place in the Fall of 1989 took us to Region 10 and, specifically to India, Singapore, and Australia. In the Fall of 1990 we visited Region 9 (Brazil, Argentina, Uruguay, and Chile).

The trips were actually quite valuable but also a source of many memories. To begin with there was one colleague Director who represented a Division that I forget (and was himself in many ways forgettable) but who stood out in my mind because he kept referring to the Colloquium as "Collegium". I was at a loss to understand his etymological reasoning but it was funny to have extensive discussions about the program of the Collegium! That same person, by the way, who, despite his French sounding name was very much a red-blooded American (or blue-blooded, I do not know the difference), considered nuclear weapons to be just another option in the arsenal (just like the famous General Lemay). He sported a heavy, albeit "graying", mustache and showed little sympathy for those hapless "international members who used to receive their Transactions envelope minus the Transactions themselves with several months of delay.

There was also another Director, (this time a Regional one, I think) who opposed IEEE adopting the metric system. When pressed to explain why, he would respond that he was for the change except that the change had to be done "properly". He never explained what is the "proper" way of converting to the metric system, but he held his ground, thereby prompting me to suggest (as Tom Cover had done, tongue-in-cheek, at a Society BoG meeting) that we establish the "nat" as the universal unit of information (in lieu of the "bit") thereby causing havoc in the Computer and Communication Industries. That certainly would be an "improper" way to make a change, I suppose.

There was another Director who came from Spain and from the Society of Industrial Electronics to eventually rise to the position of head of the Technical Activities Board (i.e. the governing body of the union of all Technical Divisions), who had "bribed" me with a bottle of Vega Sicilia Unico (if you do not know what that is, never mind) for undisclosed favors.

And then there were some wonderful Staff members. One of them, who left an indelible trace in my memory (and who is actually an IEEE member and recently became a Director himself), was Irving Engelson. Irv was a short fellow with a balding head and a stentorian bass voice. He wore a pair of spectacles that magnified his eyes as one was looking at him. And, above all, he had an inscrutable expression that always morphed into a delightful laughter and burst of humorous grimaces despite a possible heavy and funereal, original mood. He was also a poet who composed "on the fly" and displayed a sense of humor that (to me at least) set him apart from everyone else. And he was a master of the Robert's Rules of Order. I will never forget Irv.

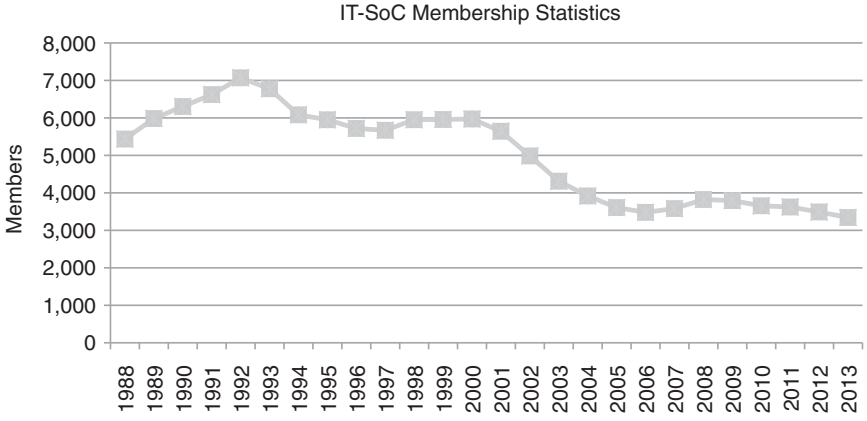
A dominant "theme" on the agenda of the Board meetings was the question of whether IEEE is an international organization, or a transnational organization, or a US organization that masqueraded as a world organization. Being incorporated in New York made the question unresolvable. To this day I do not think this fundamental identity question has been resolved but most members simply ignore it and leave it to the "graybeard elders" on the BoD to resolve it. It is not unlike the issue of how one could reconcile the role of IEEE as a technical organization without censors or limits of information flow with having a conference like MILCOM that had (and still has) "classified" sessions. The creative arguments I have heard about such issues have revealed to me the broader meaning of the Theory of Relativity. Not the General one, nor the Special one; rather the Human Theory of relativity.

After a Director's term expires, it is customary to utilize the gained "wisdom" from the term in Office by involving him/her

in some of the numerous Institute-wide committees. Thus, for a good part of the "nineties", I served on several committees that continued to enrich my appreciation of the form of government of the IEEE. I am sure I would have made a great President of the Institute. But, instead, I opted for returning to the rank-and-file level and fighting in the rafters, or the trenches, as the case may be. In future columns, I will select additional "fading" memories of amusing events, people, and situations from the "inner" circle of Institute government.

ps: As an addendum to my last column about the role of the University of Hawaii in our field, I wish to acknowledge the contribution of the latest "honorary" historian, Norm Abramson, who informed me that in addition to Slepian, Peterson, Lin, and Slepian, in the early seventies, the roster included also additional luminaries like Bill Davenport, Ned Weldon, Tom Gaarder, and three visitors who were there at the same time during that period, namely Jack Wolf, Bob Scholtz, and Tadao Kasami. Not a bad lot!

President's Column *continued from page 1*



remain high). I plan to vet these proposals among others with the BoG this year.

Declining Membership. The membership of our society has declined from a high of over 7000 in 1992 to 3400 in 2013 (see figure). This decline is partially attributed to the availability of papers through Xplore. However, as delineated in the 2012 review of the society, the decline of membership is at odds with our strategic plan to "Be the home for all technical professionals in all disciplines of interest." The report also mentions that there is a good opportunity for membership expansion given the broad scope of the "Field of Interest" of our society. In the past few years, we have enhanced our outreach via online, outreach, and student committees, which should support membership expansion. Also, last year the BoG unanimously approved differentiated fees for conferences, workshops, and schools to encourage nonmember attendees to join the society (other IEEE societies have been doing this already). I will work with the BoG to develop a plan to expand the membership especially from industry, outside the US (India and China), and among students.

Before closing, I would like to thank Gerhard Kramer for his exceptional service to the society as president and as a BoG member. The IT schools he helped create with Aylin Yener and which they have been continually supporting are arguably the most effective outreach activity in our society. Fortunately for me and for the society, he will remain involved as junior then senior past president. I would also like to thank outgoing senior past president Giuseppe Caire for his outstanding contributions to the society. I look forward to working with the society officers: senior past president Medard, junior past president Kramer, first vice president Effros, second vice president Orlitsky, newly appointed Transactions EiC Kschischang, treasurer Yener, and secretary Yeh; and the rest of the BoG members.

It is indeed an honor and a privilege to be the president of such a special society. Please stay involved in the society and do email your suggestions and comments to me at: abbas@ee.stanford.edu.

Distance-Divergence Inequalities

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***Abstract*—The method of distance-divergence inequalities was first used to simplify the proof of strong converses in multi-user Shannon theory. Its aim was to replace R. Ahlwede, P. Gács and J. Körner's *Blowing-up lemma* [1] by something simpler. Let $(\mathcal{X}, d, q)$ be a metric probability space. We consider distances W between measures on $\mathcal{X}$ that are defined by optimal couplings. Given a distance W, a distance-divergence inequality for q means that $W(p, q)$ can be overbounded in terms of (informational) divergence of p with respect to q. There are many interesting examples of such inequalities. The technique of distance-divergence inequalities yields an effective way to prove measure concentration and deviation inequalities. Distance-divergence inequalities are also closely related to the ergodic properties of q.**

I. Enlargement of sets and distances of sets of given probability

Let $(\mathcal{X}, d, q)$ be a *metric probability space*. More precisely, we assume that

- $\mathcal{X}$ is a Polish space equipped with the Borel σ-algebra;
- d is a Borel measurable distance on $\mathcal{X}$;
- q is a Borel probability measure on $\mathcal{X}$.

The subsets of $\mathcal{X}$ considered in this paper are assumed to be measurable.

We are interested in spaces $(\mathcal{X}, d, q)$ with the following property. Informally, if we enlarge any set of not too small q-probability by surrounding it with a thin layer then the enlarged set shall have q-probability almost 1.

More (but not completely) formally, for $A \subset \mathcal{X}$ and $\kappa > 0$, we denote by $[A]_\kappa$ the κ-neighborhood of A:

$$[A]_\kappa = \big\{x \in \mathcal{X}: \quad \text{there exists} \quad y \in A, \quad d(x, y) \le \kappa\big\},$$

and assume that for every $\varepsilon > 0$ there exists a $\kappa = \kappa(\varepsilon)$ satisfying

$$q(A) \ge \varepsilon \Rightarrow q([A]_\kappa) \ge 1 - \varepsilon, \tag{I.1}$$

and $\kappa(\varepsilon)$ can be overbounded in a non-trivial way.

The implication (I.1) can be written in the following symmetric form: if $A, B \subset \mathcal{X}$ then

$$d(A, B) \le \varphi(q(A)) + \varphi(q(B)), \tag{I.2}$$

with a function $\varphi(\cdot)$ that can be overbounded in a non-trivial way. This form overcomes the slight problem that $[A]_\kappa$ may not be measurable. In general, one should take inner measure of $[A]_\kappa$ in (I.1); otherwise (I.1) and (I.2) are completely equivalent (taking the complement of $[A]_\kappa$ for B).

The a metric probability spaces $(\mathcal{X}, d, q)$ satisfying (I.2) (or, equivalently, (I.1)) are said to have the *measure concentration* property, since (I.1) expresses that the measure q is concentrated in a small neighborhood of any not too small set. In this paper we consider a special, strong form of measure concentration where the function $\varphi(\varepsilon)$ is of the form $c(q) \cdot \sqrt{\log \frac{1}{\varepsilon}}$.

The best-known examples of such spaces are (i) product probability spaces with the Hamming distance and (ii) $\mathbb{R}^n$ with the Euclidean distance. But measure concentration is also studied for Riemann spaces, the symmetric group and others.

II. Measure concentration for product measures

Notation 1. *We denote by x^n the sequence $(x_1, x_2, \dots, x_n)$.*

Let $\mathcal{X}^n$ be the n-th power of the Borel space $\mathcal{X}$, let $q^n = \prod_{i=1}^n q_i$ be the product of (possibly different) probability measures on $\mathcal{X}$, and δ_n the Hamming distance on $\mathcal{X}^n$:

$$\delta_n(x^n, y^n) = \sum_{i=1}^n \delta(x_i, y_i) \quad \text{for} \quad x^n, y^n \in \mathcal{X}^n. \tag{II.1}$$

Here δ is Kronecker's distance: $\delta(x, y) = 1$ if $x \ne y$, and $\delta(x, x) = 0$. (The Hamming distance makes sense in $\mathcal{X}^n$ for any Polish space $\mathcal{X}$.)

We then have the following strong form of (I.1) for the Hamming distance δ_n, proved in this form in [2] (see also [4]):

$$q^n([A]_{n\varepsilon}) \ge 1 - \exp\left(-2n\left(\varepsilon - \sqrt{\frac{1}{2n} \cdot \log \frac{1}{q^n(A)}}\right)^2\right). \tag{II.2}$$

($[A]_{n\varepsilon}$ denotes neighborhood with respect to Hamming distance.)

By the equivalence of (I.1) and (I.2), (II.2) can be rewritten as

$$\delta_n(A, B) \le \sqrt{\frac{n}{2} \cdot \log \frac{1}{q^n(A)}} + \sqrt{\frac{n}{2} \cdot \log \frac{1}{q^n(B)}} \tag{II.3}$$

for any $A, B \subset \mathcal{X}^n$.

An inequality similar to (II.3) holds for $(\mathbb{R}^n, e_n, q^n)$, where e_n is the Euclidean distance, $q^n = \prod_{i=1}^n q_i$, and each q_i has a smooth density $\exp(-V_i(x))$, with strictly uniformly convex functions V_i: $V_i"(x) \geq \rho > 0$ for all i and $x \in \mathbb{R}$. We then have [5]

$$e_n(A,B) \leq \sqrt{\frac{2}{\rho} \cdot \log \frac{1}{q^n(A)}} + \sqrt{\frac{2}{\rho} \cdot \log \frac{1}{q^n(B)}} \qquad \text{(II.4)}$$

for any $A, B \subset \mathbb{R}^n$.

A way to prove inequalities of the type (II.3) and (II.4) is by defining distances between measures and then bounding these distances by (informational) divergence.

III. Distance-Divergence inequalities

We denote by $\mathbb{P}(\mathcal{X})$ the set of Borel probability measures on $\mathcal{X}$; thus q is a distinguished element of $\mathbb{P}(\mathcal{X})$.

Definition 1. *For $p, r \in \mathbb{P}(\mathcal{X})$ we denote by $\Pi(p,r)$ the set of all joint probability distributions $\pi = \mathcal{L}(Y,Z)$ on $\mathcal{X} \times \mathcal{X}$, with marginals $p = \mathcal{L}(Y)$ and $r = \mathcal{L}(Z)$. These joint distributions are called* couplings *of p and r.*

Definition 2. *Fix a β, $1 \leq \beta \leq 2$. For $p, r \in \mathbb{P}(\mathcal{X})$ we define*

$$W_\beta(p,r) = W_\beta^{(d)}(p,r)$$
$$= \inf_{\pi \in \Pi(p,r)} \left\{ \left(\mathbb{E}_\pi \, d(Y,Z)^\beta \right)^{1/\beta} : \mathcal{L}(Y) = p, \quad \mathcal{L}(Z) = q \right\}, \qquad \text{(III.1)}$$

where $\mathbb{E}_\pi$ denotes expectation with respect to π. $W_\beta(p,r)$ is called the Wasserstein distance*, of order β, of p and r. It is easy to see that W_β is a distance on $\mathbb{P}(\mathcal{X})$. (It may take the value ∞.) In this paper β shall be 1 or 2 (most of the time).*

The simplest Wasserstein distance is the variational distance between probability measures:

$$|p - r|_{TV} = \sup_{A \subset \mathcal{X}} \big(p(A) - r(A) \big)$$

which corresponds to the Kronecker distance (with $\beta = 1$).

For $p, q \in \mathbb{P}(\mathcal{X})$ we write $D(p||q)$ for the (informational) *divergence* (or relative entropy) of p with respect to q:

$$D(p||q) = \int_{\mathcal{X}} \log \left(\frac{dp}{dq} \right) dp \qquad \text{if } p \ll q; \quad +\infty \quad \text{otherwise.}$$

Definition 3. *We say that $q \in \mathbb{P}(\mathcal{X})$ satisfies a* distance-divergence inequality *of order β, with constant ρ, if*

$$W_\beta(p,q) \leq \sqrt{\frac{2}{\rho} \cdot D(p||q)} \quad \textit{for all} \quad p \in \mathbb{P}(\mathcal{X}). \qquad \text{(III.2)}$$

The simplest distance-divergence inequality is the *Pinsker-Csiszár-Kullback inequality*

$$|p - q|_{TV} \leq \sqrt{\frac{1}{2} \cdot D(p||q)}.$$

This is a distance-divergence inequality that holds with the same constant $\rho = 4$ for every q.

A more recent, but fundamental, result refers to Euclidean distance on $\mathbb{R}$. Let W_2 denote the Wasserstein distance on $\mathbb{P}(\mathbb{R})$ derived from the Euclidean distance.

Theorem 1. *(*Talagrand's inequality*, [5].) Let q be a probability measure on $\mathbb{R}$ with smooth density $\exp(-V(x))$, where V is* strictly uniformly convex*: $V"(x) \geq \rho > 0$ for all $x \in \mathbb{R}$. Then*

$$W_2(p,q) \leq \sqrt{\frac{2}{\rho} \cdot D(p||q)}. \qquad \text{(III.3)}$$

Talagrand's inequality holds, in particular, for Gaussian distribution. The proof of Therem 1 is based on the unique *monotone map* that takes the measure p on $\mathbb{R}$ to the measure q (provided both measures are absolutely continuous). This map realizes the coupling of p and q that is optimal with respect to the distance W_2.

Definition 4. *Given the metric d on $\mathcal{X}$, we consider the following distances on $\mathcal{X}^n$:*

$$d_{\beta,n}(x^n, y^n) = \left(\sum_{i=1}^n d(x_i, y_i)^\beta \right)^{1/\beta}, \quad 1 \leq \beta \leq 2. \qquad \text{(III.4)}$$

Thus we get the Hamming distance from Kronecker's distance, with $\beta = 1$, and the Euclidean distance from the one-dimensional Euclidean distance, with $\beta = 2$. The distance $d_{\beta,n}$ on $\mathcal{X}^n$ gives rise to the Wasserstein distance $W_{\beta,n}$ on $\mathbb{P}(\mathcal{X}^n)$:

$$W_{\beta,n}(p^n, r^n) = W_{\beta,n}^{(d)}(p^n, r^n)$$
$$= \inf_{\pi \in \Pi(p^n, r^n)} \left\{ \left(\mathbb{E}_\pi \sum_{i=1}^n d(Y_i, Z_i)^\beta \right)^{1/\beta} : \right.$$
$$\left. \mathcal{L}(Y^n) = p^n, \quad \mathcal{L}(Z^n) = r^n \right\}.$$

In Definition 4 we could use different distances for different coordinates, to allow a wider range of applications, but we want to keep the notation simple.

The Wasserstein distances $W_{\beta,n}$ play an important role in the study of particle systems, and, more recently, in the study of the trend to equilibrium of solutions of certain partial differential equations (for $\beta = 2$).

The next two lemmas are the key ingredients in proving (II.3) and (II.4).

Lemma 2. *[4] The inequality* (III.2) *implies*

$$d(A,B) \leq$$
$$\sqrt{\frac{2}{\rho} \cdot \log \frac{1}{q(A)}} + \sqrt{\frac{2}{\rho} \cdot \log \frac{1}{q(B)}} \quad \textit{for all} \quad A, B \subset \mathcal{X}. \qquad \text{(III.5)}$$

Proof: Denote by p and r the restriction of q to A resp.

B, i.e., e.g.,

$$p(C) = \frac{q(A \cap C)}{q(A)} \quad \text{for} \quad C \subset \mathcal{X}.$$

Then for any $\beta \in [1, 2]$

$$d(A, B) \le W_\beta(p, r) \le W_\beta(p, q) + W_\beta(q, r).$$

By (III.2) this can be continued to

$$\le \sqrt{\frac{2}{\rho} \cdot D(p||q)} + \sqrt{\frac{2}{\rho} \cdot D(r||q)}.$$

But it is easy to see that the definition of p and r implies

$$D(p||q) = \log \frac{1}{q(A)} \quad \text{and} \quad D(r||q) = \log \frac{1}{q(B)}.$$

■

The next lemma shows how the coefficient of the divergence term in distance-divergence inequalities increases when proceeding to product spaces. There is no increase for $\beta = 2$, and a factor n appears for $\beta = 1$ (under the square root). The proof of this lemma requires constructing good couplings between measures p^n and q^n on $\mathcal{X}^n$ from couplings between q_i and the conditional distributions $p_i(\cdot|y^{i-1}) \triangleq \mathcal{L}(Y_i|Y_1 = y_1, \dots, Y_{i-1} = y_{i-1})$ on $\mathcal{X}$.

Lemma 3. *[4],[5] Let $q^n = \prod_{i=1}^n q_i$ be a product measure on $\mathcal{X}^n$. Then:*

$$W_\beta(p, q_i) \le \sqrt{\frac{2}{\rho} \cdot D(p||q_i)} \quad \textit{for all} \quad i \quad \textit{and} \quad p \in \mathbb{P}(\mathcal{X})$$

implies

$$W_{\beta,n}(p^n, q^n) \le \sqrt{\frac{2n^{2/\beta - 1}}{\rho} \cdot D(p^n||q^n)}$$

for all $p^n \in \mathbb{P}(\mathcal{X}^n)$.

Thus any n-fold product measure satisfies a distance-divergence inequality for Hamming distance with the same constant $4/n$. On the other hand, n-fold product measures satisfy distance-divergence inequalities for Euclidean distance with the smallest of the constants valid for the factors.

Note that Theorem 1 holds more generally: for probability measures q^k on $\mathbb{R}^k$ with strictly uniformly log-concave densities, c.f. [6]. A proof may be given using the unique *monotone map* that takes the measure p^k on $\mathbb{R}^k$ to the measure q^k on $\mathbb{R}^k$. (This relatively recent result is less known in $\mathbb{R}^k$ than on $\mathbb{R}$. There is an extensive literature on this subject; we only mention [7].) Moreover, Theorem 1 can be extended for some perturbations of strictly uniformly log-concave densities.

Distance-divergence inequalities can be reformulated to yield *large deviation type* inequalities for Lipschitz functions. (In product spaces the class of Lipschitz functions is larger than that of sums of Lipschitz functions of single variables.) Let $(\mathcal{X}, d, q)$ be a metric probability space.

Theorem 4. *[8] The following two statements are equivalent:*

$$(i) \quad W_1^{(d)}(p, q) \le \sqrt{\frac{2}{\rho} \cdot D(p||q)} \quad \textit{for all} \quad p \in \mathbb{P}(\mathcal{X}),$$

$$(ii) \qquad \int_{\mathcal{X}} e^{tf(x)} dq(x) \le e^{\frac{t^2}{2\rho} + t\,\mathbb{E}_q f}$$

for all Lipschitz functions $f : \mathcal{X} \mapsto \mathbb{R}$ with Lipschitz coefficient 1, and all $t > 0$.

Theorem 5. *[9] The following two statements are equivalent:*

$$(i) \quad W_2^{(d)}(p, q) \le \sqrt{\frac{2}{\rho} \cdot D(p||q)} \quad \textit{for all} \quad p \in \mathbb{P}(\mathcal{X}),$$

$$(ii) \qquad q^n\Big\{x^n : f(x^n) \ge \mathbb{E}\, f + r\Big\} \le e^{-\frac{\rho r^2}{2}}$$

for all n, all Lipschitz functions $f : \mathcal{X}^n \mapsto \mathbb{R}$ with Lipschitz coefficient 1 (with respect to distance $d_{2,n}$), and all $r > 0$.

IV. Distance-Divergence inequalities for random processes

Distance-divergence inequalities can be proved for product spaces with non-product measures if the dependence between coordinates is weak. The results formulated in this section apply for segments of random processes with some mixing conditions. We will work with the Hamming's distance.

Let q^n be a Borel probability measure $\mathcal{X}^n$ (the n-th power of a Borel space $\mathcal{X}$). Let $y^n \in \mathcal{X}^n$, and let Y^n denote a random sequence with $\mathcal{L}(Y^n) = p^n$. We use the following

Notation 2. *For $1 \le i \le n$ we write*

- $y^i \triangleq (y_1, y_2, \dots, y_i)$ *and* $y_i^n \triangleq (y_{i+1}, y_{i+2}, \dots, y_n)$*;*
- $p_i(\cdot|y^{i-1}) \triangleq \mathcal{L}(Y_i|Y^{i-1} = y^{i-1})$*;*
- $p_i^n(\cdot|y^i) \triangleq \mathcal{L}(Y_i^n|Y^i = y^i)$*;*
- X^n *always denotes a random sequence with* $\mathcal{L}(X^n) = q^n$.

Now we formulate a condition for measures on product spaces that was inspired by ergodic theory.

Definition 5. *[10] We say that q^n* admits couplings with distance bounded by constant C *if: For every $i \in [1, n-1]$ and every pair of sequences $y^i, z^i \in \mathcal{X}^i$ such that*

$$y^{i-1} = z^{i-1}, \tag{IV.1}$$

there exists a coupling

$$\mathcal{L}(Y_i^n, Z_i^n|Y^i = y^i, Z^i = z^i) = \pi_i^n(\cdot|y^i, z^i)$$
$$\in \Pi\big(q_i^n(\cdot|y^i), q_i^n(\cdot|z^i)\big),$$

satisfying

$$\mathbb{E}_\pi\Big\{\sum_{j=i+1}^n d(Y_j, Z_j) \;\Big|\; y^i, z^i\Big\} \le C. \tag{IV.2}$$

Note that if beyond (IV.1) *we also have* $y_i = z_i$, *then* $q_i^n(\cdot|y^i) = q_i^n(\cdot|z^i)$, *thus in this case we can get* 0 *on the right hand side of* (IV.2).

Theorem 6. *[10] Assume that* q^n *admits couplings with distance bounded by the constant* C. *Then*

$$W_{1,n}(p^n, q^n) \le (C+1) \cdot \sqrt{\frac{n}{2} \cdot D(p^n||q^n)}.$$

Thus for measures admitting couplings with bounded distance the distance-divergence inequality is only slightly worse than the inequality for product measures. (By a constant factor.) This theorem can be applied to prove distance-divergence inequalities, and thus measure concentration, for segments of φ-mixing processes. It can also be applied to prove measure concentration on the symmetric group. (This was first proved in [11].)

V. Distance-Divergence inequalities for Gibbs measures

In this section we formulate distance-divergence inequalities for Gibbs measures satisfying (variants of) Dobrushin's uniqueness condition. The proofs can be carried out analyzing the Gibbs sampler defined by the local specifications of q^n. (For the definition of the Gibbs sampler see the next section.)

Let q^n be a Borel probability measure on $\mathcal{X}^n$, and let X^n be a random sequence with $\mathcal{L}(X^n) = q^n$. We use the following

Notation 3. *For* $y^n \in \mathcal{X}^n$

- $\bar{y}_i \triangleq (y_1, y_2, \ldots, y_{i-1}, y_{i+1}, \ldots, y_n)$;
- $Q_i(\cdot|\bar{y}_i) \triangleq \mathcal{L}(X_i|\bar{X}_i = \bar{y}_i)$.

The conditional distributions $Q_i(\cdot|\bar{y}_i)$ are called the local specifications of q^n.

The following condition was motivated by *Dobrushin's uniqueness condition*, which, however, was formulated by Dobrushin [12] for *infinite* ensembles of random variables, to ensure that the local specifications uniquely determine the joint distribution. In our setting, the role of Dobrushin's uniqueness condition is somewhat different, but the analogy is apparent. First we deal with the Hamming distance on $\mathcal{X}^n$.

Definition 6. *We say that* q^n *satisfies* Dobrushin's uniqueness condition *if there exist numbers* $a_{i,k} \ge 0$, $(i, k \in [1, n],\ i \ne k)$, *such that:*
(i) For any i, k, $1 \le i, k \le n$, $i \ne k$, *and any* $\bar{y}_k, \bar{z}_k \in \mathcal{X}^{n-1}$, *differing only in the* i*-th coordinate, we have*

$$\left|Q_k(\cdot|\bar{y}_k) - Q_k(\cdot|\bar{z}_k)\right|_{TV} \le a_{i,k}, \qquad \text{(V.1)}$$

and
(ii) For the matrix $A \triangleq \left(a_{i,k}\right)_{i,k=1}^n$, *where* $a_{i,i} = 0$, *we have*

$$||A||_\infty = \max_k \sum_{i=1}^n a_{i,k} < 1.$$

The numbers $a_{i,k}$ *are called Dobrushin's interdependence coefficients.*

Theorem 7. *[13] If* q^n *satisfies Dobrushin's uniqueness condition then*

$$W_{1,n}(p^n, q^n) \le \frac{1}{1-||A||_\infty} \sqrt{\frac{n}{2} \cdot D(p^n||q^n)}$$

for all $p^n \in \mathbb{P}(\mathcal{X}^n)$.

A similar theorem holds for $(\mathbb{R}^n, e_n, q^n)$, provided q^n satisfies a version of Dobrushin's uniqueness condition for Euclidean distance. The definition is the same as for the Hamming distance, except that in (V.1) we assume inequalities for the W_2-distance in place of variational distance, and the $\mathbb{L}_\infty$-norm of the matrix A is replaced by the $\mathbb{L}_2$-norm. In the next theorem the superscript (e) refers to one-dimensional Euclidean distance.

Theorem 8. *[14]* (corrected in *[15]*). *Assume that for the measure* q^n *on* $\mathbb{R}^n$, *the local specifications* $Q_i(\cdot|\bar{y}_i)$ *satisfy the distance-divergence inequality*

$$W_2^{(e)}\big(p, Q_i(\cdot|\bar{y}_i)\big) \le \sqrt{\frac{2}{\rho} \cdot D\big(p||Q_i(\cdot|\bar{y}_i)\big)}$$

for all i, $\bar{y}_i$ *and* $p \in \mathbb{P}(\mathcal{X})$. *Moreover, assume that* q^n *satisfies Dobrushin's uniqueness condition for Euclidean distance. Then*

$$W_{2,n}^{(e)}(p^n, q^n) \le K \cdot \sqrt{\frac{2}{\rho \cdot \left(1-||A||_2\right)} \cdot D(p^n||q^n)} \qquad \text{(V.2)}$$

for all $p^n \in \mathbb{P}(\mathcal{X}^n)$. *Here* K *is an absolute constant.*

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2014 Elevated Fellows

Randall Berry
Northwestern University

for contributions to resource allocation and interference management in wireless networks

Shuguang Cui
Texas A&M University

for contributions to cognitive communications and energy efficient system design

Vivek Goyal
Massachusetts Institute of Technology

for contributions to information representations and their applications in acquisition, communication, and estimation

Martin Haenggi
University of Notre Dame

for contributions to the spatial modeling and analysis of wireless networks

Syed Jafar
University of California, Irvine

for contributions to analyzing the capacity of wireless communication networks

J. Laneman
University of Notre Dame

for contributions to multihop relaying and cooperative communication for wireless networks

Ioannis Paschalidis
Boston University

for contributions to the control and optimization of communication and sensor networks, manufacturing systems, and biological systems

Balaji Rajan
Indian Institute of Science

for contributions to high performance and low complexity space-time code designs for wireless communication systems

Ashutosh Sabharwal
Rice University

for contributions to the theory and experimentation of wireless systems and networks

Philip Schniter
Ohio State University

for contributions to signal processing in communications

Emina Soljanin
Bell Labs Alacatel-Lucent

for contributions to coding theory and coding schemes for transmission and storage systems

Wei Yu
University of Toronto

for contributions to optimization techniques for multiple-input-multiple-output communications

Shengli Zhou
University of Connecticut

for contributions to wireless and underwater acoustic communications

2014 IT Society's Newly Elected IEEE Fellows

In this issue, based on a very nice suggestion by Rob Calderbank, we decided to include a short (auto-)biography on each of the newly elected IEEE Fellows that were specifically nominated by the IT society:

Guang Gong, University of Waterloo

Dr. Guang Gong received a B.S. degree in Mathematics in 1981, an M.S. degree in Applied Mathematics in 1985, and a Ph.D. degree in Electrical Engineering in 1990, from Universities in China. She received a Postdoctoral Fellowship from the Fondazione Ugo Bordoni, in Rome, Italy, and spent the following year there. She joined the University of Waterloo, Canada in 1998, as an Associate Professor in the Dept. of Electrical and Computer Engineering in 2000. She has been a full Professor since 2004. Dr. Gong's research interests are in the areas of sequence design, cryptography, and communication security, and has extensive publications in those areas. Her work on interleaved sequences, 2-level autocorrelation sequences and sequences with low correlation are of the frontier of the field and find many applications in radar, CDMA and OFDM communications. She has introduced the GH public key systems, WG stream cipher family, hyper bent functions, discrete Fourier transform attacks, and active eavesdropping attacks. She has made the contributions to key revocation for mobile ad hoc networks, cloned sensor detection in wireless sensor networks, and lightweight protections for radio frequency identification (RFID). She has co-authored a book with Dr. Solomon Golomb, entitled as Signal Design for Good Correlation for Wireless Communication, Cryptography and Radar, published by Cambridge Press in 2005, and coauthored with Dr. Lidong Chen, Communication System Security, published by CRC 2012.

Dr. Gong serves/served as Associate Editors for several journals including Associate Editor for Sequences for IEEE Transactions on Information Theory (2005–2008), and served on a number of technical program committees and conferences as co-chairs or committee members including program co-chairs for Sequences and Their Applications (SETA) 2006, Indocrypt 2010, Selected Areas of Cryptography (SAC) 2010, and general chair for SETA 2012. She has received numerous awards including the Best Paper Award (1984) from the Chinese Institute of Electronics, Outstanding Doctorate Faculty Award (1991) of Sichuan Province, China, the Premier Research Excellence Award (2001), Ontario, Canada, Best Paper Award of 1979–2009 Systems Sciences (2009), NSERC Discovery Accelerator Supplement Award (2009), Canada, and Ontario Research Fund—Research Excellence Award (2010), Canada, and Best Paper Award of IEEE ICC 2012.

Syed Ali Jafar, Univesity of California, Irvine

Syed Ali Jafar received his B. Tech. from IIT Delhi, India, in 1997, M.S. from Caltech, USA, in 1999, and Ph.D. from Stanford, USA, in 2003, all in Electrical Engineering. His industry experience includes positions at Lucent Bell Labs, Qualcomm Inc. and Hughes Software Systems. He is currently an Associate Professor in the Department of Electrical Engineering and Computer Science at the University of California Irvine, Irvine, CA USA. His research interests include multiuser information theory and wireless communications.

Dr. Jafar received the NSF CAREER award in 2006, the ONR Young Investigator Award in 2008, the Information Theory Society paper award in 2009, the School of Engineering Maseeh Outstanding Research Award in 2010, an IEEE GLOBECOM CTS Best Paper Award in 2012 and an IEEE Communication Society Best Tutorial Paper Award in 2013. Dr. Jafar received the UC Irvine EECS Professor of the Year award four times, in 2006, 2009, 2011 and 2012, from the Engineering Students Council and the Teaching Excellence Award in 2012 from the School of Engineering. He was a University of Canterbury Erskine Fellow in 2010 and is an IEEE Communications Society Distinguished Lecturer for 2013–2014. He served as Associate Editor for IEEE Transactions on Communications 2004–2009, for IEEE Communications Letters 2008–2009 and for IEEE Transactions on Information Theory 2009–2012.

Emina Soljanin, Bell Labs

Emina Soljanin received the PhD and MS degrees from Texas A&M University, College Station, in 1989 and 1994, and the European Diploma degree from University of Sarajevo, Bosnia, in 1986, all in Electrical Engineering. From 1986 to 1988, she worked in the Energoinvest Company, Bosnia, developing optimization algorithms and software for power systems control. After graduating from Texas A&M in 1994, she joined Bell Laboratories, Murray Hill, NJ, where she is now a Distinguished Member of Technical Staff in the Mathematics of Networks research department.

Dr. Soljanin's research interests are in the broad area of information and coding theory, and their applications. In the course of almost two decades with Bell Labs, she has participated in a very wide range of research and business projects. These projects include designing the first distance enhancing codes to be implemented in commercial magnetic storage devices, first forward error correction for Bell Labs optical transmission devices, color space quantization and color image processing, quantum computation, link error prediction methods for the third generation wireless network standards, and several aspects of secure communications. Her most recent activities are in the area of network and rateless coding for packet level transmission and distributed storage.

She served as the IEEE IT Society Padovani Lecturer at the 2013 North American School of Information Theory. Dr. Soljanin served as a Technical Proof-Reader, 1990–1992, and as the Associate Editor for Coding Techniques, 1997–2000, for the IEEE Transactions on Information Theory, and has organized and served as a co-chair for the DIMACS Special Focus on Computational Information Theory and Coding 2001–2005 and DIMACS Special Focus on Cybersecurity 2011–2015. She is a member of the editorial board of the Springer Journal on Applicable Algebra in Engineering, Communication and Computing AAECP), and a member of the Board of Governors of the IEEE Information Theory Society. Dr. Soljanin has been elevated to IEEE Fellow grade for contributions to coding theory and coding schemes for transmission and storage systems.

Wei Yu, University of Toronto

Wei Yu was elevated to IEEE Fellow Grade in 2014 with the citation: "for contributions to optimization techniques for multiple-input-multiple-output (MIMO) communications."

Wei Yu received the B.A.Sc. degree in Computer Engineering and Mathematics from the University of Waterloo, Waterloo, Ontario, Canada in 1997 and M.S. and Ph.D. degrees in Electrical Engineering from Stanford University, Stanford, CA, in 1998 and 2002, respectively. Since 2002, he has been with the Electrical and Computer Engineering Department at the University of Toronto, Toronto, Ontario, Canada, where he is now Professor and holds a Canada Research Chair in Information Theory and Wireless Communications.

Professor Wei Yu is being recognized for his contributions to multiuser information theory and for the practical impact of his work to both fixed-line and wireless communications. In the area of fixed-line communications, he has been a proponent in dynamic spectrum management for digital subscriber lines (DSLs). Some of the concepts in his work are now widely used in broadband-access DSL deployment. In wireless communications, he has contributed to the optimization techniques for multiple-antenna communication systems, and to the capacity analysis of the Gaussian vector multiple-access channel, broadcast channel, interference channel, and the relay channel.

Prof. Wei Yu served as an Associate Editor for IEEE Transactions on Information Theory (2010–2013), as an Editor for IEEE Transactions on Communications (2009–2011), and as an Editor for IEEE Transactions on Wireless Communications (2004–2007). Prof. Wei Yu is a recipient of an IEEE International Conference on Communications (ICC) Best Paper Award in 2013, an IEEE Signal Processing Society Best Paper Award in 2008, and an Early Career Teaching Award from the Faculty of Applied Science and Engineering, University of Toronto, in 2007.

Two Meetings on Green Data Storage at DIMACS

Organizers:
Stark Draper (University of Toronto)
Emina Soljanin (Bell Labs – Murray Hill, US)

Two short meetings on "Green Data Storage" were held at the Center for Discrete Mathematics and Theoretical Computer Science (DIMACS), Rutgers University, New Jersey, on Dec. 16–18 2013. The event brought together researchers from the coding, queueing, and systems communities, studying data storage in the cloud, operation of data centers, and content delivery. The goal was to better understand performance measures, modeling issues, evaluation methodologies, and how to bridge theory and practice.

Data centers' energy requirements have increased massively in recent years. A substantial (and growing) percentage of worldwide electricity is dedicated to cloud computing, which motivates the design of energy-efficient storage techniques. In the U.S. alone about 100 billion kWh of energy at a cost of $7.4 billon is consumed annually by these centers, producing as much CO_2 as all of Argentina. Yet, much of this power goes to waste. Many servers are busy only 5–30% of the time and up to 30% of internal network traffic is devoted to reliability, dealing with equipment failure and the threat of data loss. One reason for these inefficiencies is that users of cloud systems demand that their services be readily available and their content be reliably stored. Cloud providers today strive to meet both demands through overprovisioning: simply keeping processors ready to go at all times and replicating content throughout the storage network over multiple disks, in both cases increasing energy requirements.

A large body of recent literature draws on queuing analyses to model and control both processors and content distribution. Erasure and network coding has been proposed as a more bandwidth and storage efficient way to provide reliability and accessibility of stored content. These smart processor and storage algorithms promise to cut data-center energy use significantly, but have so far been studied and evaluated mostly in simplified theoretical settings, without taking into account all systems issues that may arise by introducing the algorithms into practical storage systems. The working group and workshop brought together experts in coding and queueing theory for distributed storage together with systems experts in order to better understand the issues involved and to find ways to evaluate how well the practice would match the theoretical predictions of energy savings.

The first two days took the form of a DIMACS "Working Group" with eight keynote talks by Tom Bostoen (Bell Lab), Alex Dimakis (UT Austin), Muriel Medard (MIT), Thu Nguyen (Rutgers), Kannan Ramchandran (UC Berkeley), Mor Harchol-Balter (CMU), Minlan Yu (USC), and Anshul Gandhi (IBM & Stony Brook). The first day also featured an icy roof-top tour of Rutgers solar powered PARASOL experimental micro-datacenter (http://parasol.cs.rutgers.edu) operated by Profs. Nguyen and Bianchini. The third day was a DIMAC "Workshop" featuring 16 talks by students, faculty, and industrial researchers from institutions across North America and Europe.

"The DIMACS workshop combined the benefits of a full-size conference with hard-hitting quality talks and the schedule of a small workshop that encourages discussion; I saw DIMACS sow the seeds for many a collaboration. I gained as many insights about the state of the field as from two or three normal conferences combined, and getting to know thought leaders at a more personal level was fantastic." —Ulric Ferner, PhD student, MIT

"This was an amazing workshop! It brought together people from information theory, queuing theory, computer systems with a common aim: energy efficiency. It was exciting to see different research approaches and styles on the same topic." —Yanpei Liu, PhD student, UW-Madison

"This was a well-organized workshop with great speakers, from which I not only learned the recent progress of the applications of Information Theory to data storage, but more importantly, had the chance to interact with lots of world-class researchers." —Zhenhua Liu, PhD student, Caltech

"The DIMACS Working Group on Algorithms for Green Data Storage was a unique opportunity for me, as a queueing theorist, to meet people in the area of network coding, and learn of problems that are quite different from standard queueing models. I was exposed to several new problems in multi-server queueing systems, motivated by error-correcting codes and energy management, wherein jobs are purposely replicated across all servers, and are considered "complete" when a subset of the servers complete their tasks. At this point, I have read all the papers on this topic by Prof. Kannan Ramchandran and by Dr. Emina Soljanin, both of whom I met at the workshop. I am working with my students on researching new solutions to some of the problems that Kannan and Emina proposed, and I look forward to collaborating with Kannan and Emina in the future." —Mor Harchol-Balter, Professor, CMU

"I learned a lot about energy management in storage and networking. It was very interesting to learn more about coding, which is typically outside of my research area, and how one might use it for improving energy efficiency. The workshop helped me to think about energy efficiency and management more holistically." —Thu Nguyen, Professor, Rutgers

The program with abstracts can be found at http://dimacs.rutgers.edu/Workshops/WGGreen/program.html for the Working Group and at http://dimacs.rutgers.edu/Workshops/Green/program.html for the workshop.

Talk slides are available at http://dimacs.rutgers.edu/Workshops/Green/Slides/slides.html

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GOLOMB'S PUZZLE COLUMN™

Elementary Arithmetic

Solomon W. Golomb

A. In a single calendar year (CY), the number of months having a Friday the 13th is at least one and at most three.

1) If a CY has only one Friday 13th, what month can it be?

2) If a CY has exactly two Friday 13th, what two months can these be?

3) If a CY has three Friday 13th, what three months can these be?

4) The answers above depend, to some extent, on whether or not the CY is a leap year. Which answers above are the same whether or not?

B. The ancient Egyptians liked to represent "proper fractions" (those between 0 and 1) as finite sums of reciprocals of distinct positive integers, such as $\frac{3}{5} = \frac{1}{2} + \frac{1}{10}$. Such sums always exist (a simple consequence of "the harmonic series diverges"). Try to represent each of the following proper fractions as finite sums of reciprocals of distinct positive integers, using the fewest summands in each case.

1) $\frac{23}{59}$ 2) $\frac{167}{385}$ 3) $\frac{687}{2800}$ 4) $\frac{22}{37}$

C. *Consequences of the "Chinese Remainder Theorem"*

1) Given a whole number N from 0 to 104, let R_3, R_5, and R_7 be the remainders when N is divided by 3, by 5, and by 7, respectively. Then N can be uniquely recovered, modulo 105, in the form $N \equiv aR_3 + bR_5 + cR_7$ (modulo 105). What are the smallest positive integer values for a, b, and c?

2) Given a whole number N from 0 to 1000, let R_7, R_{11}, and R_{13} be the remainders when N is divided by 7, by 11, and by 13, respectively. Then N can be uniquely recovered, modulo 1001, in the form $N \equiv xR_7 + yR_{11} + zR_{13}$ (modulo 1001). What are the smallest positive integer values for x, y, and z?

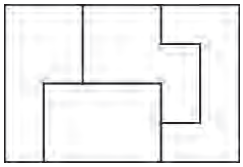
Note. With practice, you can "guess" people's secret numbers from 1 to 100, or from 1 to 1000, from "only" the three remainders in C. 1. or C. 2. respectively.

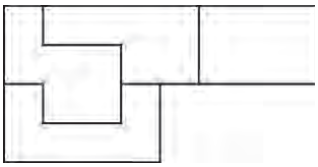
GOLOMB'S PUZZLE COLUMN™

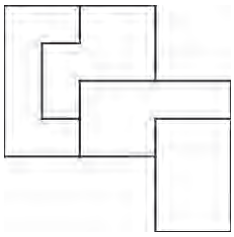
Rep-Tile Sets Solutions

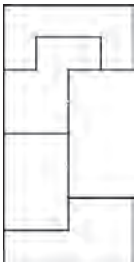
Solomon W. Golomb

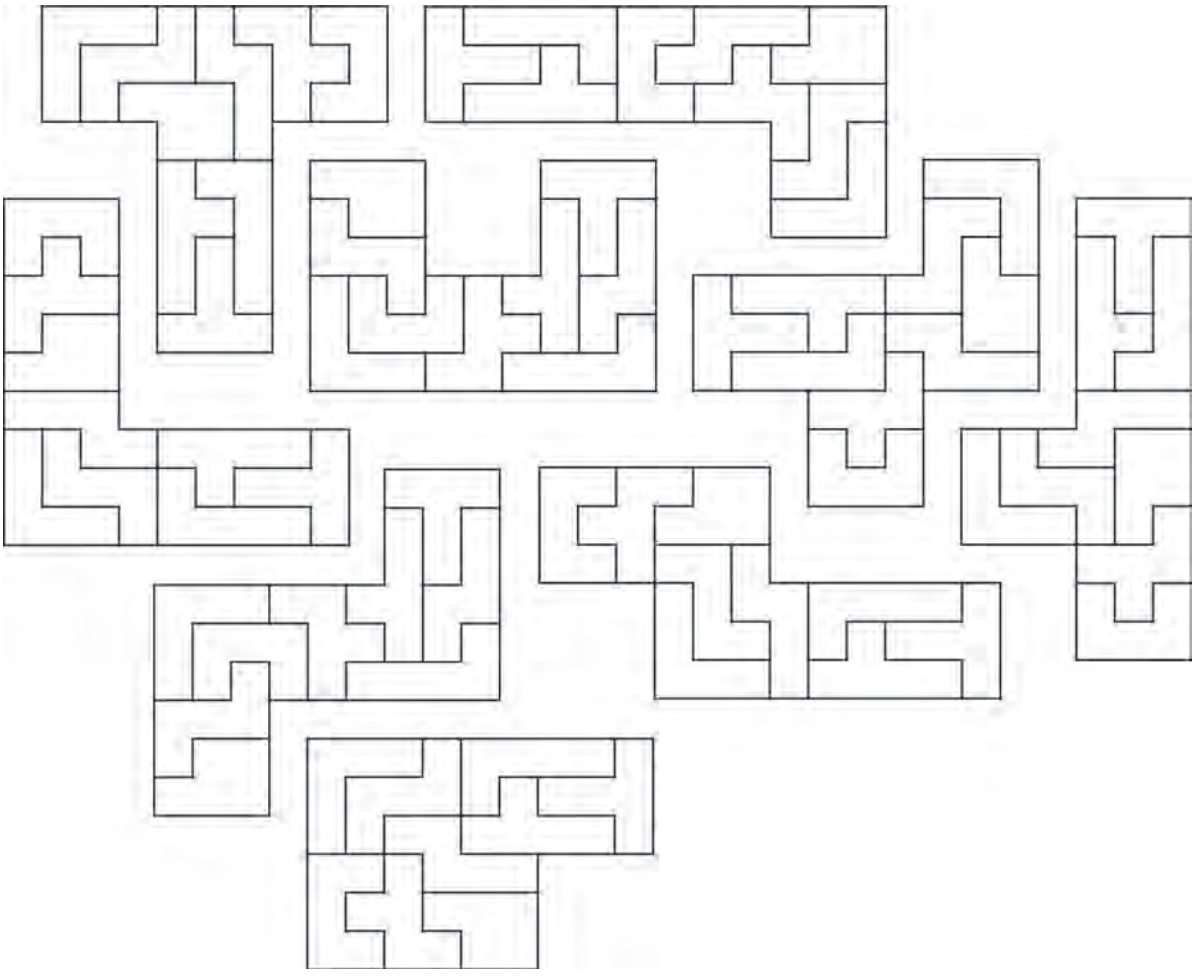
1)

a) 

b) 

c) 

d) 

2) 

Call for Nominations

IEEE Information Theory Society 2014 Claude E. Shannon Award

The IEEE Information Theory Society Claude E. Shannon Award is given annually to honor consistent and profound contributions to the field of information theory.

NOMINATION PROCEDURE: Nominations and letters of endorsement must be submitted by March 1, 2014 to the President of the IEEE Information Theory Society, who in 2014 will be Abbas El Gamal <abbas@ee.stanford.edu>. The nomination form is available at http://www.itsoc.org/honors/claude-e.-shannon-award

IEEE Information Theory Society 2014 Aaron D. Wyner Distinguished Service Award

The IT Society Aaron D. Wyner Service Award honors individuals who have shown outstanding leadership in, and provided long standing exceptional service to, the Information Theory community.

NOMINATION PROCEDURE: Nominations and letters of endorsement must be submitted by March 1, 2014 to the President of the IEEE Information Theory Society, who in 2014 will be Abbas El Gamal <abbas@ee.stanford.edu>. The nomination form is available at http://www.itsoc.org/honors/wyner

IEEE Information Theory Society 2014 Paper Award

The Information Theory Society Paper Award is given annually for an outstanding publication in the fields of interest to the Society appearing anywhere during the preceding two calendar years (2012–2013). The purpose of this Award is to recognize exceptional publications in the field and to stimulate interest in and encourage contributions to fields of interest of the Society.

NOMINATION PROCEDURE: Nominations and letters of endorsement must be submitted by March 15, 2014 to the Awards Committee chair, who in 2014 will be Michelle Effros <effros@caltech.edu>. Please include a statement outlining the paper's contributions.

IEEE Joint ComSoc/ITSoc 2014 Paper Award

The Communications Society/Information Theory Society Joint Paper Award recognizes outstanding papers that lie at the intersection of communications and information theory. Any paper appearing in a ComSoc or ITSoc publication during the preceding three calendar years (2011–2013) is eligible for the 2014 award.

NOMINATION PROCEDURE: Nominations and letters of endorsement must be submitted by February 15, 2014 to the Awards Committee chair, who in 2014 will Michelle Effros <effros@caltech.edu>. Please include a statement outlining the paper's contributions.

Thomas M. Cover Dissertation Award

The IEEE Information Theory Society Thomas M. Cover Dissertation Award, established in 2013, is awarded annually to the author of an outstanding doctoral dissertation.

NOMINATION PROCEDURE: Nominations should be submitted electronically to Michelle Effros (effros@caltech.edu) and Edmund Yeh (eyeh@ece.neu.edu) by January 15, 2014. The nomination form is available at http://www.itsoc.org/news-events/recent-news/call-for-nominations-thomas-m.-cover-dissertation-award

IEEE Fellow Program

Do you have a colleague who is a senior member of IEEE and is deserving of election to IEEE Fellow status? If so, please submit a nomination on his or her behalf to the IEEE Fellows Committee. The deadline for nominations is March 1. IEEE Fellow status is granted to a person with an extraordinary record of accomplishments. The honor is conferred by the IEEE Board of Directors, and the total number of Fellow recommendations in any one year is limited to 0.1% of the IEEE voting membership. For further details on the nomination process please consult: http://www.ieee.org/web/membership/fellows/index.html

IEEE Awards

The IEEE Awards program pays tribute to technical professionals whose exceptional achievements and outstanding contributions have made a lasting impact on technology, society and the engineering profession. For information on the Awards program, and for nomination procedures, please refer to http://www.ieee.org/portal/pages/about/awards/index.html

PRINCETON

Call for Papers CISS 2014

48th Annual Conference on Information Sciences and Systems

March 19, 20, & 21, 2014

Princeton University - Department of Electrical Engineering

and Technical Co-sponsorship with

IEEE Information Theory Society

Authors are invited to submit previously unpublished papers describing theoretical advances, applications, and ideas in the fields of: information theory, coding theory, communication, networking, signal processing, image processing, systems and control, learning and statistical inference.

Papers, requiring 20 minutes for presentation, will be reproduced in full (up to six pages) in the conference proceedings.

Electronic submissions of up to 6 pages (in Adobe PDF format) & 3-4 keywords must be submitted by **January 3, 2014**. Submissions should be of sufficient detail and length to permit careful reviewing. Authors will be notified of acceptance no later than **January 31, 2014**. Final manuscripts of accepted papers are to be submitted in PDF format no later than **February 23, 2014**. These are firm deadlines that will permit the distribution of the Proceedings at the Conference. IEEE reserves the right to exclude a paper from distribution after the conference (e.g., removal from IEEE Xplore) if the paper is not presented at the conference.

For more information visit us at: http://ee-ciss.princeton.edu/

CONFERENCE COORDINATOR	PROGRAM DIRECTORS	IMPORTANT DATES
Lisa Lewis Dept. of Electrical Engineering Princeton University Princeton, NJ 08544 Phone: (609) 258-6227 Email: CISS@princeton.edu	**Prof. Sanjeev Kulkarni** **Prof. Emmanuel Abbe** Dept. of Electrical Engineering Princeton University Princeton, NJ 08544	**Submission deadline:** **January 3, 2014** **Notification of acceptance:** **January 31, 2014** **Final manuscript due:** **February 23, 2014**

8th International Symposium on Turbo Codes & Iterative Information Processing
Bremen, Germany, Aug. 18-22, 2014

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Olgica Milenkovic, University of Illinois, USA
Ralf Müller, Norwegian Inst. of Sience and Technology
Li Ping, City University of Hong Kong, China
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Ramesh Pyndiah, Telecom Bretagne, France
Lars Rasmussen, KTH, Sweden
Jossy Sayir, University of Cambridge, UK
Igal Sason, Technion, Israel
Rüdiger Urbanke, EPFL, Switzerland
Haris Vikalo, University of Texas, USA

JACOBS UNIVERSITY

CALL FOR PAPERS

The 8th International Symposium on Turbo Codes & Iterative Information Processing will be held from Monday August 18 to Friday August 22 in Bremen, Germany. The symposium will be an opportunity to acquire a broad overview of the current status of advanced research in iterative information processing and its application to information theory and digital communications. All original contributions will be considered, in both theoretical and applied fields. The non-exhaustive list below provides possible topics for paper submissions:

- Error correcting coding
- Turbo and LDPC codes
- Bit-interleaved coded modulation
- Interleaving and labeling
- Graph codes for compression
- Joint source-channel coding
- Coding for storage
- Coding for secrecy
- Detection; iterative detection
- Multi-user and MIMO applications
- Turbo equalization
- Synchronization
- Cooperative Communications
- Iterative processing over networks
- Applications to wireless and optical
- Bounds, performance, and convergence
- Iterative algorithms
- Bayesian inference and factor graphs
- Analog decoders
- Chip applications
- Applications in bio-informatics
- Applications in neurosciences
- Data fusion

This symposium will have a session dedicated to information- and coding-theoretic investigations of genome structures, its evolution, and related topics.

The symposium will include regular papers for oral and poster sessions as well as invited papers. Accepted and presented papers/posters will appear in the symposium proceedings as well as IEEEXplore (upon final decision by IEEE).

Submissions
Authors are invited to submit a full manuscript (not exceeding 5 pages) before March 26, 2014 via the symposium website detailed below..

Submission of papers deadline: **March 25, 2014**
Notification of acceptance: **May 16, 2014**
Final papers and early-bird registration deadline: **June 11, 2014**

For further information regarding paper submission, registration, accommodation, and travel, please consult the symposium website at:

http://www.jacobs-university.de/turbo-symposium-2014

For symposium-related questions, please use

turbo@jacobs-university.de

Call for Papers

2014 Iran Workshop on Communication and Information Theory

May 7th and 8th, 2014, Sharif University of Technology, Tehran, Iran

The **second Iran Workshop on Communication and Information Theory (IWCIT)** will take place at Sharif University of Technology, Tehran, Iran on **Wednesday May 7th and Thursday May 8th, 2014.** IWCIT intends to bring together researchers in communication and information theory for exchanging their research results and latest developments. Prospective authors are invited to submit high-quality, original, and unpublished contributions to IWCIT 2014. All submitted papers will be subject to peer review. This workshop is included in the IEEE Conference Publications Program (CPP). The scope of the workshop includes the following topics:

Shannon Theory
- Complexity theory
- Information theoretic security
- Multi-terminal information theory
- Quantum information theory

Communication Theory
- Cognitive radio systems
- Cooperative communications
- Network resource sharing and scheduling
- Molecular and Nano communications
- Optical and Quantum communication theory

Coding Theory
- Compressed sensing
- Data compression
- Network coding

Applications of Information Theory
- Information theoretic learning
- Information theory and data mining
- Information theory and signal processing
- Information theory and statistics
- Information theory in biology
- Information theory in networks
- Information theory in practice

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Salehi, J. A.
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Executive Chairs:
Gohari, A. A.
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Seyfe, B.
Shahed University

Important Dates:

- Paper Submission:
  January 11th, 2014
- Notification of Acceptance:
  March 15th, 2014
- Camera Ready Submission:
  April 15th, 2014

Contact Us

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FIFTY-SECOND ANNUAL ALLERTON CONFERENCE

ON COMMUNICATION, CONTROL, AND COMPUTING

October 1 – 3, 2014
Call for Papers

The Fifty-First Annual Allerton Conference on Communication, Control, and Computing will be held from Wednesday, October 1 through Friday, October 3, 2013, at Allerton House, the conference center of the University of Illinois. Allerton House is located twenty-six miles southwest of the Urbana-Champaign campus of the University in a wooded area on the Sangamon River. It is part of the fifteen-hundred acre Robert Allerton Park, a complex of natural and man-made beauty designated as a National natural landmark. Allerton Park has twenty miles of well-maintained trails and a living gallery of formal gardens, studded with sculptures collected from around the world.

Papers presenting original research are solicited in the areas of communication systems, communication and computer networks, detection and estimation theory, information theory, error control coding, source coding and data compression, network algorithms, control systems, robust and nonlinear control, adaptive control, optimization, dynamic games, multi-agent systems, large-scale systems, robotics and automation, manufacturing systems, discrete event systems, multivariable control, computer vision-based control, learning theory, cyber-physical systems, security and resilience in networks, VLSI architectures for communications and signal processing, and intelligent transportation systems.

Information for authors: Regular papers suitable for presentation in twenty minutes are solicited. Regular papers will be published in full (subject to a maximum length of eight 8.5" x 11" pages, in two column format) in the Conference Proceedings. Only papers that are actually presented at the conference can be included in the proceedings, which will be available after the conference on IEEE Xplore.

For reviewing purposes of papers, a title and a five to ten page extended abstract, including references and sufficient detail to permit careful reviewing, are required.

Manuscripts must be submitted by **Monday, July 7, 2014**, following the instructions at the Conference website: http://www.csl.uiuc.edu/allerton/**.**

Authors will be notified of acceptance via e-mail by August 6, 2014, at which time they will also be sent detailed instructions for the preparation of their papers for the Proceedings.

Final versions of papers to be presented at the conference will need to be submitted electronically by October 5, 2014.

Conference Co-Chairs: Olgica Milenkovic and Angelia Nedich
Email: *allerton-conf@illinois.edu* URL: www.csl.illinois.edu/allerton/

COORDINATED SCIENCE LABORATORY AND THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

University of Illinois at Urbana-Champaign

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Secretary
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ISITA2014 — the **International Symposium on Information Theory and Its Applications** — will be held in **Melbourne, Australia** from **26 to 29 October 2014**. This biennial event, first held in 1990, is a leading conference in the information theory community. ISITA2014 features world-class speakers, plenary talks and technical sessions on a diverse range of topics within the field of information theory.

Call for Papers

Interested authors are invited to submit papers describing novel and previously unpublished results on topics in information theory and its applications, including, but not limited to:

- Error Control Coding
- Coded Modulation
- Communication Systems
- Detection and Estimation
- Spread Spectrum Systems
- Signal Processing
- Rate-Distortion Theory
- Stochastic Processes
- Network Coding
- Shannon Theory
- Coding Theory and Practice
- Data Compression and Source Coding
- Data Storage
- Mobile Communications
- Pattern Recognition and Learning
- Speech/Image Coding
- Multi-Terminal Information Theory
- Cryptography and Data Security
- Applications of Information Theory
- Quantum Information Theory

Paper Submission

Authors should submit papers according to the guidelines on the conference web site:

www.isita2014.org

This link points to the permanent site http://www.isita.ieice.org/2014/. Submissions will be selected on the basis of a full paper, reviewed by subject-matter experts. Accepted papers will appear in the symposium proceedings. To be published in the symposium proceedings and IEEE *Xplore*, an author of an accepted paper must register at a non-student rate and present the paper. IEEE does not guarantee inclusion in IEEE *Xplore*.

Schedule

Paper submission deadline	**6 April 2014**
Acceptance notification	**22 June 2014**
Final paper submission	**20 July 2014**

Further information on the technical program, plenary talks, social events, and registration will be posted on the symposium web site.

The IEEE Information Theory Workshop (ITW2014) will be held from 2 to 5 November 2014 in nearby Hobart, Tasmania, Australia.

Sponsor
Research Society of Information Theory and Its Applications, IEICE

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IEEE Information Theory Society

image by R. Michalski

ITW2014

IEEE Information Theory Workshop

Hobart, Tasmania, Australia | 2–5 November

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Yi Hong
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University of Southern California
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Monash University

Financial Chair

Robby McKilliam
University of South Australia

Publications

Parastoo Sadeghi
Australian National University

Local Arrangements

JC Oliver
University of Tasmania
Gottfried Lechner
University of South Australia

Publicity

Brian M. Kurkoski
Japan Advanced Institute of Science and Technology (JAIST)

The 2014 IEEE Information Theory Workshop will take place 2-5 November in Hobart, Tasmania at the Hobart Function And Conference Centre. The Australian island of Tasmania varies geographically from old-growth forests and grasslands to mountains and volcanic lakes, supporting unparalleled biodiversity, with many flora and fauna species unique to the island. Tasmania's rugged wilderness offers ample opportunities for hiking, bushwalking, kayaking, swimming and scuba. Hobart is Australia's second-oldest city, where historic buildings and districts stretch along the Derwent River. A burgeoning art and restaurant scene are complemented by fresh local seafood and established wineries.

Call for Papers

ITW2014 is a forum for technical exchange among scientists and engineers working on the fundamentals of information theory. The agenda is broad and will cover the diverse topics that information theory presently impacts. There will be both invited and contributed sessions. Papers for the contributed sessions are solicited in, but not limited to, the following areas:

- Source coding
- Distributed source and channel coding
- Joint source and channel coding
- Coding for wireless systems
- Coding for sensor and ad-hoc networks
- Coding and biology
- MIMO and space-time coding
- Graph-based codes and iterative decoding
- Cooperation in wireless systems
- Sequences and coding
- Secure communication and cryptography
- Compressed sensing
- Coding applications: optical communications, smart grid, underwater, etc.
- Information theoretic security

Paper Submission

Interested authors are invited to submit previously unpublished contributions. Papers for the contributed sessions, not exceeding five pages, should be submitted according to the directions which will appear on the conference website:

itw2014.jaist.ac.jp

The ITW proceedings will be published by the IEEE and will be available on IEEE *Xplore*.

Schedule

Paper submission deadline: 4 May 2014
Acceptance notification: 27 July 2014
Final paper submission: 1 September 2014

Plenary Speakers

Presentations by plenary speakers are planned.

ISITA2014 will be held nearby in Melbourne, Australia on 26-29 October 2014

images: ccdoh1, Jyot Boparai

ITW Jerusalem 2015

2015 IEEE Information Theory Workshop
Jerusalem, ISRAEL | April 26 – May 1

General Co-Chairs
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The 2015 IEEE Information Theory Workshop will take place from April 26th until May 1st in Jerusalem, Israel, at the Mishkenot Sha'ananim Conference Center. Jerusalem is one of the oldest cities in the world, a place where ancient history intertwines with the twenty-first century. Located in the Judean Mountains, between the Mediterranean and the Dead Sea, it offers a unique experience for the visitor with relics dating back as far as around 1000 BC, finest museums and breathtaking scenery.

Built over 150 years ago, Mishkenot Sha'ananim became the first Jewish residential area outside the Old City walls. Nowadays it is an alluring place with a conference center that serves as a center of academic inquiry and cultural value, a critical piece of Jerusalem's landscape that reframes the city as a vibrant, dynamic, cultural center of local, national and international appeal.

Call for Papers

Original technical contributions are solicited in all areas of Information Theory, with special emphasis on innovative and interdisciplinary research related to:

- Information theory and computer science
- Information theory and estimation
- Network information theory
- Codes for special applications

Paper Submission

Interested authors are invited to submit previously unpublished contributions. Papers for the contributed sessions, not exceeding five pages, should be submitted according to the directions which will appear on the conference website:
http://itw2015.eew.technion.ac.il

Schedule

Paper submission deadline: Oct. 24th 2014
Acceptance notification: Jan. 10th. 2015
Final paper submission: March 1st. 2015

Plenary Speakers

Plenary lectures will feature leading researchers in the workshop's emphasis areas

NASIT'14

June 18 - 21. 2014
Toronto, Canada

The 2014 North American School of Information Theory will be held at the Fields Institute, Toronto. In its 7th year, the School is intended to provide graduate students and post-doctoral researchers with opportunities to

- Present work for feedback and potential collaboration
- Learn from distinguished researchers in the field who will present long-format tutorials
- Participate in a stimulating and inviting forum of scientists

Tutorial Lecturers

- **Robert Calderbank, Duke**
- **Brendan Frey, Toronto**
- **Andrea Goldsmith, Stanford**
- **Alon Orlitsky, UCSD**
- **Henry Pfister, Texas A&M**
- **En-hui Yang, Waterloo**

Organizing committee:

- Stark Draper - Chair (Univ. of Toronto)
- Warren Gross (McGill University)
- Ashish Khisti (Univ. of Toronto)
- Patrick Mitran (Univ. of Waterloo)
- Serdar Yüksel (Queen's University)

Program Overview:

- Lectures by invited speakers
- Student presentations/posters
- Special social events/activities

Advisors:

- Gerhard Kramer (Technical Univ. Munich)
- Frank Kschischang (Univ. of Toronto)
- Aylin Yener (Pennsylvania State Univ.)

Deadline to Apply: 7 March, 2014

For further details and applications:
http://www.fields.utoronto.ca/programs/scientific/13-14/infotheory/

2014 North American School of Information Theory

Conference Calendar

DATE	CONFERENCE	LOCATION	WEB PAGE	DUE DATE
March 19–21, 2014	**48th Annual Conference on Information Sciences and Systems (CISS 2014)**	Princeton, NJ, USA	http://ee-ciss.princeton.edu/	Passed
April 14–18, 2014	**2014 IEEE European School of Information Theory (ESIT 2014)**	Tallinn, Estonia	http://www.itsoc.org/european-school-2014	TBD
April 27–May 2, 2014	**33rd IEEE International Conference on Computer Communications (INFOCOM 2014)**	Toronto, Canada	http://www.ieee-infocom.org/	Passed
May 7–8, 2014	**2014 Iran Workshop on Communication and Information Theory (IWCIT)**	Tehran, Iran	http://iwcit.org/	Passed
May 12–16, 2014	**WiOpt 2014**	Hammamet, Tunisia	http://www.wi-opt.org/	Passed
May 18–21, 2014	**2014 79th Vehicular Technology Conference (VTC2014-Spring)**	Seoul, Korea	http://www.ieeevtc.org/vtc2013spring/	Passed
May 25–28, 2014	**2014 IEEE Communication Theory Workshop (CTW 2014)**	Curaçao		March 1, 2014
May 27–30, 2014	**2nd International Black Sea Conference on Communications and Networking (IEEE BlackSeaCom 2014)**	Odessa, Ukraine	http://www.ieee-blackseacom.org/2014/index.html	Passed
June 10–14, 2014	**IEEE International Conference on Communications (ICC 2014)**	Sydney, Australia	http://www.ieee-icc.org/	Passed
June 18–21, 2014	**2014 IEEE North American School on Information Theory**	Toronto, Canada	http://www.fields.utoronto.ca/programs/scientific/13-14/infotheory/	March 7, 2014
June 22–25, 2014	**The 15th IEEE International Workshop on Signal Processing Advances in Wireless Communications (SPAWC)**	Toronto, Canada	http://www.spawc2014.org	March 1, 2014
June 29–July 4, 2014	**2014 IEEE International Symposium on Information Theory (ISIT 2014)**	Honolulu, Hawaii, USA	http://www.isit2014.org/	Passed
August 18–22, 2014	**8th International Symposium on Turbo Codes & Iterative Information Processing**	Bremen, Germany	http://www.jacobs-university.de/turbo-symposium-2014/	March 25, 2014
October 1–3, 2014	**52nd Annual Allerton Conference on Communication, Control, and Computing**	Monticello, Illinois, USA	http://www.csl.uiuc.edu/allerton/	July 7, 2014
October 26–29, 2014	**2014 International Symposium on Information Theory and its Applications (ISITA 2014)**	Melbourne, Australia	http://www.isita.ieice.org/2014/	April 6, 2014
November 2–5, 2014	**IEEE Information Theory Workshop (ITW 2014)**	Hobart, Tasmania, Australia	http://itw2014.jaist.ac.jp/	May 4, 2014

Major COMSOC conferences: http://www.comsoc.org/confs/index.html