IEEE Information Theory Society Newsletter

President's Column

Rüdiger Urbanke

It was a pleasure to see many of you at ISIT in Aachen. As expected, it was perfectly organized. If you like numbers: 836 participants of which 290 were students, 649 presentations out of 1028 submissions in 160 sessions. But as impressive as these numbers are, arguably more important is the content. And I saw much to my liking. The two keynotes by Urbashi Mitra and David Tse (Shannon Lecture) perhaps best captured the new spirit of our society to boldly branch out into new areas such as biology or machine learning. We have much to contribute as these two talks showed. I would like to thank both of them for having the courage and foresight to lead the way. It is not easy and it can take years, but the benefits are considerable. If you look e.g. at NIPS in recent years you will find paper awards and highlight talks given to and by members of our Society. And this is likely only the beginning.

In case you were not at Aachen and missed it. Our next Shannon recipient will be Gottfried Ungerboeck. You all know how trellis-coded modulation changed the history of communications, but did you also know that it inspired a Dilbert cartoon! Congratulations to Gottfried. I am sure that you are all looking forward to seeing Gottfried in Vail!

I have mentioned in my last column that our Society is thinking of both a new Special Topics Journal as well as a Magazine to broaden and strengthen our outreach efforts. The idea of the Journal is to be complementary to our current Transactions—we aim for quick turn-around times allowing us to explore new topics on a fast time scale. The Magazine will build on our already great Newsletter (due to the efforts of M. Langberg!) with the intent of making its content available to a broader community and to expose our community to outside developments.

Jeff Andrews and Elza Erkip are leading this effort. Many thanks to them! After many rounds of discussions we have passed a new milestone—letters of intent for both initiatives have been sent to IEEE. It is of course still a long way from this to the printing of the first issues. Much still needs to be clarified and there are considerable hurdles to be passed. In particular, we are a relatively small Society with already many ongoing activities. It therefore remains to be seen if we can muster the necessary (human) resources. But I am excited about both of these projects and I hope you are as well.

You probably have all heard by now that our Society is producing a Shannon documentary, directed by Mark Levinson, of Particle Fever fame. It is a large undertaking by any measure and you might be eager to hear how things are progressing.

This summer saw a lot of activity. Gaylord MI of 1925, Cambridge MA of 1939, the Institute for Advanced Study in 1940, and Bell Labs in the 40s were all re-created to film events in Shannon's life. It was almost certainly the first time anyone juggled while riding a unicycle down the hallway of Bell Labs since Shannon did it himself! With the completion of these flashback scenes, work on the documentary has shifted primarily to editing. Moving from "theory" to "experiment," our director, Mark Levinson, and editor, Tim Sternberg, have begun to assemble the various pieces of the puzzle. A top graphics/animation company has also started working on the film, designing sequences intended to be both entertaining and informative about Shannon's work.

And now some good news on IT Society politics. I am happy to announce that Elza Erkip was elected the incoming President, Emina Soljanin is the incoming Vice President, and Helmut Boelcskei has been elected as 2nd Vice President. Congratulations to all of them, and also to us for having such great representatives guiding our society in the years to come.

These decisions were made where most of our activities start—the board room. Elections for the new Board of Governors will be held soon, and I invite you all to participate. Happy voting!

IEEE

From the Editor

Michael Langberg

Dear colleagues,

As fall settles in, we are glad to present the September issue of our society newsletter. The issue opens with the compelling presentation of David Tse, the 2017 Shannon award recipient, given at this year's ISIT. I am sure that the presentation's optimistic call for change in our community alongside the clear support in fundamental (and beautiful) research will resonate. Next, continuing our tradition from last year, we are delighted to include an article by Rick Brown and Phil Regalia, the NSF Program Directors in the Communication and Information Foundations (CIF) cluster in the Division of Computing and Communication Foundations (CCF), which highlights new aspects of the 2017 Coordinated CISE Solicitation and outlines NSF's continued commitment to fundamental research through several concrete programs of interest to the society. Many thanks David, Rick and Phil for your significant efforts in preparing these contributions!

The issue continues with a number of special columns alongside our regulars. We start by congratulating several of our fellow colleagues for their outstanding research accomplishments and service recently recognized by our community, including a report on the seminar in honor of Kees Schouhamer Immink, the 2017 IEEE Medal of Honor recipient, prepared by Han Vinck. We then turn to an illuminating and comprehensive contribution by Raymond W. Yeung summarizing his recent experience in the preparation and offering of a Massive Open Online Course (MOOC) on Information Theory. We continue with Tony Ephremides's Historian's column; our ``Students' Corner'' column presenting reflections on the IEEE Jack Keil Wolf ISIT Student Paper Award from finalist and award winners Alejandro Lancho, Ori Peled, S. B. Balaji, Ganesh R. Kini, and Jie Li (compiled by Parham Noorzad); the column ``From the field'' highlighting the recent activities of the recipient of this year's Chapter of the Year Award, the IEEE Sweden Section Joint Chapter, written by Tommy Svensson and Michael Lentmaier; an additional report ``From the field'' by Bikash Kumar Dey highlighting the recent activities of the IEEE Information Theory Society India Chapter; a report by Bikash Kumar Dey on the 2017 IEEE IT Society Summer School at the Indian Institute of Technology Bombay; a report by Han Vinck on the 10th Asia-Europe Workshop on "Concepts in Information Theory and Communications"; a report by Vladimir Sidorenko and Antonia Wachter-Zeh on the "Munich Workshop on Coding and Applications 2017" (MWCA 2017); a report by Tobias Koch, Alfonso Martinez, Pablo M. Olmos, and Gonzalo Vazquez-Vilar on the "2017 European School of Information Theory"; minutes from the IEEE Information

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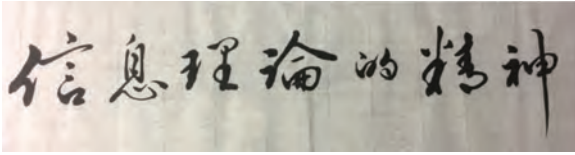
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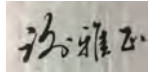
(This article is a written version of the Shannon lecture I gave on June 28, 2017 at ISIT in Aachen, Germany. A video of the lecture can be found at https://www.youtube.com/watch?v=O_uBxFGk-U4.)

It is a great honor to deliver this lecture today. Before I begin, I would like to thank the people who made it possible for me to be here. First, my Ph.D. advisors, Bob Gallager and John Tsitsiklis. They started me off on the right path. Without them, there is definitely no way I will be here. Second, my students and postdocs. Without them, there is no reason for me to be here: at the end of the day, the most important things are not papers or awards, but people. Lastly, my family: my father J.T., my mother Evelyn, my wife Lea, our daughter Qing Qing, my sister Nadja, Uncle John and their daughter Mun Mun. Most of them are here today.

The Essence of the Spirit

Most talks I gave are on technical subjects, using tools from the field to solve specific problems. This talk is different. It is about the field itself. I want to gain an understanding of the spirit, the energy of information theory, what keeps it alive and kicking after so many years. I believe it is timely. *Our field is a at a crossroad. A better understanding of the field, its strengths but also its weaknesses, will help us chart the path forward.*

The essence of the spirit is captured in Figure 1. Beauty and utility. Two facets of information theory. Not each in isolation but as part of a cycle, fed by and provide energy to each other. I would like to elaborate on this picture through stories from my own research. So this is my personal view. I would also take this opportunity to highlight people who have helped me understand this picture better.

Learning about the Spirit

My story started when I became a graduate student in the Laboratory of Information and Decision Systems at MIT in 1989. When I arrived at MIT, I wanted to do machine learning. But then in the first year I took an information theory course from Bob Gallager and I got hooked ever since. I still remember vividly a line of his in the first lecture:

"Good theory should prune rather than grow the knowledge tree."

I had no idea what this line meant. I thought my job as a graduate student was to add my own twig or leaf to the tree.
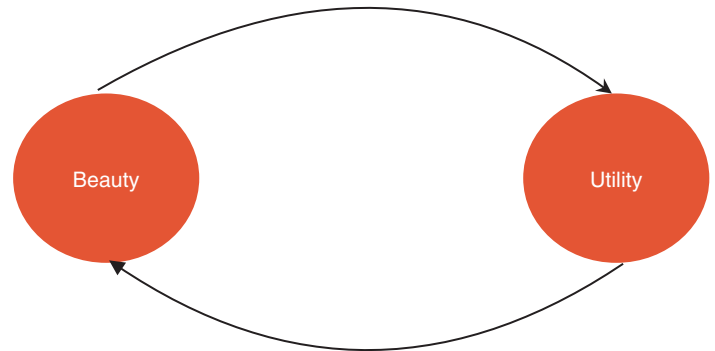

Figure 1: The essence.

But it sounded wise. So I wanted to do information theory and I wanted to work with Bob.

Bob gave me two important bits of advice during my graduate school. First, when I asked him what I should work on for my Ph.D., he said: "Don't work on information theory." Second, towards the end of my graduate school, he said: "Keep an eye on wireless."

To see how wise both these bits of advice were, let us plot the number of citations to Shannon's entire collection of papers over the years (Figure 2.) This is a very rough proxy of the influence and visibility of the field. Up until my graduate school days, the number of citations per year was in the hundreds. The field was not very visible. So following Bob's advice to do a thesis in networking instead of information theory was a good idea. It helped me find a job at Berkeley.

But the field then exploded. This explosion was in part powered by the rise of wireless. Following Bob's advice again, I moved into wireless after I graduated and I was able to ride this wave.

Communicating Opportunistically

Before I joined Berkeley, I spent a year doing a postdoc at Bell Labs. I was really fortunate to meet Stephen Hanly, who was also a postdoc there. Stephen was already working in wireless, and he was trying to get me interested. It helped that we were also apartment mates, and since there was not much going on around Bell Labs at night, so we just talked about research every night.
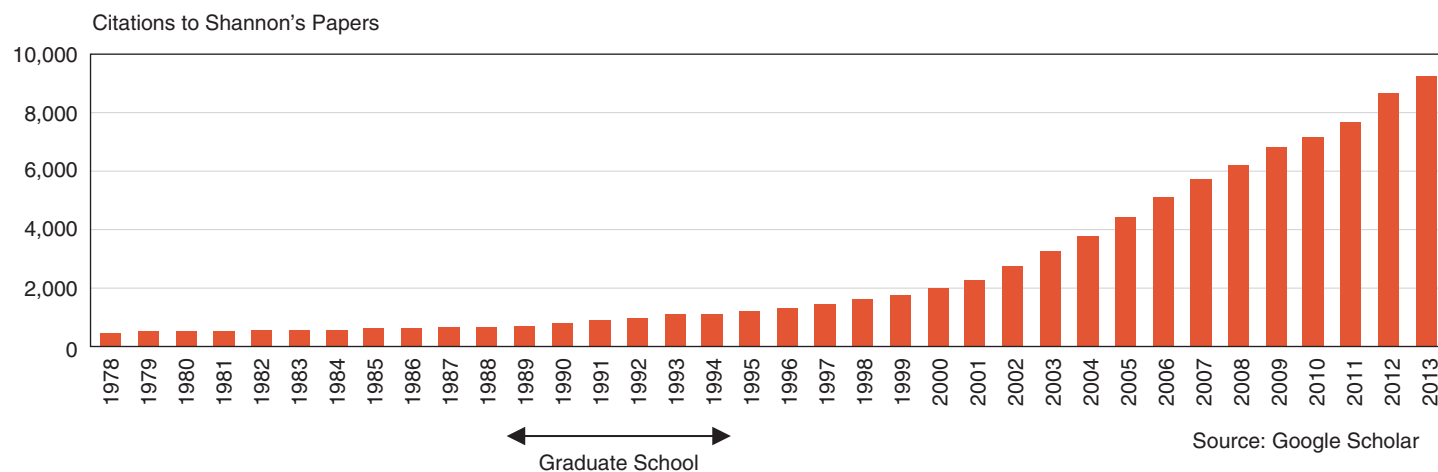
Citations to Shannon's Papers

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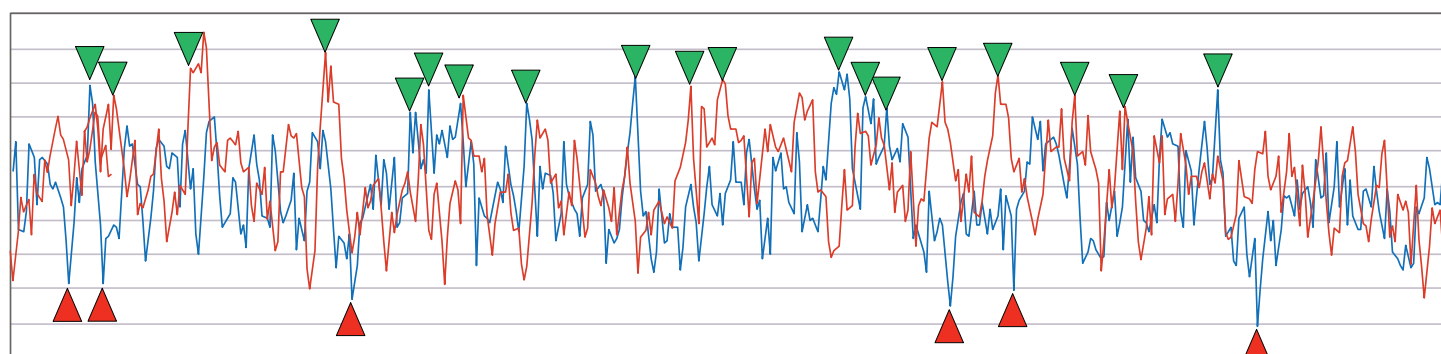
Figure 2: Historical trend I.

Figure 3: Focus on peaks rather than valleys. More users, more peaks.

The problem we looked at was *opportunistic communication*. The central object in wireless is the fading channel (Figure 3). The whole thing started with a very interesting result by Andrea Goldsmith and Pravin Varaiiya on the capacity of this channel with channel state feedback [1]. They showed that to achieve capacity, one should communicate opportunistically, when the channel is at the peaks. This is in contrast to the traditional view on wireless channels, focusing on the deep fades.

Several groups were working to generalize their result to the multiuser setting. First, Raymond Knopp and Pierre Humblet solved the sum capacity, and highlighted a *multiuser diversity* phenomenon: with more users to choose transmission from, there are more peaks to exploit [2]. Stephen and I followed up with a complete solution for the capacity region [3]. We also defined and characterized a notion of delay-limited capacity [4], quite relevant since opportunistic communication often incurs a significant delay.

Although characterizing the capacity region is an information theory problem, the essence is an optimal resource allocation problem, i.e. a networking problem. How to optimally allocate powers to the users at a given channel state? On the face of it, the problem is very complicated, since there is an exponential number of information theoretic rate constraints. However, by exploiting an underlying polymatroid structure of the problem, we found a simple solution. The solution is simply describing

by certain marginal utility functions of the users (Figure 4, top left). One allocates power incrementally benefiting always the user with the highest marginal utility.

Having done all this theory on wireless, I decided to spend six months at Qualcomm in 1999 to see the real world. I met two great people there: Andy Viterbi, who hired me, despite a healthy skepticism of academics in the company, and Roberto Padovani, who was heading a team to design a brand new air interface (which eventually became part of the 3G standard).

Unlike CDMA, which is what Qualcomm was famous for, the downlink of this new air interface is actually TDMA, and a central part of the system is the dynamic scheduling of resources among the users. They already had a scheduler when I arrived, but it was ported over from wireline networking. Knowing what I had known from information theory, I knew there was a better way. So I got cracking.

The main result of the six months at Qualcomm is three lines of MATLAB code: the proportional-fair scheduler [5]. Although it is only 3 lines of code, it embodies the full spirit of the earlier information theory results :

proportional-fair scheduling = multiuser diversity + fairness
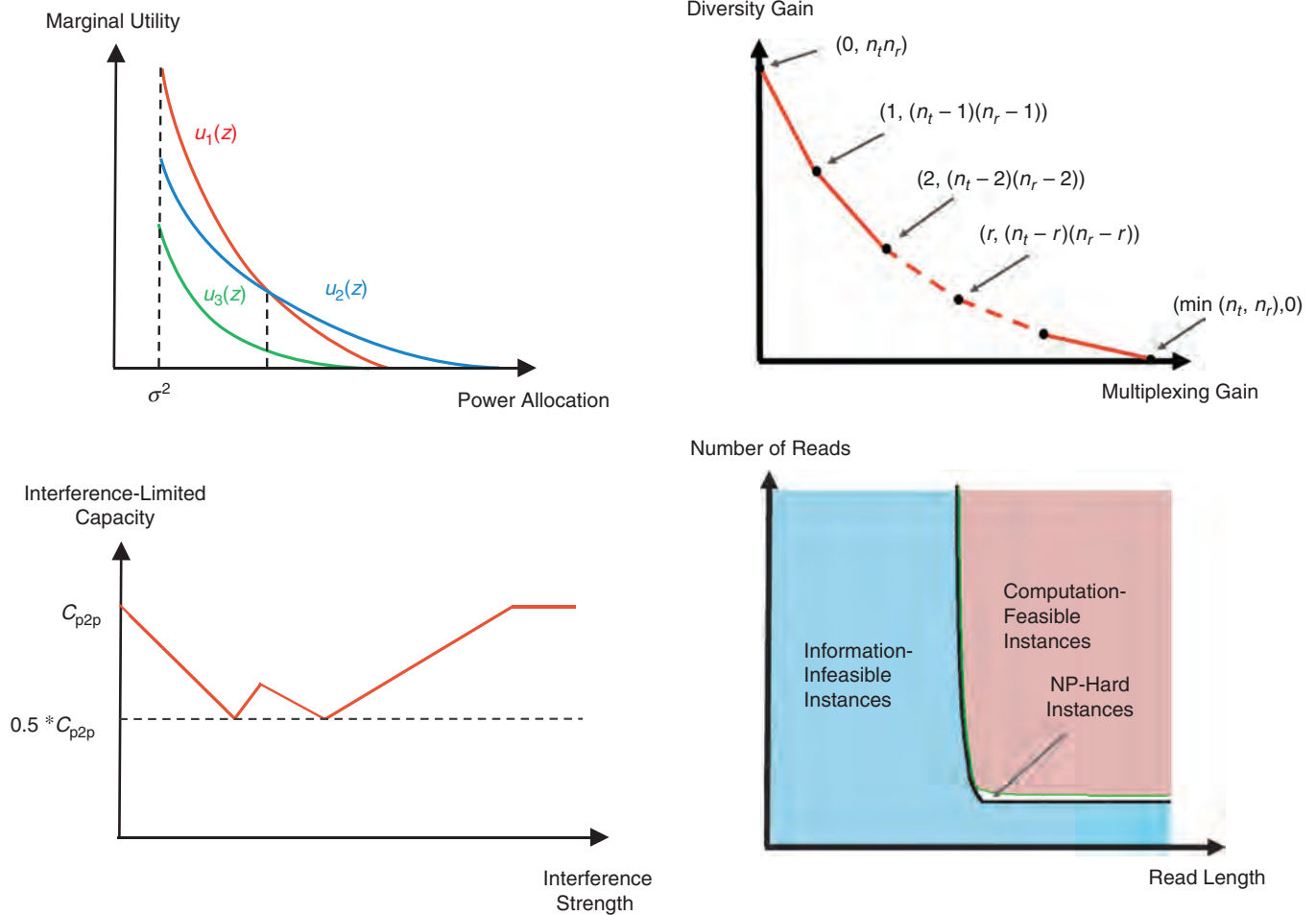+ delay.

Figure 4: Four results, four pictures.

Multiuser diversity we learnt from Knopp and Humblet; fairness is controlled by utility functions assigned to different users, as in our capacity region analysis; delay control is motivated from our delay limited formulation.

It is now 18 years later. A few months ago I asked my Qualcomm colleagues to survey all the major cellular infrastructure manufacturers. It turns out that the proportional-fair scheduler is the default scheduler for best effort traffic in all third and fourth generation networks. The scheduler is now running on 10 million base stations serving 2.7 billion people. I designed the scheduler, but it is the culmination of the efforts of a lot of people in our community. So I would like to think of the scheduler as belonging to our community. Our impact is amplified by joining the wireless revolution on the ground floor.

We have now completed the full cycle of Figure 1. We started with a real problem and a messy channel. We came up with a beautiful theory. We were able to give back to practice. On hindsight, the timing of the work was perfect. It was indeed a bit of luck to be at the right place at the right time. But it was more than just luck. Because the theory prepared us, provided us with the grounding, we were able to seize the opportunity when it arose.

Pruning the Tree

MIMO was another exciting research area during the late 1990's and early 2000's. There were two distinct views of MIMO at that time: *diversity*, the traditional view of using multiple antennas to improve the deep fades, and *multiplexing*, the modern view of using multiple antennas to send parallel streams of traffic. The two views were also espoused by different subcommunities of the field: the first mainly by coding theorists who focused on code constructions guided by the criteria of diversity and coding gains, the second mainly by Shannon theorists who focused on capacity analysis of various MIMO architectures. Two separate views but yet the very same channel. Lizhong Zheng and I found this state of affair extremely puzzling. But puzzles are often opportunities for progress.

The resolution of this puzzle is the diversity-multiplexing tradeoff [6] (Figure 4, top right.) Diversity and multiplexing, no long in isolation, but governed by a fundamental tradeoff between the two. Only when this picture emerged did I truly understand what Bob Gallager had meant by pruning the knowledge tree. Two branches of the tree were pruned into one.

At that time Pramod Viswanath and I had already been talking about writing a book on wireless. With opportunistic communication and the diversity-multiplexing tradeoff under our belt, we felt ready. After two years, the book was done [7]. This book is a sum of information theory and something we called *system view*. Information theory provides the theoretical structure of the book. System view provides the engineering structure of the book. It says that the performance of an entire wireless system
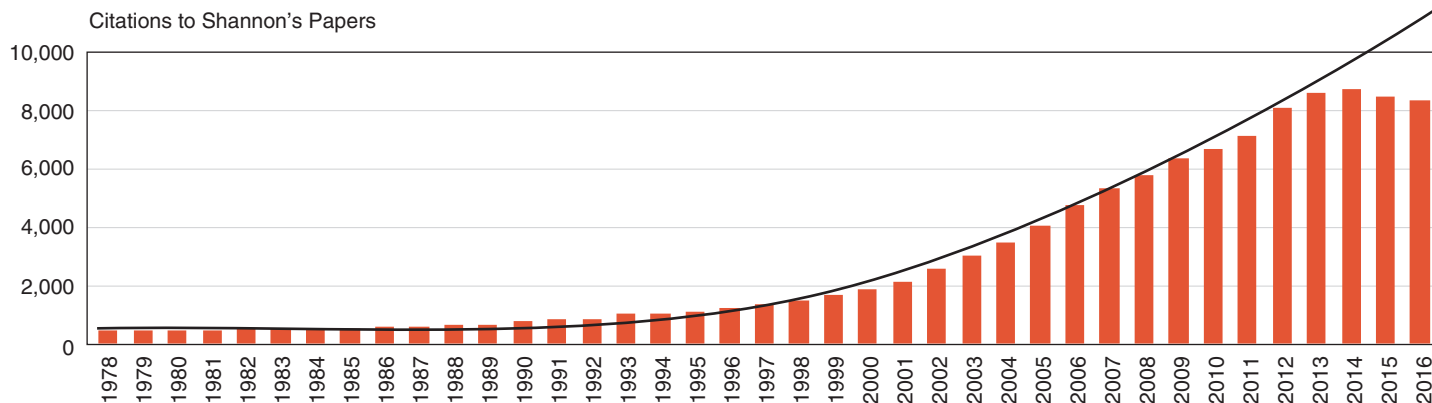
Citations to Shannon's Papers

Figure 5: Historical trend II.

depends not only on the individual components but also on how they interact with each other. Our understanding of this system view benefited a lot from our interactions with Rajiv Laroia, who was building the startup Flarion at that time. Since he was designing an entire wireless system from scratch, the system view was central to his success. It was also central to the success of our book.

Over the last 12 years, the book has made an impact beyond our expectations: used in more than 60 institutions, received more than 9000 citations. Why did the book have such a broad utility? We trace back to the natural coherence of information theory: in addition to the beauty of individual results, there is also a beauty in how the many results fit together into a coherent whole. This is the result of many years of tree pruning. The coherence of information theory brought coherence to our book, and made the subject understandable to many.

Understanding Interference

After we finished the book, I was a bit burnt out from wireless. But there was some unfinished business.

Over the years I had always wanted to crack the capacity of the Gaussian interference channel. With our understanding of the high SNR behavior of wireless channels from the diversity-multiplexing tradeoff analysis, I thought I would give it one last try. In the summer of 2005, with my student Raul Etkin and Pramod's student Hua Wang who was visiting us, we finally kicked the door open.

Our main result was a characterization of the interference capacity region to within $1 \ bit/s/Hz$ [8]. Using this theorem, we can ask, for example, how does the high SNR interference-limited capacity change with increasing interference strength? The answer is shown in the bottom left of Figure 4. It is rather surprising that this curve has so many ups and downs. Tom Cover said in his Shannon lecture that good theorems, like good jokes, are surprising. Hopefully he found this theorem funny. Even more surprisingly, this theorem is only part of a bigger story.

A key inspiration to prove the converse part of our interference channel theorem came from a paper by El Gamal and Costa in 1982 [9] on the capacity of a deterministic interference

channel. But the connection was at an inspirational level. However, it led Salman Avestimehr, Suhas Diggavi and myself to ask the question: can we come up with a *specific* deterministic model to approximate Gaussian channels? Answering this question led to our work on using deterministic models to approximate Gaussian networks broadly [10]. When the theory is applied back to the Gaussian interference channel [11], the capacity of the resulting deterministic interference channel is exactly the high SNR Gaussian interference channel capacity shown in Figure 4.

At that time, Gaussian wireless networks were considered very complex. On the other hand *noiseless* wireline networks are simpler, the capacity of which is governed by Ford Fulkerson's max-flow min-cut theorem. Our deterministic model provides a bridge to connect the two worlds. For example, it enables us to prove an approximate max-flow min-cut theorem for wireless networks. Moreover, the important advance of network coding on wireline networks [12] can now be exploited for Gaussian networks through this bridge. This is yet another example of pruning the knowledge tree.

The tradition of simple models in information theory started with Shannon's 1948 paper. They provide an important bridge to abstract messy realities to form beautiful theories, to bridge beauty and utility. Our deterministic approach suggests that the models for more complex problems may have to be even simpler.

Broadening Information Theory

In the last few years, my research has shifted away from communication. One reason is intellectual restlessness. Another reason is Figure 5. If we extrapolate the explosive growth trend of the information theory field in the past twenty years, we would expect to see a very bright future. But the reality in the past few years is a bit alarming. To go back to the growth curve, we need to broaden ourselves. But how?

Let us first consult our founding father [13]:

*"The fundamental problem of communication is that of **reproducing** at one point either exactly or approximately a message selected at another point.*

*Frequently messages have **meaning**......These semantics aspects are irrelevant to the engineering problem."*

This suggests two ways of broadening information theory: 1) find other types of messages, other than communication messages, to **reproduce**; 2) extracting **meaning** from messages. Let me give an example of each of these ways.

Sequencing Genomes

The first story started at the Newton Institute in Cambridge in 2010. I was attending a program in communication networks. For personal reasons, I needed to stay after that program ended, and happened to attend a few talks in the next program, "Statistical Challenges Arising from Genomic Resequencing." I had no idea what this was but what I learnt there blew my mind.

What I learnt was that in parallel to the wireless revolution, there has been another revolution going on, the sequencing revolution. Just like wireless, this revolution is powered by technological growth, in this case sequencing technology. The cost of sequencing genomes went down 5 orders of magnitude in the past 15 years. I got excited because I learnt from wireless that this kind of technological growth provides opportunities for research. I got even more excited when I discovered the central equation in this field:

$$sequencing = biochemistry + computation.$$

So I started cracking.

A central computational problem in sequencing is genome assembly (Figure 6.) Just like the communication problem Shannon talked about, genome assembly is also a *reproduction* problem: the goal is to reproduce as accurately as possible the genome from hundreds of millions of overlapping short fragments called *reads*. These reads are the result of the shotgun sequencing of the genome.

My experience with the genome assembly problem can be summarized by Figure 7: information meets computation, Shannon meets Turing.

Computer scientists have worked on this problem for decades; it is perhaps the most basic computational biology problem. The basic result there says that the assembly problem is NP-hard; thus most practical assemblers are designed using heuristics without much guidance from theory. When I started thinking about the problem: I asked a more basic question: what is the information limit of genome assembly? How much read data and how long the reads have to be to provide enough information for reconstructing the genome? For someone outside information theory, this seems like a very strange approach, since I seem to be avoiding the issue of computation, the elephant in the room. But for an information theorist, this approach of focusing on *information before computation* has a proven track record in communication, particularly in channel coding.

We first took a classical, simple-model approach to the problem. With Abolfazl Motahari and Guy Bresler, we assumed a simple i.i.d. model for the genome and derived a clean characterization of the fundamental limit, which we showed can also be achieved efficiently [14]. As good engineers, we looked at which aspect of the model is most crucial for our result. It turned out to be the repeat length statistics in the genome, as
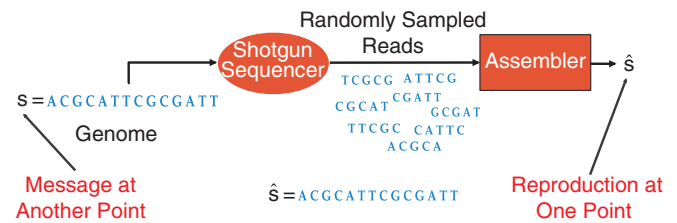

Figure 6: Genome assembly is another reproduction problem.

Figure 7: Shannon meets Turing.

they determine how difficult it is to put the reads back together in this gigantic jigsaw puzzle. But when we plotted the repeat statistics of an actually sequenced genome, we saw that the repeats are much longer than those predicted by an i.i.d. model. In fact it was difficult to model the repeats statistically. With Guy and Ma'ayan Bresler, we took a different path [15]: we bypassed statistically modeling the genome altogether and instead we directly characterized an information lower bound on the read length and the number of reads in terms of the empirical repeat statistics of the genome (Figure 4, lower right.) Using this as a target, we derive an efficient algorithm which gets close to the lower bound. These curves were based on deterministic necessary conditions for unique reconstruction, and on sufficient conditions for our algorithm to succeed.

But remember that the assembly problem is NP-hard? How could we solve the problem efficiently? One way to explain it is that the hard instances of the assembly problem are all information-infeasible. So by only focusing on the information feasible instances, we overcome the computation barrier. This turns out to be almost the case, but not quite. There is actually a small gap in the necessary and sufficient conditions we couldn't get rid of despite repeated attempts. Finally, in a recent work with Ilan Shomorony and a theoretical computer scientist Nisheeth Vishnoi [16], we showed that there is a basic reason for our failure: there *have* to be NP-hard instances in the gap, however small. This is a consequence of a very interesting result in the theory of computation concerning the interplay between information and computation. I believe there is more to come in this story. Stay tuned.

While we have had a lot of fun doing all this theory for assembly, we would also like to convince the biologists that our theoretical understanding is useful. The only way to do that was to build a software tool. The result is an assembler called HINGE [17]. The work was done by a team of very talented and brave students and
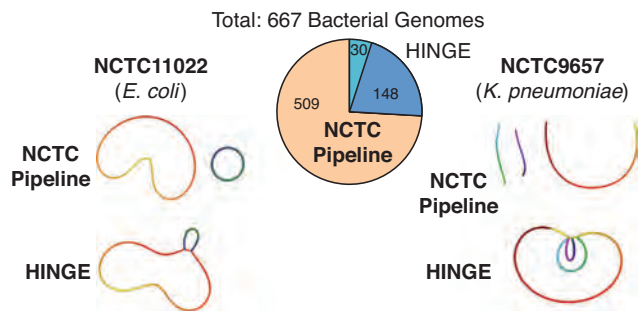
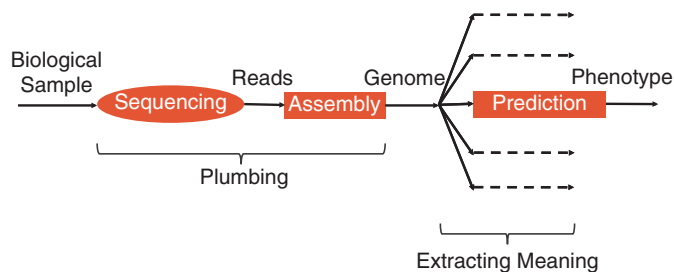Figure 8: Assembling many genomes; two examples here.

Figure 9: Plumbing and meaning.

postdocs: Govinda Kamath, Ilan Shmomrony and Fei Xia, and the project was co-led with Tom Courtade at Berkeley. This work was just published in a special issue of *Genome Research* where all the top assembly groups in the world are represented. Many of these groups have decades of experience in building assemblers. So we are proud to say that we have earned ourselves a seat at the table, so to speak.

The software is no longer 3 lines of code, but 30,000 lines. The output of the software is an assembly graph. When there is enough information to reconstruct the genome, this will be a single linear sequence. In general, it is a compact representation of all the repeats that cannot be resolved from the read data. We put the assembler to work on 667 bacterial genomes, in a dataset called NCTC 3000 generated by Public Heath of England. Of the 667 genomes, we were able to assemble 148 more genomes than the state-of the-art pipeline used in the NCTC 3000 project (Figure 8).

Working on the assembly problem for a few years, we learnt two more things about the beauty-utility picture. To develop useful theory for many data science problems, the theory needs to be data driven. Otherwise one loses touch with reality. In fact, it is the close contact with the data that enables us to finally build the assembler. This suggests an alternative to the simple statistical model approach in classical information theory: data-driven information limits. Second, computation plays an equally important role as information in translating the theory to useful results. Computation has been central in our field to translate capacity results to codes. Computation takes on an even more central role in many emerging problems.

The essence of each of the first three communication stories I told was captured in a simple picture (Figure 4.) This is what I mean by beauty. The fourth story is in a totally different application area, but the result is also captured by a simple picture. Beauty knows no border.
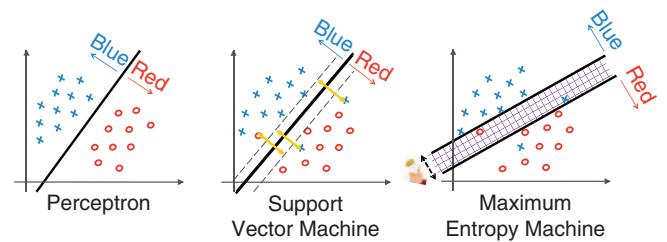

Figure 10: Linear classification: three approaches.

From Plumbing towards Meaning

Let us now explore the second direction for broadening information theory: extracting meaning.

To make our discussion more concrete, we take another look at the genome sequencing problem, but from a broader perspective (Figure 9). The sequencer and the assembler together form the basic infrastructure of genomics, the goal being to get as good a reproduction of the genome as possible. Just like communication, this is an infrastructure problem, a plumbing problem. Engineering good infrastructure is really important. It is the foundation. But the genome by itself has no meaning, it doesn't serve any particular human need. One needs to build additional pipelines to extract meaning and to make use of the information about the genome. For example, I want the genome sequence to help predict whether I have type-2 diabetes.

The genome assembly problem is an infrastructure problem, so it is similar in spirit to the communication problem we information theorists are very familiar with. The prediction problem, on the other hand, is at the core of statistics and machine learning. Do us information theorists have anything to say? Let us see.

Extracting Meaning

Let us consider a specific prediction problem: the classic linear classification problem. We are given training samples. Each sample is a point in high dimensional feature space and labeled blue or red (Figure 10). In a genomics application, each point may be a vector of the expression levels of the 20,000 genes of a participant in a study. Red means the participant has type-2 diabetes and blue means he/she does not. Given these training samples we want to build a classifier that can label a new sample.

One of the simplest classifiers is the linear classifier. The Perceptron algorithm[18], invented by Rosenblatt in 1957, is one of the earliest works in the area. It efficiently computes the classifier in the case when the samples are linearly separable (Figure 10, left). The challenge is the linearly inseparable case. A natural formulation is to find a hyperplane that minimizes the number of misclassified points, i.e. minimizing the so-called 0–1 loss. The optimization problem is unfortunately NP-hard. This line of work culminated in the support vector machine (SVM) [19]. Their approach got around the NP-hardness issue by changing the loss function from 0–1 loss to a surrogate loss function, the hinge loss (Figure 10, middle). While the 0–1 loss assigns the same penalty to a misclassified point no matter where it is, the hinge loss assigns a penalty which increases linearly with the distance from the dividing hyperplane.

The support vector machine is one of the biggest success stories in machine learning. Empirical results are excellent, but there

is something not so beautiful about the solution because the original 0–1 loss function is arbitrarily changed. Is there a more conceptually consistent approach?

We have recently tackled this problem from a different approach, an approach very much rooted in information theory: the maximum entropy principle. This principle originated with E.T. Jaynes in 1957 [20]. The question is how to find a distribution that models a random variable X given samples of X. The proposal is to find the distribution that maximizes the Shannon entropy and is consistent with the data as described by a set Γ:

$$\max_{p_X \in \Gamma} H(X).$$

A least committed model. There is freedom in choosing Γ, but it is usually specified by certain empirical moments of the distribution, calculated from the data.

The maximum entropy principle sounded a bit mystical when it was first proposed, but 20 years later, it was given a min-max decision theoretic interpretation by Topsoe [20]. He showed that in the case when Γ is convex, the principle is equivalent to finding a distribution that minimizes the worst-case *log loss* among all distributions X can take on in the set Γ. 25 years later, Grunwald and David generalized this interpretation to general loss functions ℓ [22], and defined a generalized maximum entropy principle over a generalized, loss-dependent, entropy function:

$$\max_{p_X \in \Gamma} H_\ell(X).$$

In a different direction, Berger, Della Pietra and Della Pietra extended Jaynes' maximum entropy principle to the prediction problem [23]. The proposal is to find a joint distribution between the feature vector $\mathbf{X}$ and the label Y that maximizes the *conditional entropy* of Y given $\mathbf{X}$ subject to data-consistent constraints:

$$\max_{p_{\mathbf{X},Y} \in \Gamma} H(Y \mid \mathbf{X}).$$

This paper became very influential in natural language processing.

In last year's NIPS, my student Farzan Farnia and I pruned the knowledge tree and unified these two threads of work to propose a principle of *maximum generalized conditional entropy* [24]:

$$\max_{p_{\mathbf{X},Y} \in \Gamma} H_\ell(Y \mid \mathbf{X}).$$

This principle has a minmax interpretation of minimizing the worst-case loss of estimating Y based on $\mathbf{X}$ according to a general loss function ℓ. We applied the principle to many loss functions, recovering many known prediction models. But applying to the case when the loss function is 0–1 and the distributions in the set Γ are constrained by the cross moments between $\mathbf{X}$ and Y, the principle gives rise to a new model: the maximum entropy machine.

The support vector machine is based on the function-fitting paradigm. This is the central paradigm in machine learning: a function is picked from a function class to fit the data the best. In the linear classification problem, the classifier is picked from the class of all possible hyperplanes and the coefficients of the optimal hyperplane are chosen to minimize the 0–1 loss on

Maximum Entropy Machine Timeline

1957	1979	1996	2004	2016
Jaynes	Topsoe	Berger et al	Grunwald & Dawid	Farnia & Tse

Support Vector Machine Timeline

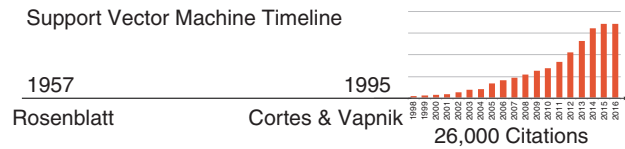| 1957	1995
Rosenblatt	Cortes & Vapnik

26,000 Citations

Figure 11: Historical trend III.

the training samples. Unfortunately, this optimization problem is NP-hard so the loss function has to be adhocly changed to convexify the problem. As a result, there is a mismatch between what the classifier is supposed to do (minimizes number of classification errors on new samples) and the loss function used to learn the classifier.

The maximum entropy approach, on the other hand, optimizes over *distributions*. It chooses the distribution that maximizes the conditional entropy of the label Y given the feature vector $\mathbf{X}$, subject to the constraint that the distribution matches the data in cross moments between $\mathbf{X}$ and Y. Being an entropy optimization problem, it is naturally convex. The resulting classifier is the Bayes' classifier given the entropy maximizing distribution. The classifier is now defined by two hyperplanes instead of one (Figure 10, right). Above the top plane one decides blue, below the bottom plane one decides red. In between one randomizes, with the bias of the coin depending on how far one is from the hyperplanes. Note that since the loss function is never changed, there is a perfect match between what the classifier is supposed to do and the loss function used to learn the classifier. Slightly enlarging the class of classifiers to allow randomization makes the problem of learning the coefficients of the hyperplanes convex without changing the 0–1 loss function. And the class of functions, i.e. the randomized structure, emerges naturally from the maximum entropy optimization, rather than forced on the problem as in the function-fitting paradigm.

We Were Not Prepared

The maximum entropy machine is more beautiful than the support vector machine. But is it more useful? Empirically, we found that the maximum entropy machine performs as well or even better than support vector machine on many datasets [24]. But what about its potential impact?

To answer this question, let us put the works that led to the maximum entropy machine in a timeline (Figure 11). Starting with Jaynes, the theory developed at a leisurely pace and took 59 years to get to the maximum entropy machine. Contrast it with the support vector machine timeline. Starting with Rosenblatt's Perceptron, it took 38 years to get to the support vector machine. And as they say, the rest is history. 26,000 citations. Cortes and Vapnik's timing was perfect: they caught the beginning of the machine learning revolution. So while we information theorists do have something very useful to say about the linear classification problem, our timing was not so good.

You may say that our timing was not so good because we weren't so lucky. Cortes and Vapnik were more lucky. But is it a

matter of simply luck? Let us look at where the papers on the maximum entropy machine timeline were published: *Physical Review, Kybernetika, Computational Linguistics, the Annals of Statistics, NIPS*. None of these works were published in the Transactions of Information Theory. It looks like we as a community have outsourced this line of research, even though it is about entropy, the central object of our field. What happened?

It is interesting to contrast this story with the wireless story we told earlier in the talk. Since the beginning of our field, we information theorists have been very focused on the communication problem. When the wireless revolution came, we had already laid down decades of ground work. We were prepared. We were ready to contribute and we contributed greatly. In contrast, when the machine learning revolution came, we were not prepared. We had not made the necessary investment. We had not put in sufficient energy. As a result, our field missed a great opportunity to join in that revolution at the ground floor, even though we had the capability to. Perhaps we paid the price for being too narrowly focused on communication. Going forward, will we continue to pay this price?

Bin Yu gave an excellent plenary talk at ISIT two years ago on data science [25]. At the end of that talk, she gave a reprise of her presidential address for the Institute of Mathematical Statistics: "Let us own data science." She explained that "us" refers to statisticians, and this was a call-to-arms for the statisticians to co-own data science with computer scientists. After her talk, I asked her: what about us information theorists? You can find her answer in the video of her talk, but, more importantly, we should ask ourselves the same question: what about us information theorists? Are we ready to commit, to take a seat at the table? My answer is clear:

seat at the table = information + computation + data

Data science is about extracting information from data using computation. We know better than anyone about information. We have worked decades on computation to extract information. If we take a holistic view together with data, we certainly have the capability to contribute. But do we have the commitment? Individuals in the field are already making forays into data science. But to take a seat at the table, our field as a whole needs to be engaged. This is *my* call-to-arms to information theorists.

Taking the Spirit Forward

We owned communications for 70 years. During this time, we worked sweat and blood to develop a spirit, a spirit of beauty and utility. Now I believe it is our time to broaden our field, to take the spirit forward, to use the spirit to conquer other worlds. Thank you.

Acknowledgements

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From the Editor (continued from page 2)

Theory Society Board of Governors Meeting that took place in San Diego, CA, taken by Stark Draper; and reports from a number of our societal communities: news from the ITSoc Online Committee, by Anand D. Sarwate; news and information regarding the IT Society Chapters, by Mine Alsan and Emina Soljanin; WITHITS activities and updates, by Lalitha Sankar and Natasha Devroye; and a report on the activities of the IEEE Information Theory Society Outreach Subcommittee, by Joerg Kliewer, Aaron Wagner, Tara Javidi, Bobak Nazer, and Vincent Y. F. Tan. We conclude with a list of recent publications from the IEEE Transactions on Information Theory, Foundations and Trends in Networking, Foundations and Trends in Communications and Information Theory, Foundations and Trends in Theoretical Computer Science, and Problems of Information Transmission. Many thanks to all for their significant efforts in the preparation of their contributions!

Please help to make the newsletter as interesting and informative as possible by sharing with me any ideas, initiatives, or potential newsletter contributions you may have in mind. I am in the process of searching for contributions outside our community which may introduce our readers to new and exciting problems and, as such, broaden the influence of our society. Any ideas along this line will be very welcome.

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 at the IT Society website http://www.itsoc.org. Articles and columns can be e-mailed to me at mikel@buffalo.edu with a subject line that includes the words "IT newsletter."

The next few deadlines are:

Oct 10, 2017 for the issue of December 2017.

Jan 10, 2017 for the issue of March 2018.

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 hearing your suggestions and contributions.

With best wishes,
Michael Langberg.
mikel@buffalo.edu

NewS From NSF: Communications and Information Foundations Cluster

Rick Brown and Phil Regalia

Greetings again from the National Science Foundation! A lot has happened since our last contribution to the IT Society Newsletter. If you are reading this in September, one big change is that the NSF headquarters has been relocated from Arlington to Alexandria, Virginia. Another big change is that Phil Regalia returned to NSF earlier this year, this time as a federal employee rather than a rotator. Phil continues with the Communications and Information Foundations (CIF) program, in addition to other cross-directorate programs such as Cyber-Physical Systems (CPS) and Secure and Trustworthy Cyberspace (SaTC), as two areas where information theory, communications and signal processing also play important roles. We are confident that the information theory community will continue to benefit from the enthusiasm that this subject elicits within NSF.

The Coordinated CISE Solicitation, including NSF 17-571 for CIF, was released in July and reflects several advances on the technical front, alongside some logistic changes. On the technical side, and characteristic of a vibrant scientific discipline, information theory continues to chart out new application domains commensurate with new foundational advances. Among the more recent evolutions, increased emphasis on statistical learning and inference—traditionally within the purview of signal processing—has come to the forefront. At the same time, we are witnessing the scope of information theory expand to encompass security, biological systems, and social networks, thus affording cross-fertilization of ideas into areas that welcome the foundational approach that information theory researchers bring.

On the logistical side, the biggest change in this year's Core CISE solicitation is the absence of the Large competition in many clusters, including CIF, thus allowing us to confidently invest proportionally more in Medium and Small projects this next year. The CCF Core solicitation lists several other logistical changes including a new submission checklist, additional requirements for Medium proposals with regards to broadening participation, and new submission requirements for collaborators and other affiliations. Please be sure to familiarize yourself with these changes before submitting proposals this fall.

Would you like more frequent news from NSF? In addition to these occasional articles in the IT Society Newsletter, CIF has set up a CIF-Announce mailing list where we send news of general interest to the CIF community on approximately a quarterly basis. Typical news items include upcoming deadlines, new program announcements, workshop announcements, and our annual volunteer panelist survey. The volunteer panelist survey conducted in January 2017 had over 300 responses (thank you!) and helped to streamline and update our reviewer invitation process. If you responded to the survey and weren't invited to be a reviewer, please respond to our survey again next year. The next survey is especially enticing as it allows you to be among the first to serve as a panelist in our new location in Alexandria. Our new building in Alexandria promises improved panel rooms with superior A/V technology, better temperature control, fewer network outages, and a lower carbon footprint. (OK, the view from the windows is perhaps not as good.) It's also much closer to the DCA Airport (Reagan-National) than the previous location.

Keep an eye out for the link to the volunteer panelist survey in a CIF-Announce email in January 2018. As of July, we have over 1100 subscribers to the CIF-Announce mailing list. If you aren't already subscribed to the CIF-Announce mailing list and would like to do so, just follow these simple instructions:

- Compose an email to LISTSERV@listserv.nsf.gov (leave the subject blank)

- In the body of the message, just write "SUBSCRIBE CIF-Announce Firstname Lastname" (without the quotes and replacing Firstname and Lastname with your name). Alternatively, you can subscribe anonymously by writing "SUBSCRIBE CIF-Announce ANONYMOUS" (without the quotes).

- Send the message. You will receive a confirmation email that you have subscribed. Please read the confirmation email since you may need to respond to it.

A special invitation to Information Theory researchers visiting the US or Canada on sabbatical: *Please respond to the volunteer panelist survey or contact us directly to serve on an NSF panel*! This will offer you a first-hand view of how projects are selected for funding in the US merit-review system, and allow you to judge whether the NSF Merit Review process is indeed the gold standard (as NSF maintains ;). It's also an excellent opportunity to network with your colleagues, and to be exposed to the latest and greatest from some of the brightest minds in the field. In short, any sabbatical stay in North America cannot be considered complete if you have not served on an NSF panel while here.

In other items of interest, a new program of potential relevance to the information theory society was announced this May: Semiconductor Synthetic Biology for Information Processing and Storage Technologies (SemiSynBio NSF 17-557). This program is focused on addressing the scientific issues and technological challenges associated with the underpinnings of synthetic biology integrated with semiconductor technology. One example is storage technology where it is anticipated that these concepts could enable long-term high-density storage devices orders of magnitude better than current technology. This program strongly encourages interactions among various disciplines including biology, engineering, physics, chemistry, materials science, computer science, and information science.

We should also note that the Secure and Trustworthy Cyberspace (SaTC) solicitation is aligned with the coordinated CISE Core solicitations. The SaTC program funds cutting edge research in all areas of security, and has measurably benefitted in recent years from the infusion of information-theoretic ideas to privacy, anonymity, and secure communications and storage. Many CIF-funded researchers have been successful with SaTC submissions as well, and we encourage security-minded researchers within the information theory community to take a closer look at SaTC. Of course, other programs, including Network Technology and Systems (NeTS), Spectrum Efficiency, Energy Efficiency, and Security (SpecEES), Information Integration and Informatics (III), Energy,

Power, Control and Networks (EPCN), and Communications, Circuits and Sensing Systems (CCSS), remain areas where information theory, in collaboration with adjacent disciplines, can tip the scales.

We'd also like to take this opportunity to mention the upcoming NSF Workshop on Low-Latency Wireless Random Access, co-sponsored by CIF and NeTS, to be held at MIT on November 2–3, 2017. The workshop focuses on new challenges created by the envisioned future of large-scale machine-type communications. The workshop website (https://iot2017.mit.edu/) lists 25 talks from many of the top researchers from all over the world working in this area and provides a link to register if you are interested in attending.

Finally, we'll conclude with a reminder of upcoming proposal submission deadlines:

- CCF Core Medium proposal submission window: September 20–September 27, 2017

- CCF Core Small proposal submission window: November 01–November 15, 2017

- CCF Core Large proposal submission window: Did you read this newsletter?

- SaTC Medium submission window: October 3–October 10, 2017

- SaTC Frontier submission window: October 13–October 20, 2017

- SaTC Small submission window: November 1–November 15, 2017

- SemiSynBio submission window: October 02, 2017–October 30, 2017

Progress in information theory is an amalgam of steady forward motion interspersed with gushes of creativity, reminiscent of how Ogden Nash characterized the flow of a peculiar condiment:

The Catsup bottle
First a little
Then a lottle

Information Theory is richer than ketchup, but either way, let's keep it flowing.

Rick Brown (ribrown@nsf.gov)
Phil Regalia (pregalia@nsf.gov)

Awards

Congratulations to the members of our community that have recently received recognition for their exceptional scholarly contributions.

Gottfried Ungerboeck: The 2018 Claude E. Shannon Award

The Claude E. Shannon Award is the highest honor from the IEEE Information Theory Society. The award has been instituted to honor consistent and profound contributions to the field of information theory.

Muriel Medard: 2017 Aaron D. Wyner Distinguished Service Award

The Aaron D. Wyner Distinguished Service Award of the IT Society has been instituted to honor an individual who has shown outstanding leadership in, and provided long-standing, exceptional service to, the Information Theory community.

Information Theory Society Paper Award

The purpose of the Information Theory Paper Award is to recognize exceptional publications in the field and to stimulate interest in and encourage contributions to fields of interest of the Society. The 2017 award winning publication is:

- **C. Bennett, I. Devetak, A. Harrow, P. Shor, A. Winter**, "The Quantum Reverse Shannon Theorem and Resource Tradeoffs for Simulating Quantum Channels", *IEEE Transactions on Information Theory, May. 2014*

Joint Communications Society/Information Theory Society Paper Award

The Joint Communications Society/Information Theory Society Paper Award recognizes outstanding papers that lie at the intersection of communications and information theory.

The 2017 award winning publication is:

- **I. Tal, A. Vardy**, "List Decoding of Polar Codes", *IEEE Transactions on Information Theory, May. 2015*

Aaron B. Wagner: 2017 James L. Massey Research & Teaching Award for Young Scholars

Recognizes outstanding achievement in research and teaching by young scholars in the Information Theory community.

Lele Wang: 2017 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 contributing to the mathematical foundations of any of the information sciences within the purview of the Society.

- **Lele Wang,** "Channel Coding Techniques for Network Communication", *Ph.D. Thesis, University of California, San Diego, Dec. 2015*

Jack Keil Wolf ISIT Student Paper Award

The IEEE Jack Keil Wolf ISIT Student Paper Award is given to up to 3 outstanding papers for which a student is the principal author and presenter. The award is based on the paper's technical contribution as well as the quality of its presentation. The prize was awarded to 3 papers this year:

- O. Peled, O. Sabag, H. Permuter, "Feedback Capacity and Coding for the (0,k)-RLL Input-Constrained BEC", *Proceedings of the 2017 IEEE International Symposium on Information Theory, Aachen, Germany, Jun. 2017*

- J. Li, X. Tang, C. Tian, "A Generic Transformation for Optimal Repair Bandwidth and Rebuilding Access in MDS Codes", *Proceedings of the 2017 IEEE International Symposium on Information Theory, Aachen, Germany, Jun. 2017*

- Q. Yu, M. Maddah-Ali, S. Avestimehr, "The Exact Rate-Memory Tradeoff for Caching with Uncoded Prefetching", *Proceedings of the 2017 IEEE International Symposium on Information Theory, Aachen, Germany, Jun. 2017*

2017 Chapter of the Year Award

The Chapter of the Year Award recognizes a chapter that has provided their membership with the best overall set of programs and activities. The 2017 winner is the

- **Sweden Section Joint Chapter (Vehicular Technology / Communications/ Information Theory): Tommy Svensson** (Chairman, Student activities, and Interface to ComSoc), **Elisabeth Uhlemann** (Vice Chair and Interface to VT Society), **Michael Lentmaier** (Vice Chair and Interface to IT Society), **Danyo Danev** (Treasurer), **Joachim Björsell** (Secretary and Membership and Social media development), **Lars Kildehøj** (Coordinator DLTs[*] and Membership development), **Luis Guillermo Martínez Ballesteros** (Coordinator DLTs[*], Student and Industry activities and Interface to IEEE Sweden Section), **Gabor Fodor** (Industry activities).

Amin Shokrollahi: 2017 Padovani Lecturer

The Padovani Lecture is held annually at the North-American School of Information Theory.

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*Distinguished Lecturer Tours

Seminar in Honor of Kees Schouhamer Immink

Jos Weber, Han Vinck, and Peter H. N. De With

Kees Schouhamer Immink

Kees Schouhamer Immink (Turing Machines Inc) received the 2017 IEEE Medal of Honor on May 25, 2017, in San Francisco, CA, USA, "for pioneering contributions to video, audio, and data recording technology, including compact disc, DVD, and Bluray". In order to celebrate the unique fact that this award was bestowed upon a member of the Benelux information theory community, a seminar in honor of Kees was held in Rotterdam, the Netherlands, on June 16, 2017. The venue was the beautiful Sociëteit KR&ZV "De Maas" (Royal Maas Yacht Club). The seminar, which was preceded by a lunch and followed by a reception and dinner, attracted 45 participants. It was organized by Han Vinck, Jos Weber, and Peter de With and sponsored by the Shannon Foundation, the IEEE Benelux Chapter on Information Theory, and the Werkgemeenschap voor Informatie-en Communicatietheorie (WIC). Presentations were given by

- Han Vinck (University of DuisburgEssen, Germany): "Four myths about Kees Immink",

Kees with seminar speakers

- John Watkinson (Run Length Limited, UK): "Impact of Kees Immink's work on digital data- video-and audio recording",

- Hiroshi Kamabe (Gifu University, Japan): "Immink Codes for Phase Change Memory",

- Ronald Aarts (Philips Research & Eindhoven University of Technology, NL): "Kees and his channel coding for CD",

- Peter de With (Eindhoven University of Technology, NL): "In the beginning ..... there was Justesen",

- Dirk Van Hertem (KU Leuven, Belgium & Chairman of the IEEE Benelux Section): "The IEEE and its Medal of Honor",

- Jos Weber (Delft University of Technology, NL): "Kees Immink: his current work, his importance to the Benelux IT Community, and his UJ Honorary Doctorate".

The slides are available via the seminar website

http://homepage.tudelft.nl/2k00k/ImminkSeminar/.

An interview with Kees appeared in the May 2017 issue of IEEE Spectrum.

Reflections on MOOC on Information Theory

Raymond W. Yeung

When Editor Mike Langberg invited me to write an article about the MOOC on Information Theory I made some time ago, I did not hesitate to accept because there are quite a lot about the MOOC I would like to share with the community.

The whole thing was started in early 2013 when CUHK joined Coursera. The upper management of the University asked me to consider making a MOOC. I agreed to do so because there were something about teaching mathematics that I would like to explore, and I had some ready materials from my book (*Information Theory and Network Coding*, Springer 2008) that I could make into an MOOC.

The MOOC was launched in January 2014, with over 25,000 registrations. This number was at least one order higher than I had expected, and it is nothing but a manifestation of the size of the cyber community. The MOOC was subsequently offered twice, in September 2014 and January 2015. The number of registrations for September 2014 was about 7,000. The number of registrations for January 2015 dropped below 5,000, and so I decided to put the courseware in public domain. All the videos and slides can now be accessed at

http://www.inc.cuhk.edu.hk/InformationTheory/index.html

Producing the MOOC

Like many, I used to hold the view that there is no better way to teach mathematics than teaching on the whiteboard. I changed my mind a little bit when my colleague Chandra Nair organized the Broadcast Channel Summit at CUHK in March 2010. Among the invited speakers was Abbas El Gamal. In his talk, he presented the theorems (taken from his book with Young-Han Kim to be published) on slides, and filled in the proofs on the whiteboard. I thought it was a pretty good idea. For one thing, the audience does not have to wait for the speaker to copy the theorems on the whiteboard, which is boring.

Subsequently, I taught my graduate course on information theory twice in this fashion. I took videos of my lectures and put them on the web. The students loved it. However, upon seeing some Khan Academy presentations, I immediately realized that myself appearing in the videos was completely redundant—I was simply blocking the whiteboard!

So, when I made the MOOC, I decided to use a style somewhat similar to that of Khan Academy. However, because I was going to teach very detailed mathematics, I could not possibly write all the equations on the screen like Khan Academy. First, my handwriting is admittedly not pretty and I cannot write and explain simultaneously very well. Second, handwritten equations simply take up too much space on the screen.

Instead, I prepared all the text and equations by Latex, and on top of them I put layers and layers of animations using Keynote on Mac. It was a tremendous effort because on a single slide there could be more than 100 animation steps.

Most MOOCs use a cursor on the screen for presentation. I was debating with myself whether I should do the same. After some thought, I decided to develop my own style which I believe is most suitable for teaching mathematics. Instead of a cursor, I use highlighters. The advantages are i) I can highlight more than one thing on the screen; ii) I can use different colors to highlight different things; iii) the highlighting "boxes" can move around on the screen; and iv) the highlighting boxes can disappear after they have finished their jobs, thus making room for new highlighting. In addition to highlighting, I also use underlining with different colors. The advantages are similar.

After getting the slides ready, I recorded the narration in the studio while playing the animation. I used a popular software called Camtasia to do the screen capturing and recording. To me, the recording was not at all easy because I needed to coordinate my narration with the playing of the animation. At first, I tried to speak out the narration perfectly in one go, but I found that this put too much stress on myself as I am not a professional speaker. After some experiments, I decided to speak out the narration as perfectly as I could, but if I made a mistake, I simply repeated that part and edited the audio track afterwards.

By the way, it is important to record in the studio instead of in the office. High quality audio does extend the concentration span of the viewers.

Very often I needed to record the same segment three or four times to get it perfect. This made the recording process tedious

and painstaking. Nevertheless, I believe it is important to get rid of all the small mistakes in the narration because the videos are expected to be watched over and over again. Small mistakes, if any, would be repeated over and over again, which is annoying. Sometimes I was not happy with a few words I used in the narration, and I would go back to the studio to redo that part and then inserted it in the sound track.

I was planning to make the MOOC a 15-week course, with a 1-hour video uploaded every week. Except for a few sections, the MOOC covers thoroughly the materials in the first 11 chapters of my book. It turns out that 1 hour of video teaching is equivalent to 3 to 4 hours of classroom teaching. Surprising, isn't it?

The ultra-high efficiency of MOOC teaching is worth explaining. First of all, classroom teaching is inefficient. We not only have to spend time copying the text and equations line by line, but also need to slow down from time to time in order to give the students time to absorb. For MOOC teaching, it is not necessary to slow down. As long as the materials are self-contained, the students can pause and rewind as often as they want, depending on their learning habits and how well they can understand the materials. This is a unique advantage of MOOC teaching. The students can even play the videos at 1.5x or 2x, which is extremely useful for reviewing the materials (Coursera supports this feature.)

This phenomenon can perhaps be understood in terms of wireless communication.[1] Classroom teaching is analogous to broadcasting using TCP, whose rate is constrained by the weakest receiver, and so the rate is low. MOOC teaching is analogous to broadcasting using a rateless code, where each receiver receives at its own rate.

In classroom teaching, we make all the time small mistakes and occasionally big mistakes. This may not be a bad thing after all, but it does slow down the teaching. For MOOC teaching, the process of the teaching can be made perfect because it is not done in real time.

The most important advantage of MOOC teaching, as far as I can see, is that teaching can indeed be made very effective through the use of animation. For example, I can bring up a lemma on the screen when I need it in a proof. After I have finished using the lemma, I can "disappear it" to make room for other things. To present a proof, I use the two-column format, and I divide the proof into small steps which show up on the screen one by one. I try my best to finish the proof on one page so that it is easy for the student to see the whole picture. Sometimes I manage to do it by disappearing along the way some parts of the proof that are no longer important.

For very long proofs (e.g., the direct part of the channel coding theorem), upon filling up the first screen, instead of starting a new screen, I scroll the screen halfway to the left to create a new blank column. This way, I can continue to make reference to the last column which is now the left column on the screen. This works extremely well.

I mentioned that I use highlighting and underlining very extensively in the videos. I also very often use different colors for different symbols in a mathematical expression. This instantly makes a very complex expression visually understandable, so that the stu-

dent can better focus on the meaning of the expression instead of struggling through the process of figuring out which part is which.

For classroom teaching, highlighting is out of the question. Underlining is possible, but removing the underlining is painstaking. The same are true for the use of multiple colors. Imagine that you have to change a few markers before you finish writing an expression.

MOOC Disadvantages

A major disadvantage of MOOC teaching is that there is no real-time interaction between the instructor and the students. If the student does not understand something in the video, unlike in a live lecture, he or she cannot seek further explanations from the instructor on the spot.

Another disadvantage of MOOC teaching is that the instructor cannot slow down for students who have difficulty understanding the materials. However, this disadvantage can be offset by the advantage that it is not necessary to adopt a single pace for teaching the whole class; the students can learn at their own pace by pausing and rewinding the video.

With these factors in mind, when I made the videos, I tried to explain things as clearly as possible, so that the students have no need to seek further explanations. In fact, I realized only subsequently that many of the explanations I gave in the videos are far more explicit than I had ever given in my live lectures.

Launching the MOOC

I started to work on the slides and videos in summer 2013, chapter by chapter. I regretted that I had agreed to make the MOOC because very quickly I found the production process much more time-consuming than I originally thought. I worked extremely hard, but by the time the MOOC was launched in early January 2014, I was only halfway through. As a result, I was under the gun to finish the rest of the videos before the end of the MOOC in late April. I had only 4 more months to go. What a nightmare!

During this time, I literally worked on the MOOC full-time, everyday from morning to night. With very hard work, I finally managed to finish all the video in time. It was a big relief.

I used two of my PhD students as the TAs for the MOOC. Before the MOOC was launched, I was wondering how many TAs I would need. Regarding this, I sought advice from Mung Chiang of Princeton who offered a MOOC on Coursera early on. His course had almost 50,000 registrations, but he used only 3 TAs. According to Mung, for MOOC teaching, when a student comes up with a question in the discussion group, most of the time other students can provide an answer without the TAs' intervention. He was correct. As such, the TAs basically only needed to monitor the discussion group.

A 1-hour video was uploaded every week. To ensure that the students would keep up with the pace, weekly homework was assigned. The assignments consist of selected problems at the end of the chapters in my book. The students needed to submit their solutions two weeks after the assignment was posted. They either typeset their solutions or scanned their handwritten solutions. In either case the solutions were submitted online. The model answers were posted two weeks after an assignment was made.

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[1]My colleague Alfred Ho at CUHK owns the IP of this analogy.

Assessment was an issue. As we all know, most information theory problems involve rather lengthy mathematical derivations. For such a large class, it is impossible for the TAs to grade them all. Rather, we used peer-to-peer grading, i.e., the students graded other students' homework based on the model answers. If there is any appeal, the TA would look into it. The students did not receive a letter grade for the MOOC. Instead, they obtained an electronic completion certificate if they could score at least 70% for their homework.

According to our statistics, at the last week of the MOOC, there were still about 1,100 students actively watching the videos. Eventually 55 students obtained the completion certificate. While this number is small, it does not mean that the MOOC is a failure. After all, the MOOC was a full-fledged graduate level course, did not bear any credit, and was completely free of charge. (If the students pay, they tend to work harder.) I believe most students spent time only on topics they were most interesting in.

As mentioned, the MOOC was again offered in September 2014 and January 2015. I took the opportunity to add the materials from two sections in the book. I also recruited a student who had taken my information theory course before to design some quizzes to be inserted in the videos. The video stops once in a while, and the students are required to answer some multiple choice questions correctly before they can continue. In addition to checking the understanding of the students, these quizzes also serve the purpose of giving the students a chance to regain their concentration.

Some Highlights

Perhaps too much talking already. So I would like to invite you to take a look at some of the representative animations in the MOOC:

http://www.inc.cuhk.edu.hk/video/IT_c21b.html
(don't miss the animation from 3:43 to 4:18)

http://www.inc.cuhk.edu.hk/video/IT_c35a.html
(0:30 to 1:00)

http://www.inc.cuhk.edu.hk/video/IT_c74b.html
(5:44 to 6:20)

http://www.inc.cuhk.edu.hk/video/IT_c113a.html
(3:36 to 4:14 and 5:17 to 8:01)

Offering as a Regular Graduate Course at CUHK

At CUHK, I have offered the MOOC as a regular gradate level course twice. Instead of coming to class to attend lectures, the students watch a 1-hour video online every week. This goes on even during the semester break, so that 15 videos can be covered in a 14-week semester. Every week, the students come to class for 2.5 hours to work on their homework assignments, and I was there to answer their questions. I told the students that I expected them to spend at least 5 hours on their homework every week, so coming to class for 2.5 hours to do the same was not going to use any more of their time. Besides, they would have a chance to ask questions on the fly.

In order to force the students into this weekly routine, I took attendance of the students and allowed them to miss only one class (unless they apply for a leave of absence). This arrangement was very well received by the students. Very often, they stayed behind after the class to continue discussion with their fellow students.

Two or three weeks after the course had started, I asked the students how they watched the videos. One student said he stopped every 5 seconds to take notes. Another student said he watched the video in one pass. It was indeed a learning process of the students because learning from a MOOC was something entirely new for them. After a while, they all developed their own ways of using the videos.

As it was a credit-bearing course, in-class midterm and final exams were given. I was particularly happy with the MOOC because I was able to cover at least 25% more materials due to the high efficiency of teaching. In the past, when I taught my information theory course, I was able to cover either rate-distortion theory and the Arimoto-Blahut algorithms, or continuous time channels, but not both. With the MOOC, I could cover all these topics in great detail, making it a very complete course on classical information theory.

Even though the students were learning at a faster pace, the good news was the effectiveness of teaching remained high. As mentioned, the explanations I give in the videos are more explicit than ever before, and so I believed that the students should also be able to learn better. As such, I deliberately made the exam questions somewhat more difficult. It was most encouraging that the students were able to cope with the exams very well. But of course, I cannot say this for sure because the sample size so far is still quite small.

Epilogue

It is noteworthy that almost all mathematics books nowadays are still published in exactly the same way as they were published a few centuries ago, i.e., in black and white.

After finishing the MOOC, I realized that it is a multimedia version of my own book (the first 11 chapters), which indeed can to a very large extent replace the book itself. The MOOC is also my own experiment on new methods for teaching mathematics. While the outcome of the experiment may not be very mature at this point, it has no doubt opened up new possibilities for further explorations. Who knows? Perhaps efforts to be made along this direction may eventually lead to a merging of publishing and teaching, not only for mathematics but also for other subjects.

The Historian's Column

Anthony Ephremides

Once again, after at least thirty or more similar occasions over the last fifty years, I returned from attending the Aachen ISIT with many vivid impressions, ideas, and, in general, lots of food for thought. Our younger members, I am sure, are not aware that until the year 2000 (the fateful year that marked the end of the second AD or AC millennium) the ISIT was being held approximately every 18 months. So, the exact count of the number of symposia that I attended (especially since I did miss two of them) would require some arithmetic that I prefer to assign as a homework problem to "challenged" elementary school students. (Another similar one, by the way, due to my friend Apostolos Kakaes, is to determine the value of $3 + 2 \times 5$; is it 13 or 25?).

But, back to the ISIT; one thing that struck me was that I recognize fewer and fewer attendants. Perhaps it is just a sign of ...time passing by (I do not want to say "ageing"). Or, perhaps, it is a sign of large numbers of newcomers and of fewer "repeat offenders". Another observation was the increasing diversity of topics covered. Not just Source Coding, Channel Coding, Shannon Theory, of which there used to be dozens of sessions. Topics ranging from caching, to big data, to bio topics, diverse applications, and to the Age of Information (that had a remarkable three sessions, and then some, after having had just a single session in last year's ISIT) which, by the way, was attended by overflow crowds, added to the diversity and vitality of the Symposium.

But the main topic that I want to discuss arose from David Tse's splendid Shannon Lecture. He did pay tribute to several key and traditional Information Theoretic topics on which he worked and he did emphasize the cyclical relationship between aesthetics and impact that permeated all of them, which he called the "Spirit" of Information Theory. In a way, it was a view that parallels the view of "form" and "function" in Architecture. But to me, the more remarkable observation he made, and then proceeded to substantiate, was the departure from the limits of the traditional Theory that Shannon bequeathed to us. As he reminded us, Shannon's Theory clearly stated that its objective and motivation was the reproduction at one point of a choice made at another point and that it had nothing to do with "meaning" of information. He proceeded to then fit into the same mold of the cyclical "beauty-impact" nature of Information Theory two examples of his recent work that depart from these two key characteristics that delimit the scope of Information Theory. That is, in a cautious and skillful way, he dared to voice the message of "going beyond Shannon". As with all sects of religious nature, "Shannonism" is something one needs to treat with respect.

But, joking aside, it is indeed high time that the arsenal of Information Theory, which includes formidable tools and weapons, along with techniques, approaches, modeling philosophies, inference methods, and, above all, a unique sense of scientific aesthetics, be used to fight new battles. It needs to be extended, cautiously and carefully, to several new challenging areas that break the traditional mold. To begin with, it is well known that Shannon himself declared that, although multi-user systems were amenable to similar analysis methods as single-user systems, networks that involved multiple hops were not! And he backed his statement with as simple and astute an argument as the ones he used throughout his scientific career. He said that since in networks there has to be a delay constraint, and since the delay-constraint on each link would have some value D, once you traverse two hops it would become 2D. So, there it goes. New methods and techniques would have to be developed.

Making the transition away from the cornerstone of the Theory, as David noted in his talk, is more important and challenging. In his work, the assignment of "meaning" took the form of "prediction" and "computation". That is you communicate not just to reproduce a message chosen at the source, but in order to predict future values of a related quantity or to perform a related computation task. This, by the way, bears some similarity to the notion of "age" of information, since the main reason for wanting to maintain small values of age is not just to stay young but, rather, to predict the future values of the monitored process.

There can be several other ways in which the notions of meaning, context, storage, control, computation, and similar attributes of information, can enter into the agenda of an enlarged Theory of Information. My feeling is that this is already happening. And it would be wrong to consider such a transition as a departure from the foundations that Shannon laid out. Rather, it should be viewed as an extension of that foundation. Next year will mark the 70th anniversary of the founding of Information Theory. There has been so much that happened during these seventy years. But the vitality of the field has not diminished. So, the call to move on into new pastures is just a reconfirmation of that vitality.

Two more things that occurred during this ISIT that are worth mentioning are the memorial special session honoring Roberto Fano, one of the giants of our field, and the distribution (finally) of the "Mind at Play", the book that marks the first and only, so far, biography pf Claude Shannon. By next year, we will finally have the film about Shannon. It will help immensely to popularize broadly the image (and impact) of that remarkable genius throughout the world. Special thanks are due to Sergio Verdu and to the Society for concluding this project.

Students' Corner: Reflections on the Best Paper Award

Parham Noorzad

One of the greatest honors for any student researcher working in information theory is to be considered for the IEEE Jack Keil Wolf ISIT Student Paper Award, which is presented every year at the International Symposium on Information Theory (ISIT). In continuing our tradition from last year, we asked the finalists and award winners to write about their experiences regarding the

research that led up to their papers. Below are the responses we received.

As always, for any questions, comments, and suggestions feel free to contact me. Any contributions on student-related issues are also greatly appreciated. My email address is: parham@caltech.edu

A High-SNR Normal Approximation for Rayleigh Block-Fading Channels or How Proving the "Obvious" Can Take a Long Time

Alejandro Lancho[1] (alancho@tsc.uc3m.es)

When I started my PhD around two years ago, my supervisor, Tobias Koch, suggested to me various topics. After reading different papers, I decided to work on the finite-blocklength analysis of fading channels. I liked this topic because of its practical relevance. Indeed, short packet communications will be important for the future generation of wireless communications systems, and a refined analysis of the maximum coding rate as a function of the blocklength will be needed. Thus, we decided to follow the work by Polyanskiy, Poor and Verdú. In their 2010 paper, "Channel coding rate in the finite blocklength regime", they derived a normal approximation for the maximum coding rate of various channels with a positive capacity. The normal approximation characterizes the behavior of the maximum coding rate for a given blocklength and a probability of error not larger than a given value. Specifically, it illustrates that, in the finite blocklength regime, the capacity is penalized by a term that depends on a quantity called "channel dispersion" and that decays proportionally to the square root of the blocklength.

Our goal was to derive a normal approximation of the noncoherent Rayleigh block-fading channel, which models short-packet wireless communications when there is no line-of-sight (this is a common scenario in big cities). Now, the usual strategy to obtain normal approximations is to evaluate achievability and converse bounds for the capacity-achieving input and output distributions, and then perform an asymptotic analysis as the blocklength tends to infinity. The problem is that the capacity-achieving input distribution is unknown for the noncoherent Rayleigh block-fading channel, so this strategy cannot be followed. However, the behavior of capacity at high SNR is well understood (it was studied by

Hochwald and Marzetta in 2000). Our goal was therefore to derive a high-SNR normal approximation for noncoherent Rayleigh block-fading channels, where capacity and channel dispersion are approximated within error terms that vanish as the SNR tends to infinity.

As is common in information-theoretic analyses, we derived lower and upper bounds on the maximum coding rate and showed that they matched. Our achievability bound was the easier part. We applied the Dependence Testing (DT) lower bound and followed the steps of the paper by Polyanskiy, Poor and Verdú, carefully bounding the error terms so that they either depend on the blocklength or on the SNR but not on both quantities together. The main difficulty was the converse part. To obtain an upper bound that matched the lower bound, we needed to show that using maximum power was optimal. However, we couldn't show this in a direct way so we had to think of something more elaborate. We couldn't first apply the Berry-Esseen theorem and then optimize the capacity and channel dispersion over the power allocations either, because the error terms would "blow up" as the power allocations become small. Finally, we found an approach that worked. We first showed that using small powers was suboptimal, thereby restricting the set of possible power allocations, and then applied the Berry-Esseen theorem.

Deriving the converse bound was sometimes frustrating. Intuitively, one would think that using the total available power has to be optimal, but proving this was more difficult than we originally thought. So we eventually spent a lot of time on the problem. Nonetheless, I don't think that it was a waste of time. In the end, I learned something from every approach that we tried.

Needless to say, I could not have carried out this work without the help and endless patience of my supervisor, Tobias Koch. I further would like to thank Giuseppe Durisi. His inputs were always well appreciated.

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[1]Finalist for the paper:
Alejandro Lancho, Tobias Koch, and Giuseppe Durisi, "A High-SNR Normal Approximation for Single-Antenna Rayleigh Block-Fading Channels," ISIT 2017, Aachen.

The importance of perseverance in research

Ori Peled [2] (oripe@post.bgu.ac.il)

The origins of the current work date back to a discussion that Professor Navin Kashyap, Oron Sabag and my supervisor Professor Haim Permuter had in ISIT 2014, Honolulu, Hawaii. They thought to investigate the feedback capacity of a memoryless channel but in the presence of input constraints. Subsequently, they were able to find a simple capacity formula for the case where no consecutive '1's are allowed (the $(1,\infty)$-runlength limited constraint).

When I began my master's, I was tasked by Haim to generalize their previous result. The most natural course of action was to study the (d,∞)-RLL constraint, where every '1' must be followed by at least d '0's. After investing a great deal of time learning the necessary basics and relevant past works, we reached a simple coding scheme in the form of a finite-state encoder, which seemed to be a solution for any natural d. However, when I sat down to write the formal proof, I noticed that I had made a mistake. Unfor-

tunately, I was not able to correct that mistake and thus was forced to abandon the result I thought I had achieved.

When I chose to pursue a Master's degree, I did so because I wanted to experience being a researcher. I wanted to work on a problem that did not have an answer in the solution section of the textbook or somewhere online. My biggest concern had always been that all my work would eventually amount to nothing, and that I'd have no interesting results to show for the time spent researching. That certainly seemed to be the case when my (d,∞) result fell apart. It really was a big blow to my morale.

Rather than giving up on this line of research, we decided to tackle a similar problem- that of the $(0,k)$-RLL constraint where no more than k consecutive '0's are allowed. I was able to utilize the knowledge I gained working on the previous problem to find a capacity expression and coding scheme, again as a finite-state encoder, for any natural k. This time no mistakes popped up during the writing process.

I am thankful for being able to finish this part of my studies with a positive experience. I am especially grateful to my co-writers for making me realize that the life of a researcher is full of uncertainty and perseverance is paramount.

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[2]Ori Peled, together with Oron Sabag, won the award for the paper: Ori Peled, Oron Sabag, and Haim H Permuter, "Feedback Capacity and Coding for the $(0,k)$-RLL Input-Constrained BEC," ISIT 2017, Aachen.

Our Pursuit of the Rate Bound for Codes with Sequential Local Recovery

S. B. Balaji (balaji.profess@gmail.com) and Ganesh R. Kini [3] (kiniganesh94@gmail.com)

There has been a great deal of interest in codes with locality, also known as locally recoverable codes, on account of their application to distributed storage. The initial focus was on building codes which can recover from just a single erasure. That problem has largely been solved. A natural extension is to the case of multiple erasures; here, there are multiple approaches, including making the local codes stronger, building codes with availability and codes with sequential recovery. The study of codes with locality under sequential recovery was initiated by our advisor Professor P. Vijay Kumar who was motivated by the fact that these codes offer higher rates. The case of two erasures was examined in our group by former students Prakash Narayanamoorthy and V. Lalitha. Although introduced in a distributed storage setting, codes with sequential recovery are of interest even outside the distributed storage community and there has been prior work on this topic mostly focused on achieving a certain fractional minimum distance and using a probabilistic approach to building codes. However, the problem of determining the maximum achievable rate by codes with sequential recovery for correcting a fixed number t of erasures remained

open and this is the problem that we worked on. We ended up giving a complete solution that included identifying the maximum achievable rate by first deriving an upper bound and then following this up with the construction of codes that achieved this upper bound. Most interestingly, while the rate bound is independent of field size, we were able to provide constructions of *binary* codes that achieved this maximum rate. Furthermore, this result is applicable to any number t of erasures and any value of locality parameter r, i.e., the number of code symbols contacted to recover from each erasure.

It was truly an honor to be selected as one of the finalists for the student paper award for our work on this problem. We started to work on this problem in 2016 and after solving the problem for the case of $t = 4$ erasures, we then moved on to work on a different set of problems for the 6 months following. Around this time, our advisor returned from a trip to the University of Maryland where he had interacted with Professor Alexander Barg and Professor Itzhak Tamo and we came to know from him that both Professor Tamo and Professor Barg have expressed interest in the sequential approach to handling multiple erasures. This renewed our interest in the problem and we started to work on it once again. We then made a crucial observation concerning the structure of the parity-check matrix for the case of $t = 4$ erasures which we had solved earlier, and used this observation to derive a rate bound for the general case of t erasures. It turned out that the parity-check matrix

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[3]S. B. Balaji and Ganesh R. Kini were finalists for the paper: Balaji Srinivasan Babu, Ganesh Kini, and P Vijay Kumar, "A Tight Rate Bound and a Matching Construction for Locally Recoverable Codes with Sequential Recovery from Any Number of Multiple Erasures," ISIT 2017, Aachen.

of a rate-optimal code was forced to have a very interesting structure. We then used insight gained from this forced structure of the parity-check matrix to eventually obtain a construction achieving the maximum rate. It was a pleasure working on this problem as we were able to make several interesting observations, encountered interesting graphical structures such as the class of Moore graphs and also learned that one should not be deterred from pursuing a well-motivated and promising research direction, simply because there are not many others walking along that path.

Finding Simple Solutions to Big Challenges

Jie Li[4] (jieli873@gmail.com)

Today, we are in the age of big data; everyone creates data everyday. For example, if you post some pictures on Facebook or shopping on Amazon, then data is created. With the rapid development of the Internet, the amount of data is increasing in a crazy manner. Jim Gray, the Turing Awardee, predicted that the global amount of information would be doubled every 18 months. Therefore, the problem of storing big data efficiently is a big challenge.

In 2012, when I started my Ph.D degree in Southwest Jiaotong University, China, I had the privilege to dig into this hot issue with my supervisor Prof. Xiaohu Tang. Later in 2015, I fortunately got a scholarship from the China Scholarship Council and therefore have the privilege to study with Prof. Chao Tian in The University of Tennessee-Knoxville. During the period of reading relevant papers, from my two advisors, I learned how to find the fundamental idea of each paper and try to understand the idea in my own way, and how to find problems and solve them creatively.

After reading some papers and understanding the basic ideas in my own way, I found that in the literature, most high-rate MDS storage codes can only optimally repair systematic nodes, while few can optimally repair all nodes. This gave us the impression that there might be a barrier between explicitly constructing high-rate MDS storage codes that can only optimally repair systematic nodes and those that can optimally repair all nodes. Thinking about the problem for a long time, we finally found a generic transformation that can convert any nonbinary MDS storage codes with optimal repair property for only systematic nodes to new MDS storage codes with optimal repair property for all nodes (also named MSR codes). I was very excited when I found this result, but writing the paper was not that simple; it took us two years to prepare it. Initially, the technical parts of the result were in big block matrix form, which looks a bit complicated. After discussing this issue with my two advisors for a long time, we significantly simplified the technical parts of the result other than using big block matrices and were quite satisfied with it. This lead to the ISIT paper, which received The IEEE Jack Keil Wolf ISIT Student Paper Award at ISIT 2017. The process of preparing the ISIT paper taught me that we should try our best to find simple solutions to big challenges.

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[4]Jie Li won the award for the paper:
Jie Li, Xiaohu Tang, and Chao Tian, "A Generic Transformation for Optimal Repair Bandwidth and Rebuilding Access in MDS Codes," ISIT 2017, Aachen.

From the Field: IEEE Sweden Section Joint Chapter

Tommy Svensson, Chalmers University of Technology and Michael Lentmaier, Lund University

At the ISIT 2017 in Aachen the IEEE Sweden VT/COM/IT Chapter proudly received the 2017 Chapter of the Year Award from the Information Theory Society. We take this as an opportunity for presenting some of our activities in this edition of the newsletter.

Our chapter actually represents three different, but closely related societies: Vehicular Technology, Communications, and Information Theory. With only about 9.6 million people living in Sweden, we can be very satisfied about counting 419 unique VT/COM/IT members in 2016 (VT:104, COM:403, IT:80). We think that the composition of our board is an important enabler, comprising very committed persons who span competencies across our technical/scientific areas; academia and industry; senior and younger professionals; as well as a geographical span in Sweden. We have been quite efficient in creating activities for our members. We think the key there is to distribute responsibilities among the board members, taking opportunities when they appear, and working with minimal administrative overhead. For instance, we promote individual initiatives, and we meet using regular telephone conferences (around once per month) where we try to sort out most things, to avoid lengthy email discussions. We also store all our documents on a common server, so that all board members can always be up-to-date even if they cannot attend a telephone meeting.

Regular Events

We have initiated two Swedish workshops that are given on a regular basis every year. The Swedish Communication Technologies Workshop (Swe-CTW), first held in 2011, is a typically three-day

Shannon Centennial Panel (from left to right): Erik Ström (moderator), Erik Agrell, Michael Lentmaier, Tobias Koch, and Gerhard Kramer.

workshop that provides an opportunity for researchers and research students in Sweden to gather in a largely informal setting to share ideas, make contacts, and foster new collaborative links for their future careers. The 2016 edition of this workshop took place May 31–June 2 at Mid Sweden University, Sundsvall, and attracted 50 attendees.

The Workshop on Wireless Vehicular Communications was first organized in 2010 and is a one-day event taking place at Halmstad University every year. On November 2, 2016, 30 participants attended seven presentations, including an invited speech on "Reliable and scalable vehicular networking for cooperative automated driving" by Geert Heijenk from University of Twente, Netherlands.

To promote the visibility of young talented researchers, we have initiated two annual best paper awards for young researchers in Sweden: the IEEE Sweden VT-COM-IT Joint Chapter Best Student Journal Paper Award, and the IEEE Sweden VT- COM-IT Joint

Chapter Best Student Conference Paper Award. These awards are given to the winners during the annual Swe-CTW.

Particular Recent Events

The 2016 edition of the European School of Information Theory was held at Chalmers University of Technology Gothenburg, Sweden, on April 4–8, 2016. The school was attended by 96 researchers, including 68 students. The areas covered were lattice index codes, distributed storage systems, fiber-optical systems, modern coding theory, secrecy and stealth, and non-asymptotic Shannon theory. A panel discussion for celebrating the hundredth anniversary of Shannon's birth was also part of the program (see picture).

A workshop on next-generation 5G wireless networks with applications to Mobile and Vehicular Communications was held on May 3 2016 at Chalmers University of Technology, Gothenburg. Eight presentations were given, including a keynote on "An Introduction to Stochastic Geometry and its Applications in Vehicular Networking" by Martin Haenggi from University of Notre Dame, USA. About 40 people attend this one-day workshop.

During 2016, we organized 19 further IEEE technical seminars, including two IT society distinguished lectures, on "Bounds on the capacity of optical fiber channels" by Gerhard Kramer from Technical University of Munich and on "Graphical Models and Inference: Insights from Spatial Coupling" at Linköping University, and by Henry Pfister from Duke University, USA at Lund University. An upcoming IT society distinguished lecture tour by Osvaldo Simeone will take place September 4–8, 2017 with lectures at Chalmers University of Technology, Lund University, and Royal Institute of Technology (KTH).

This years' CTW took place June 1–2, 2017 at Chalmers University of Technology. You can find the newly selected paper awards and those from previous years on our joint chapter webpage:

http://sites.ieee.org/sweden-vtcomit/

From the Field: IEEE Information Theory Society India Chapter

Bikash Kumar Dey

The IEEE Information Theory Society (ITSoc) India Chapter and its members organize several technical events throughout the year. JTG/ITSoc Summer School on Signal Processing, Communications and Networks has been conducted every year since 2009 in one of the Indian Institutes of Technology (IITs) or the Indian Institute of Science (IISc). The summer school features 2–3 short courses, each consisting of 8 hours of talks and 2 hours of discussion over a span of 4 days. It also features a few invited talks and student presentations. About 120–180 students and faculty from all over India attend the summer school. The event is sponsored by the ITSoc.

National Conference on Communication (NCC) is a premier Indian conference in the broad area of communication engineering, and it has been held annually since 1995. Held in February/March, the conference has seen a significant focus on information theory in recent years. It is technically cosponsored by the IEEE Communication Society, and the members of the ITSoc play a considerable role in the organization. It features 6–8 preconference tutorials, 3–4 plenary talks, 8–12 invited talks, 80–100 regular peer reviewed paper presentations over two days, and technology workshops and demonstrations. Some best paper awards are given out to deserving papers authored by students.

The International Conference on Signal Processing and Communications (SPCOM) is another major event, held biennially at IISc since 1990. Over the years, it has evolved into its present signature style, in which a high quality contributed program is blended with a large number of invited talks and tutorials. Two to three papers are selected for best student paper awards. The conference typically attracts some 250–300 attendees from India and abroad.

A new event kicked off the Shannon Centenary celebrations in India last year—Bombay Information Theory Seminar (BITS). Held at IIT Bombay and Tata Institute of Fundamental Research (TIFR) during 1–3 January, 2016, it featured 17 hour-long research talks by invited speakers over the three days. A total of 137 participants including 104 students attended the seminar. With the second edition of BITS on the anvil for 2018, we expect this to be continued biennially.

The year 2016 also saw various other information theory related technical activities around India as part of the Shannon Centenary celebrations. Among these were the Shannon Centenary Day at IIT Kanpur, Shannon Centenary Exhibitions at IISc and IIT Guwahati, Shannon Day at IIT Madras, and another Shannon Centenary Day at SGSITS, Indore.

The chapter website at http://www.ee.iitb.ac.in/itsoc/ includes the urls for all the various events mentioned above.

2017 IEEE IT Society Summer School at Indian Institute of Technology Bombay

Bikash Kumar Dey and Nikhil Karamchandani

The 2017 IEEE IT Society Summer School was held at the Indian Institute of Technology (IIT) Bombay, India during May 28–31, 2017. The summer school has been held annually and rotated biennially between IIT Bombay, IIT Madras, and the Indian Institute of Science (IISc) since 2009, and the IEEE Information Theory Society started supporting it as a financial and technical cosponsor since 2014.

The summer school traditionally comprised of two, occasionally three, short courses on contemporary topics in the broad areas of communications, signal processing, and networking. This year's summer school had two short courses, each of eight lecture hours and an additional two hours of discussion, over four days. Additionally, we had four invited talks by some recent entrants into the Indian academic community in the relevant areas, and student poster presentations.

The two courses in the 2017 Summer School were taught by Babak Hassibi, Professor, California Institute of Technology, Pasadena, USA, and Sergey Yekhanin, Senior Researcher, Microsoft Research, Redmond, USA. Prof. Hassibi lectured on Non-Smooth Convex Optimization and Structured Signal Recovery, and Dr. Yekhanin spoke on Codes with Local Decoding Procedures.

Babak Hassibi started by describing several practical problems in the space of structured signal recovery that could be cast as convex optimizations with non-smooth regularizers, including
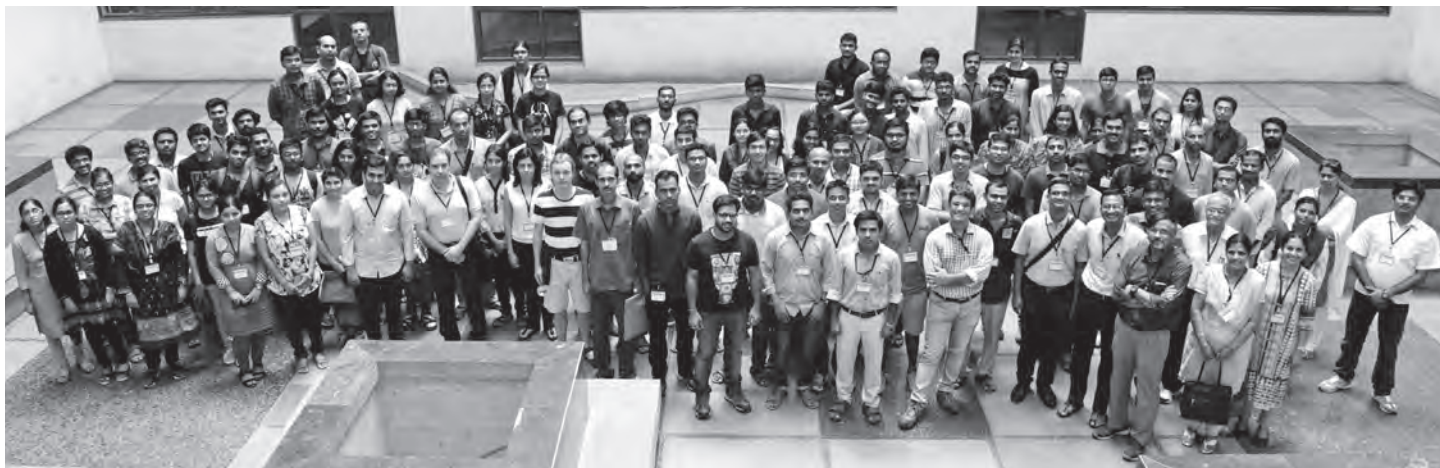
Attendees of the 2017 Indian Summer School.

compressed sensing, low rank matrix recovery, and phase re-trieval. He then presented a framework for designing the regu-larization functions via atomic norm decomposition. With this background, Babak provided an analysis of the number of ob-servations required for noiseless sparse signal recovery. Invok-ing Gaussian comparison lemmas due to Slepian and Gordon, he characterized the required number of observations in terms of the Gaussian width of the dual cone of the subgradient cone of the regularization function. The analysis highlighted the crucial role of the non-smoothness of the regularization function for ef-ficient signal recovery. Finally, Babak discussed how the analysis can be extended to the noisy case.

Sergey Yekhanin started with the basics of codes and finite fields and discussed the Singleton bound and MDS codes. He showed the existence of MDS codes over large enough finite fields. He then introduced the concept of locality of a code and proved a Singleton-like lower bound on the code-length for local recon-struction codes (LRC). He defined canonical LRCs and showed that any LRC meeting the bound with equality is canonical. He proved by construction that over large enough finite fields, a maximally recoverable canonical LRC meeting the lower bound on length with equality exists. On the last day, Sergey discussed locally decodable codes. After introducing Reed-Muller codes, he showed that they are locally decodable. Finally, he discussed

matching vector codes and finished with some open problems on the topic.

Both the lectures were very nicely paced to keep the audience en-gaged throughout the courses. The lectures were very well received by the audience, most of whom stuck with the program over the four days. During the open sessions between the lectures, the speakers were usually busy elaborating and responding to the eager students. This year, the number of attendees was over 170—a record number in the history of this summer school. The speakers own notes and scribe notes were made available on the summer school website.

The IEEE Information Theory Society generously funded the summer school. All outstation students were hosted in the students' hostels of IIT Bombay, and lunch and tea was provided to the participants on all the four days. The funding from the ITSoc helped to make all this possible. The organizers are thankful to the ITSoc for their support.

The details of the summer school and the lecture notes of the speakers and of the scribe are available on the website of the sum-mer school at https://www.ee.iitb.ac.in/~jtg17/

The next edition of the summer school, 2018 JTG/IEEE IT Society Summer School will also be held at the IIT Bombay in the summer of 2018.

10th Asia-Europe Workshop on "Concepts in Information Theory and Communications"

Han Vinck

Hirosuke Yamamoto

The 10th Asia-Europe workshop on "Concepts in Information Theory and Communications" (AEW10) was held in Boppard—Germany on June 21–23, 2017. Forty-one participants enjoyed the beautiful environment of the Rhinevalley and the setting of the romantic Bellevue hotel venue in Boppard.

The workshop is based on a long-standing cooperation between Asian and European scientists. The first workshop was held in Eindhoven, the Netherlands in 1989. The idea of the workshop is threefold: 1) improvement of the commu-nication between scientists in different parts of the world; 2) exchange of knowledge and ideas; 3) pay a tribute to a well re-spected and special scientist. For this workshop Hirosuke Yama-moto accepted the invitation to be the guest of honour and to be the key lecturer. His lecture on almost instantaneous fixed-to-variable (AIFV) length codes was clear and inspiring. The other

25 presentations contained concepts of error correcting codes, time series analysis, prediction, cryptography and coding for memories. Kees Immink (IEEE 2017 medal of honour recipient)

Some of the participants on the Rhine valley hiking tour.

Music during the banquet by: f.l.t.r. Han Vinck, Frauke Koerdt-Wattjes and Stan Baggen.

gave a presentation on progress in constrained codes. Martin Vinck presented his results on image processing in the brain. A special session "Hardware-Aware Information Theory" was organized by Brian Kurkoski and Dirk Wübben and a special session on Powerline Communications was organized by Adel Ghazel and Han Vinck.

The mayor of Boppard, Dr. Walter Bersch, opened the AEW10 and he welcomed our guests from Japan. Boppard has a long tradition in the cooperation with Japan, especially the city of Ome. The workshop contained a banquet, excursion around the Rhinevalley and a wine tasting in the ancient Roman cellar of the Bellevue hotel.

Proceedings: https://www.uni-due.de/imperia/md/content/dc/aew10-proceedings.pdf

Report on the Munich Workshop on Coding and Applications 2017 (MWCA 2017)

Vladimir Sidorenko, Antonia Wachter-Zeh and Gerhard Kramer

Date and location: July 3, 2017, Institute for Communications Engineering, Technical University of Munich, Germany

Organizers: Antonia Wachter-Zeh and Vladimir Sidorenko

The "Munich Workshop on Coding and Applications 2017" (MWCA 2017) was held on July 3, 2017 at the Institute for Communications Engineering at the Technical University of Munich (TUM). Over 70 international scientists participated in an exciting and fruitful workshop.

This workshop continues a tradition started by Gerhard Kramer, Norbert Hanik, Gianluigi Liva, and Georg Boecherer, who have been organizing workshops at TUM for several years. MWCA 2017 was organized by the "Coding for Communications and Data Storage" (COD) group headed by Antonia Wachter-Zeh.

The technical program included 8 invited talks by leading researchers in coding theory and 20 posters presented by doctoral candidates, postdocs, and scientists from several academic and industrial institutions.

Invited talks:

Alexander Barg (University of Maryland, USA): "Construction of MDS Array Codes with Nearly Optimal Sub-Packetization"

Olgica Milenkovic (University of Illinois, USA): "Access-Balanced Distributed Storage Codes via MaxMin Sum Steiner Triple Systems"

Ilya Dumer (University of California Riverside, USA): "Arikan's Polarization: a Simplified Geometric Description"

Group photo of MWCA 2017.

Audience during an invited talk.

Coffee break with Bavarian music.

Eitan Yaakobi (Technion, Israel): "Mutually Uncorrelated Codes for DNA Storage"

Joachim Rosenthal (Unversity of Zurich, Switzerland): "Hiding Distinguishers in Code Based Cryptography"

Tuvi Etzion (Technion, Israel): "Thermal-Management Coding for High Performance Interconnects"

Grigory Kabatiansky (Skolkovo Institute of Science and Technology & IITP RAS, Russia): "Multimedia Fingerprinting Codes as Codes for Multiple-Access Channels"

Itzhak Tamo (Tel Aviv University, Israel): "Optimal Repair of RS codes: Achieving the Cut-Set Bound"

Posters:

Francisco M. de Assis (Federal University of Campina Grande (UFCG), Brazil)

Rawad Bitar (Illinois Institute of Technology, USA)

Elena Egorova (Skolkovo Institute of Science and Technology (Skoltech), Moscow, Russia)

Christian Franck, Ulrich Sorger, (University of Luxembourg)

Stanislav Kruglik, Alexey Frolov (Skolkovo Institute of Science and Technology & IITP RAS, Russia)

Ryan Gabrys (Spawar Systems Center, USA and UIUC, USA)

Onur Günlü (TUM, Germany)

Anoosheh Heidarzadeh (Texas A&M University, USA)

Thomas Jerkovits (DLR, Germany)

Serge Kas Hanna (Illinois Institute of Technology, USA)

Julien Lavauzelle (École polytechnique and INRIA Saclay, France)

Andreas Lenz (TUM, Germany)

Julia Lieb (University of Würzburg, Germany)

Alireza Sheikh, Alexandre Graell i Amat, Gianluigi Liva (DLR, Germany)

Wai Ho Mow (Hong Kong University of Science and Technology)

Sven Müelich, Michael Schelling (Ulm University, Germany)

Sven Puchinger (Ulm University, Germany)

Netanel Raviv (Ben-Gurion University & Technion, Israel)

Moustafa Ebada, Ahmed Elkelesh, Sebastian Cammerer and Stephan ten Brink (University of Stuttgart, Germany)

D. Napp, R. Pinto, and P. Vettori (University of Aveiro, Portugal)

The social program included coffee breaks accompanied by Bavarian folk music and lunch. In the evening, the attendees enjoyed the Beer garden at "Chinesischer Turm".

Deatails of the workshop including the Program, list of participants, and more photos are available at the web address:

https://www.lnt.ei.tum.de/events/munich-workshop-on-coding-and-applications-2017-mwca2017/

Report on the 2017 European School of Information Theory

Tobias Koch, Alfonso Martinez, Pablo M. Olmos, and Gonzalo Vazquez-Vilar

The 2017 edition of the European School of Information Theory (ESIT) was held at the headquarters of the Spanish Royal Academy of Engineering, the Marqués de Villafranca Palace, in Madrid, Spain on May 8–11 (http://www.itsoc.org/conferences/schools/european-school-2017). The school was attended by 65 researchers, including 49 students. The participants came from 15 different countries, with Spain, France, and the UK being the most represented ones.

The school featured four plenary lectures of three hours each, given by four experts in various fields of information theory:

- Daniel J. Costello Jr. (University of Notre Dame) on "Spatially coupled LDPC codes: From theory to practice"

- Marco Dalai (University of Brescia) on "Channel reliability: From ordinary to zero-error capacity"

- Aslan Tchamkerten (Telecom ParisTech) on "Fundamental limits of asynchronous communication"

- Ram Zamir (Tel Aviv University) on "Information-theoretic signal processing"

The school further featured poster presentations by the students and three mini-plenaries of thirty minutes each:

- Paul de Kerret (Eurecom) on "Degrees-of-freedom robust transmission for the *K*-user distributed broadcast channel"

- Josep Font-Segura (Universitat Pompeu Fabra) on "Asymptotics of the error probability in quasi-static channels"

- Enrico Paolini (University of Bologna) on "Coded random access: Using coding theory to build random access protocols"

The school provided a unique opportunity for students to learn, interact, and network in an informal environment. We would like to thank the lecturers for accepting our invitation and for providing such inspiring presentations. We further would like to thank Aníbal R. Figueiras Vidal for establishing the contact with the Spanish Royal Academy of Engineering and Gerhard Kramer for his helpful advice and guidance regarding the organization of this event. Last but not least, many thanks go to our local student helpers, Alejandro Lancho, Yanfang (Vivian) Liu, and Grace Villacrés, who helped with the local arrangements and who were largely responsible for the high spirits during this school.

We would like to express our gratitude to the IEEE Information Theory Society, to the Universidad Carlos III de Madrid, and to the Universitat Pompeu Fabra for their generous support, which allowed us to reduce the registration fee to a minimum.

Next year's European School of Information Theory will take place in Bertinoro, Italy. We are already looking forward to it!

IEEE Information Theory Society Board of Governors Meeting

Location: Catamaran Resort Hotel, San Diego, CA

Date: 12 February 2017

Time: The meeting convened at 1:05pm PST (GMT-7); the meeting adjourned 5:15pm PST.

Meeting Chair: Rüdiger Urbanke

Minutes taken by: Stark Draper

Meeting Attendees: Matthieu Bloch, Suhas Diggavi, Alex Dimakis, Stark Draper, Michelle Effros, Elza Erkip, Christina Fragouli, Andrea Goldsmith#, Stephen Hanly, Matt LaFleur#, Pierre Moulin, Prakash Narayan, Krishna Narayanan, Alon Orlitsky, Vincent Poor, Anand Sarwate#, Anna Scaglione#, Emina Soljanin, Daniela Tuninetti, Rüdiger Urbanke, Emanuele Viterbo, Michelle Wigger*, Greg Wornell*, Aylin Yener, Wei Yu. (Remote attendees denoted by *, nonvoting attendees by #.)

The IEEE Information Theory Society (ITSoc) President Rüdiger Urbanke called the meeting to order at 1:05pm. Two motions were approved by the ITSoc Board of Governors (BoG) by email voting since the October 2016 meeting:

1) The minutes of the October 2016 BoG meeting were approved.

2) A $20k USD request to support the 2017 North American School for Information Theory (NASIT'17) to be held at Georgia Tech was approved.

Rüdiger next reviewed the meeting agenda.

Motion: A motion was made to approve the agenda. The motion was seconded by Tara Javidi. The motion was passed unanimously.

1) **President's Report:** Rüdiger presented the President's report. Rüdiger started by thanking society members for their concluding (and beginning) service on and to the BoG. He first thanked Abbas El Gamal for his service as President and officer of the ITSoc. He then welcomed Emina into the presidential sequence. Rüdiger next welcomed incoming BoG members: Alexander Barg, Alex Dimakis, Christina Fragouli, Prakash Narayan, Tara Javidi, Michelle Wigger, Gregory Wornell. He thanked Aylin Yener for staying on as chair of the Schools Subcommittee for one additional year. He welcomed Helmut Bölcskei as the new chair of the Massey Committee. He also recognized Prakash Narayan as the new Editor-in-Chief (EiC) of the Transactions and Alexander Barg as the new Executive Editor of the Transactions. Rüdiger thanked retiring ("bogging-out") BoG members for their service: Abbas El Gamal, Tracey Ho, Frank Kschischang, Nick Laneman, Stephen ten Brink, Alexander Vardy, Emanuele Viterbo. He also thanked Frank Kschischang for his service as Transactions EiC and Nick Laneman for his service as head of the Massey Committee. He welcomed

Andrew Barron, who has been reelected, back to the BoG as a regular member.

Rüdiger next congratulated all members of the Information Theory society that were elevated to Fellow status in the class: Ravi Adve, Alexei Ashikhmin, Huaiyu Dai, Xinzhou Dong, James Fowler, Michael Gastpar, Stephen Hanly, Masahito Hayashi, Amir Khandani, Witold Krzymien, Teng-Joon Lim, and Xiajun Lin.

Rüdiger reported that a large number of society members that were recipients of significant honors this year. Andrea Goldsmith was elected to the U.S. National Academy of Engineering. Kannan Ramachandran received the IEEE Koji Kobayashi Computers and Communications Award. Vincent Poor received the IEEE Alexander Graham Bell Medal. Shlomo Shamai received the IEEE Richard W. Hamming Medal. Martin Vetterli received the IEEE Jack S. Kilby Signal Processing Medal. Stephen Boyd received the IEEE James H. Mulligan, Jr. Educational Medal. Kees Schouhamer Immink received the IEEE Medal of Honor, the top award bestowed by the IEEE. On a light note, Rüdiger congratulated Polar codes for their adoption into the 5G standards!

Three new Information Theory Society chapters were established this year: in India, in Italy, and in Switzerland.

Rüdiger then provided updates from the IEEE Technical Activities Board (TAB) meeting in New Orleans. New ad-hoc committees have been formed this year to further IEEE contributions in four multi-disciplinary areas and to bring IEEE technology and technical expertise to bear in each. The focus areas include "Food engineering", "Dig once" "IEEE at the North and South poles," and "Design for ethics". Rüdiger observed that ITSoc is less plugged into these IEEE-wide priorities than are a number of other societies. A second significant topic at the TAB meeting was a proposed motion to change the distribution of IEEE income to the societies. Currently 10% of IEEE income is distributed evenly across all societies (amounting to roughly $92k USD each). The balance of income is distributed according to performance metrics wherein click counts play a big role. The proposed motion was to change from the 10%/90% split to having 100% of the distributed be based on performance metrics. The motion was tabled (put aside for future discussion). Rüdiger noted that small societies, which includes ITSoc, benefit from the current 10%/90% formula.

Rüdiger next outlined the ITSoc priorities for 2017. The first priority is to finish the Shannon movie, the second concerns membership, the third is branching out technically and in terms of education. In the second two are included (i) the possibility of a new publication (journal or magazine), (ii) a new series of talks, (iii) the development and distribution of short educational videos, and (iv) a children's book on information theory. The target is to have serious discussions of these priorities in the June BoG meeting at ISIT, with votes to follow at

the October BoG meeting. Rüdiger noted that, in addition to the initiatives mentioned above, there is $100k USD left to fund new initiatives. Little of that $100k is spoken for, so new ideas and proposals would be welcome.

Regarding topics of discussion, Rüdiger noted three. First is the possibility of a new journal. Second concerns the previously observed fact that the impact factor and click rate of the Transactions on Information Theory (the "Transactions") have slowly been decreasing. We should understand why this is happening, what it means, and whether it can be reversed. One possibility may be because many ITSoc members post to the ArXiv and often use the ArXiv posting for citation purposes, even after the final version of a paper has appeared in the Transactions. Rüdiger hoped that by June we would understand the factors and would have a proposal on what steps to take. The final topic of discussion concerns the presidential model used by the ITSoc. Unlike most societies in the IEEE, the ITSoc president serves for only one year. This means that by the time an individual president has learned what is going on in the IEEE, and who the players are, their term has ended. This makes ITSoc, in some ways, one of the least plugged-in of the IEEE societies. A good fraction of other societies have a two-year presidential term. This isn't really compatible with the ITSoc "shift-register" model, but it does raise the question of how ITSoc can have a greater impact on the IEEE. One possibility, followed by some societies is to bring multiple BoG members, e.g., both the president and vice-president, to IEEE meetings to develop and advocate for a longer-term vision. That might perhaps be the easiest thing to do. Rüdiger noted that while each society can bring multiple representatives to meetings, each society does have only a single vote on the TAB, regardless of society size.

2) **Treasurer's Report:** Daniela Tuninetti presented the treasurer's report. While the 2016 ITSoc budget targeted a surplus go $61k USD, as of November 2016 (the most recent numbers we have from the IEEE) the budget is in the negative by about $28k USD. That said, $100k USD was spent on new initiatives in 2016 which means that, operationally, ITSoc is "in the black". Final number for 2016 will be received from the IEEE in March 2017.

Regarding the 2017 budget we requested $140k USD from our reserves (under the "3% rule") for new initiatives. IEEE approved $105k USD. Generally these resources are intended to continue the broad outreach of the 2016 Shannon Centennial. Specific allocations need to be determined, proposals are welcomed. Overall, in 2017 ITSoc expenses are projected to be higher than income by $94k USD. However, once the $105k USD of reserve spending is accounted for, ITSoc will still be "in the black", operationally, which is important so as not to be "black-listed" by the IEEE. There is also the "50% rule" through which ITSoc can spend 50% of the previous year's surplus on new initiatives. The amount of funds available through this mechanism will become clear when IEEE reports the final numbers for 2016.

Daniela then reviewed the current membership and publication offerings. Any possible changes in membership dues or subscription rates need to be proposed by mid-April 2017. While dues and subscription rates have not increased for a long time (other than to receive print copies of the Transactions), overall dues and subscriptions amount to 3–4% of ITSoc revenue, and Daniela proposed to keep everything as is. There was a discussion about the cost of student membership, currently about $15 USD per year. This is in line with related societies such as the Communications and Signal Processing Societies.

3) **Nominations and Appointment Committees:** Michelle Effros first reviewed the membership of the various 2017 ITSoc Committees, announcing new members and reminding committee chairs of the few positions that remain open and need to be filled. Michelle then reviewed the Bylaws and Constitution Committee. The role of this committee is to identify aspects of the Constitution and Bylaws that need clarification and/or revision, or are out of synch with the IEEE. Proposed changes will be presented for discussion at the ISIT BoG meeting. Finalized proposals need to be distributed a few weeks prior to the formal vote, which is scheduled for the fall BoG meeting. Michelle mentioned two items the BoG will hear about at ISIT. The first has to do with language on diversity (technical/regional/under-represented groups) and ensuring broad representation. The second has to do with the recent change in the length of eligibility for the ITSoc Paper Award. In particular, the window of paper eligibility was extended last year from three years to four, but some parts of the Bylaws were not updated to reflect this change. In general, Michelle asked all committee chairs and members to keep an eye out for needed changes and to send proposed changes to Michelle.

Michelle than introduced a motion to allow Emanuele Viterbo to finish his term as Conference Committee Chair. The Bylaws (Article III, Section 2) dictate that no member of the BoG can serve continuously for more than six years unless in the presidential chain. There was a discussion of how, when ex-officio BoG membership was extended to the Conference Committee Chair because of the importance of the position, this possible conflict with the bylaw had not been anticipated.

> **Motion**: "To allow Emanuele Viterbo to finish his term as Chair of the Conference Committee, and hence voting member of the BoG, despite Article III, Section 2." The motion was seconded by Vince Poor. All votes were in favor with one abstention.

4) **Shannon Documentary:** Rüdiger next introduce Mark Levinson, director of the Shannon Documentary, who joined the BoG meeting by conference call. Mark talked the BoG through a key aspect of the documentary, an imaginary interview with Shannon at the Shannon family house in Winchester Massachusetts. This was a five-day shoot that took place in the few weeks just prior to the BoG meeting. Many of the props for the shoot were lent by the MIT museum and by Andrew Shannon. John Hutton played Shannon and wowed the crew and the Shannon family with his resemblance to Claude Shannon both physically and in his manner. Peggy Shannon commented that she really felt like she was watching her father being interviewed. This mock interview will serve as the core of the film, taking up about half of the run length. The team has also conducted about a dozen interviews and is now in editing mode. A full-time editor is working on assembling the film.

There was a discussion of time-lines. The shoot took place on-time with no overtime. Most filming is now complete. While there are some small scenes left to be shot, e.g., a flash-back of a young Shannon, there is no dialog in these scenes and so they will be much less work. The final piece is graphics and animation. Mark is working with a pair of designers on this. Mark would love to have most of the film together by the fall. If things run smoothly that's possible. Initial pieces should start coming together in the next month.

5) **Conference Committee:** Emanuele Viterbo started by thanking retiring members of the Conference Committee: Jeff Andrews, Stephen Hanly, and Alon Orlitsky. Emanuele then reviewed the current composition of the committee.

> **Motion:** "The Conference Committee Chair requests the approval of Alfonso Martinez as a new member of the Conference Committee." The motion passed with one abstention.

Following the motion there was a discussion about making the appointments in the future to increase geographic diversity. It was commented that it would also be useful to recruit members of recent ISIT organizing committees.

Emanuele then reviewed recent and upcoming ITSoc conferences. ISIT Barcelona is still closing and currently estimates a surplus of 34K Euros. Budgets for ISIT 2017, 2018, and 2019 were approved by email in the fall. There was nothing to discuss regarding ISIT 2020 or 2021. Regarding ITWs, ITW 2016 Cambridge U.K. is closing with a 6% anticipated surplus, ITW 2017 Kaohsiung Taiwan is on track. There are two proposals to consider: for 2018 in Guangzhou, China, and for 2018 or 2019 in Northern Italy, the venue of the latter is yet to be decided.

Krishna Narayanan presented the proposal for ITW 2018 in Guangzhou on behalf of the organizers. The proposed date is the last week of November, one week prior to the Turbo Coding Symposium scheduled to be held nearby in Hong Kong. The Chinese arm of the ITSoc was founded in 1962, has had yearly national conferences since (other than a break in the 1980s), and has about 200 members. ITW 2018 would take place near Sun Yat-sen University, would be four days in length with two parallel sessions and one keynote per day. There will be 130 papers, and roughly 160 attendees are expected with 50 from mainland China. The BoG reviewed the budget, drew comparison to other ITWs, and provided feedback.

> **Motion:** "The conference committee recommends to approve the proposal for ITW 2018 in Guangzhou." The motion was approved unanimously.

Emanuele next presented a proposal to hold an ITW in northern Italy in early September 2018. Three venues have been considered: Venice (registration of 650 Euro), Como (registration 580-500 Euros), and Milan (registration of 580–600 Euros); pros and cons of each were presented. The BoG provided feedback on the proposal, leaving the choice of the location to the organizers based on their further budget analyses.

There was a discussion about how developments in US border entry rules might impact attendance at ITSoc conferences, both inside and outside of the United States, and our professional society.

Emanuele then discussed a number of candidate conferences for technical co-sponsorship (TCS): Systems, Communications and Coding (SCC 2017), to be held February 6–9, 2017 in Hamburg, Germany; the Int. Symp. on Inf. Theory and its Applications (ISITA 2018), to be held October 28-31, 2018 in Singapore; and the Annual Conf. on lnf. Sciences and Systems (CISS 2018), to be held March 21–23, 2018 in Princeton, N.J. After discussion the following motion was made.

> **Motion:** "The conference committee recommends BoG approval of the technical co-sponsorship for SSC 2017, ISITA 2018, and CISS 2017." The motion was approved.

Emanuele proposed a change in the approval process for technical cosponsorship. The general idea is for the BoG to delegate to the Conference Committee the power to approve continuing technical co-sponsorship of conferences, with only periodic review by the BoG.

> **Motion**: "The conference committee proposes to:
>
> • Request BoG vote only for new conferences seeking TCS or when there is not agreement within the Conference committee.
>
> • In all other cases where the conferences have obtained TCS from the Society in the previous editions (at least two previous editions), the TCS can be approved directly by the Conference committee after verifying the conference has maintained its scope.
>
> • In the latter case, conferences will be brought to the BoG for approval at least every five (5) years."

The motion passed.

6) **Schools Subcommittee:** Aylin Yener next initiated discussed on the schools of information theory. Matthieu Bloch first updated the BoG on the 2017 North American School of Information Theory (NASIT), to be held at Georgia Tech in June. Next, the proposal for the 2018 European School of Information Theory (ESIT) was presented on behalf of the organizers by Alexandre Graell i Amat. The proposal is to hold the school at a fortress in Bertinoro, Italy. He reviewed the facility, and services, noting that all attendees can be hosted at the site. The school would run in early May 2018. There is no overlap with major ITSoc or CommSoc conferences. He reviewed the plenary lecturers.

> **Motion:** "To support 2018 ESIT in Italy in the amount of $20000 USD." The motion passed unanimously.

7) **Publications:** Editor-in-Chief (EiC) Prakash Narayan first thanked Frank Kschischang for his work as Editor-in-Chief (EiC) of the Transactions. Prakash then welcomed Sasha Barg on board as Executive Editor (EE) of the Transactions. Prakash reviewed the change in the editorial board of the Transactions

with each EE serving for 18 months, and then serving as EiC for another 18 months. Prakash served as EE in 2017. Frank Kschischang stepped down as EiC on 31 December 2016, Prakash started his term as EiC, and Sasha as EE, on 1 January 2017.

Every five years there is a review of each IEEE Transaction by the IEEE Technical Activities Board (TAB) Periodicals Review and Advisory Committee (PRAC). The objectives are to ensure timeliness and quality, compliance with IEEE policies, and financial health. This is also an opportunity to get suggestions for improvements and advice on best practices. The report to PRAC was submitted on 9 January, the review occurred on 9 February, there will be another round between PRAC and the EiC before the report is archived by the TAB.

An Ad-Hoc Group for the self-examination of the Transactions will be initiated. Members of the group will include the EiC, the EE, the executive editorial board, and the two previous EiCs. The goals of the review are to assess (i) how to attract papers of relevance to a broader community, and (ii) how to increase the impact factor and the number of clicks on IEEEXplore. The group wants to have formulated recommendations by mid-April 2017.

Prakash thanked the retiring Associate Editors (AEs): Salman Avestimehr, Stephan ten Brink, Jun Chen, Sae-Young Chung, Sidharth Jaggi, Tie Liu, Chandra Nair, Haim Permuter, S. Sandeep Pradhan, and Osvaldo Simeone. He next reviewed the current editorial board, which consists of about 48 AEs. Prakash's aim is to boost the number of AEs to about 60, and next introduced a slate of candidate AEs.

> **Motion**: "The BoG is requested to consider a motion to approve the following appointments to the Editorial Board of the IEEE Transactions on Information Theory (see report for the list)." The motion passed unanimously.

Prakash told the BoG that he needs additional AEs in machine learning and in sparse signal processing. This was reflected in the slate of candidates presented. There was a discussion on the distribution of papers by topic. The slate is driven in part by the current per-AE load. There was a discussion of how the BoG can help the EiC put together a good list of candidates — make suggestions.

8) **Shannon Centenary Outreach:** First, Christina Fragouli reviewed outreach efforts conducted as part of the Shannon Centenary. There were somewhere between 35-40 events worldwide. Christina thanked the many ITSoc members who volunteered their time to make these events possible, the Shannon Centennial Committee members who helped supervise and advise these events, and ITSoc Coordinator Matt LaFleur for all his efforts behind the scene. As a Society, support provided included photos, slides, links to videos and articles, a logo, information sheets, and banners. Significant publicity was associated with the Centennial. This included a Google Shannon juggling doodle, articles in paper and online magazines, a stamp in Macedonia, and many event websites. About $108k USD in total was awarded to assist with these events and to develop the materials for the Centennial.

Next, Matthieu Bloch discussed the pilot videos project. The topics of the first two videos are space-time coding and network coding. These videos have been developed for a target audience of 10th graders and up. The challenge is to explain concepts simply and concisely without using jargon. The first video available on YouTube at https://www.youtube.com/watch?v=ZpcT7QhXbVs. The second will be ready soon. Matthieu summed up the principles that were learned in the process: identify seminal papers, extract their essence, identity a rough story, and develop an outline. Then iterate to develop a narrative voice-over and animations. He summed up the main challenge as being to forget one's expert knowledge and rather to focus on formulating simple analogies. The cost to the Society was $15k USD per video.

Finally, Anna Scalione presented the children's book. Concepts the book discusses include what is information, what is error correction, and what is network coding. She shared one chapter with the BoG. The current status is that the designer who helped with the Google doodle will put the remaining chapters into the same format as the chapter shared with the BoG. An open question remains about how to distribute the book, whether through a regular publishing house or through some other channel. Anna confirmed that the budget allocated is sufficient to complete the design of the remaining chapters.

9) **Diversity and Inclusion in ITSoc, the IEEE, and in Engineering more widely:** Andrea Goldsmith presented to the BoG on diversity and inclusion in our society, professional organization, and field more widely. She is now chairing the just-created IEEE TAB Committee on Diversity and Inclusion. Andrea first talked about whether things are better now than in the 1980s or 1990s. Currently women make up 12% of the undergraduates in EE, 17% in CS, and 19% in engineering generally. In fact, peak enrollment for women in CS occurred in 1984, at 36%, and has been dropping since. In graduate programs 20% of master's degrees in EE are awarded to women and 14% of PhDs. In term of faculty appointments, 16% of professors in EE and CS are women, with the percentages being below 10% at Stanford and other top engineering schools. Industry isn't doing much better, only 13% of the engineering workforce is female, and more than 50% of these women leave careers in technology. Those departing report that it is not the work/life balance that is causing them to seek other careers, but rather that the climate is bad, and deteriorates with seniority due to challenges in climbing the corporate ladder. Fewer than 3% of patent holds are women and only 8% of Bay Area series-A startups had women founders last year. These numbers are low, they are not improving, and they are below critical mass to ignite change. The outlook is even bleaker for under-represented minorities (URMs). This lack of diversity hurts both individuals and organizations. Women and URMs entering the work force are missing out on the possibilities of great careers, and our field is missing out on half the talent pool. Studies show that diverse organizations are more creative, perform better, and deliver higher job satisfaction. Start-ups that are led by women have great track records.

Andrea then provided some statistics to help figure out how the IEEE is doing and to underline why fostering diversity is

important to the IEEE. (The IEEE only tracks statistics for women members, and not for URMs or other under-represented groups, so the following data only concerns women members.) First off were membership statistics. While 12% of IEEE members are female, much of that stems from student members: 30% of IEEE undergraduate members are women while among graduate student members only 8.8% are women (below the female percentage of graduate students), regular member 8.7%, senior members 7.8%, and among IEEE fellows 4.4% are women. This decline can be interpreted to mean that the IEEE is not providing the same benefit to its female members (and URMs) as to other members. Regarding IEEE awards, the percentage of female winners (and nominees) are in the low single-digits. Indeed, 21 out of 29 mid-career awards have never had a female recipient. Even more tellingly, in 2011–15, 4–6% of the mid-career award nominees and 1–7% of the medal award nominees were women. In 2015 two-thirds of IEEE mid-career awards did not receive a single nomination of a female candidate. In terms of publications and conferences, there is a lack of female editors-in-chief and women are under-represented on editorial boards and in conference organization (as general chairs, TPC chairs, TPC members). Within ITSoc Andrea described the history of female representation, noting that 2004 was a turning point when many initiatives were seeded. Committees were formed such as the Outreach Subcommittee (in 2008) and WiTHITS (in 2009). Three female ITSoc presidents have served since 2004 with two more in the pipeline. Although until 2009 no women had been elevated to IEEE fellows through ITSoC, several have been elevated through the Society in the last few years. In addition, Katalin Marton won the Shannon Award, women have been awardees of the joint ITSoc-CommSoc paper twice, and women are now represented on the awards committee.

After setting this picture, Andrea discussed effective strategies to "move the needle". In fact, the IEEE recognizes it has a problem. Jose Moura (chair of TAB board) asked Andrea to co-chair an ad-hoc committee on Women and Under-represented Groups (WUG) in 2016. The Committee delivered its final report in November 2016, the top recommendation of which was to form the just-approved standing committee mentioned above (the IEEE TAB Commitee on Diversity and Inclusion), with sufficient resources and power to implement its recommendations. Other recommendations include: (ii) require data collection and track metrics on female and URMs by all societies and IEEE activities, set targets, and track progress; (iii) build a repository for society best practices on diversity/inclusion, and incorporate questions about these activities into societal reviews, (iv) training for IEEE/society/committee leadership and staff addressing diversity, inclusion, and best practices, include implicit bias training; (v) create a briefing on implicit bias to raise awareness within the IEEE and beyond beyond, similar to Royal Society document on this topic (https://royalsociety.org/topics-policy/publications/2015/unconscious-bias/) or the one the IEEE Awards Board now sends to all its awards committee chairs , (vi) make the "face" of the IEEE and its marketing more inclusive, (vii) create IEEE-wide initiatives for URMs, (viii) support the creation of a climate survey for all IEEE members. Looking forward the IEEE can be a role model for the profession, a profession currently struggling to attract and retain diverse members.

In conclusion Andrea stated that individuals can have a big impact and encouraged all present to think what they can do to help. She stated that, in particular, "we need the guys" to advocate for recognition and representation of women, as they comprise the critical mass needed for change.

10) **New Publications:** Elza Erkip presented an update on the initiatives surrounding new publications. She first reviewed the two ideas in hand. The first is an IT Magazine to replace the Newsletter, to provide a venue for tutorial/vision articles, to be archival, and to increase visibility of IT. The second is a special topics journal. Each issue would be on a focused topic, led by a team of guest editors, would increase exposure for emerging topics in IT, would have a short sub-to-pub time, and would relieve pressure on the Transactions. The next steps are to form an ad-hoc committee chaired by Jeff Andrews and Elza to study feasibility, the financial impact, and to develop a plan with the aim of providing a committee report at the ISIT BoG meeting with voting to follow at the Chicago meeting.

11) **Adjournment:** The meeting adjourned at 5:15pm PST.

News from the ITSOC Online Committee

Anand D. Sarwate, Online Editor, ITSOC Online Committee

Society members may have noticed that in the last few months emails have been going out containing the table of contents (TOC) for the most recent issue of the Transactions. Our tireless Editor-in-Chief, Prakash Narayan, sends the Online Committee the TOC from IEEE in the month before the issue appears. The email contains links to the papers on IEEExplore for easy browsing and downloads. We are still working out some issues with the program that generates the email: correctly resolving accents in author names and extracting full author information from what IEEE sends can be challenging. Any feedback and suggestions can be directed to the Online Editor (oe@itsoc.org) as we continue to make improvements.

Outreach Through IT Society Chapters

Mine Alsan and Emina Soljanin

The IEEE Society Chapters are uniquely well positioned to support outreach efforts of their respective societies. This brief series of announcements aim to bring to your attention some of the latest news and information regarding Chapters affiliated to our Society.

- *"Instructions for adding chapters to the new image map."*

  The IT Society has more than 20 active IEEE (joint) Chapters. Geographically speaking, while Asia, Europe, and North-America is represented by several chapters, unfortunately the remaining continents are under-represented. Nevertheless, Brazil and South-Africa have the only two currently active IT Society Chapters in North-America and Africa, respectively. For the current period, Officers from the—Benelux, Brazil, Hamilton, Hong Kong, India, Italy, Finland, Germany, Madras, Montreal, New York-North Jersey, Philadelphia, Seoul, Spain, Sweden, Tokyo/Japan, Vancouver—(joint) IT Society Chapters reported the organization of several technical seminars, talks by Distinguished Lecturers, special sessions dedicated to the celebration of Shannon Centennial events in 2016, IT Schools and Summer Schools for students, Conferences and Workshops with special emphasis on Wireless Communications and 5G, Internet of Things and Smart Objects, Information Theoretic Security, Quantum Computation and Communication, and more.

  You can now check your nearest local IT Chapter by navigating through the Chapters Map feature recently brought to you by the IT Society Online Committee lead by Anand D. Sarwate. If you spot an IT Society Chapter in your local neighborhood, feel free to contact the Chapter Officers to get more information about their programs and activities. If your neighborhood does not feature an IT Society Chapter, then why not consider starting one or joining forces with an IEEE Chapter of sister societies (such as Communications, Signal Processing, Vehicular Technology, Computer Science, etc.) to represent the IT arm of the joint chapter? More information in forming a Chapter and the map view of the Chapters is available here.

  http://www.itsoc.org/people/chapters

- *"Congratulations! Formation of the IEEE Mars Section IT Society Chapter."*

  Not quite yet, but the IT Society is proud to announce the formation of two new Chapters in Europe this year: Italy and Switzerland Sections. The Italy IT Society Chapter has made a quick start and was involved in the organization of the Fano Memorial held during ISIT 2017. The Switzerland Section IT Society joint Chapter was formed under the well-established IEEE Switzerland Chapter on Digital Communication which has been active for more than 30 years: it organizes the International Zurich Seminar on Information and Communication.

- *"The purpose of the Chapter of the Year Award is to recognize annually a chapter that has provided their membership with the best overall set of programs and activities."*

  The Award went this year to the Sweden IT Society joint Chapter. The news was announced during the Chapters Lunch event held during ISIT 2017 in Aachen. Sweden won the award with the organization of 16 technical seminars and multiple workshops in the area of wireless communications. The runner-up chapter was the New York-North Jersey IT Society joint Chapter which organized 21 events in 2016. Past recipients of the Award are listed here.

  http://www.itsoc.org/people/honors/chapter-of-the-year-award

- *"Who would have thought watermelon could be so nicely cooked to be served as entrée?"*

  Thanks to the generous funding made available by the IT Society, the traditional Chapters Lunch event welcomed this year, in addition to chapter Chairs and representatives, several Distinguished Lecturers and serving members of the Society in the hope to facilitate exchanges in the future.

WITHITS 2017: Activities and Updates

Lalitha Sankar and Natasha Devroye

The Women in Information Theory Society (WITHITS) has been organizing events at multiple venues since ISIT 2016 when its current co-chairs Natasha Devroye and Lalitha Sankar introduced a new interactive format entitled *The Samoan Circle Event* as a means to discuss many relevant topics to the community. The success of the event set the stage for three events since culminating in a *Speed-Networking Event* at ISIT 2017. We briefly describe these events below.

The first of the three events was a student-focused event held at the 2016 Allerton Conference to discuss the role of gender in student-adviser relationships as well as discuss the pros and cons of academia and industry for graduating female students. The second event, held at the 2017 Information Theory and Applications Workshop in San Diego, focused on recent efforts made at the institutional level (IEEE). Prof. Andrea Goldsmith of Stanford University discussed at length the newly approved standing committee on diversity and inclusion by the IEEE Technical Activities Board (TAB). This recommendation came out of the ad hoc committee that she chaired on women and URMs in 2016, and is an important step to ensuring recognition and representation of women in the IEEE and its Societies through awards, honors, and leadership opportunities. Andrea discussed the process and the consequences at length; such was the interest in this discussion that what was initially intended for 15 minutes led to an hour long discussion!

WITHITS events.

The last event was the Burning Questions Speed-Networking Event hosted at the 2017 ISIT in Aachen. Our goal here was to enable interactions between senior and junior members (irrespective of gender, as with all our previous events) in a one-to-one setting on topics that included finding research collaborators, work-family balance, finding jobs, and finding mentors. The experienced members were wonderful in giving their time and feedback to many curious researchers eager to have their questions answered. Enforcing speed fell to one of us and couldn't have been achieved in a room with at least 30 loquacious participants without the sharp crisp tones obtained from bringing a piece of silverware in touch with German glass water bottles! As is to be expected from a community of tenacious information theorists, it was evident to all present that maximizing the information exchange under time constraints appeared to be driving the attendees who were eager to have their questions answered. Finally, we are extremely grateful to Giulia Fanti for her enthusiastic help both before and at the event given one of us (Natasha) couldn't be present.

Overall, as has now become the norm, the past several WITHITS events have been very well received by the community; in fact, while no official numbers have been collected, attendance at these three events consistently exceeded expectations with upwards of forty plus participants attending all three events described here. We wish to thank all the participants for their willingness to spare an hour to meet, interact, and address important and timely questions that are relevant to a sizeable number of researchers.

Stay tuned for the next WITHITS event at the 2017 Allerton Conference.

Activities of the Outreach Subcommittee

The charge of the outreach subcommittee is to foster the professional development of the IT Society members, especially underrepresented members, by providing mentoring opportunities and organizing events at conferences that sponsored or co-sponsored by the IT Society. The committee focuses in particular on the needs of young professionals such as postdocs or tenure-track faculty, as there is a separate subcommittee charged with serving the needs of students. However, everyone is welcome at committee-organized events. The committee coordinates its events with the student subcommittee and WITHITS. In particular, the committee recently co-organized a panel discussion centered around Hamming's "You and Your Research" talk at the Information Theory and Applications (ITA) Workshop in San Diego with the student subcommittee.

At previous ISITs the outreach subcommittee organized panel discussions about various aspects of professional development, such as how to manage the tenure process, how to find a job in industry or academia, and why it is useful to study IT. The subcommittee also highlighted the biggest professional mistakes of some of our distinguished society members, including the ones of our current society president, in a panel discussion at ISIT 2015 in Hong Kong.

Recently, the subcommittee focused its attention on optimizing the society's mentoring program. In the program's current incarnation, the subcommittee chairs assign a mentor to each interested mentees at the latter's request. While this bilateral arrangement works extremely well in some cases, in many cases little or no mentoring actually occurs. The subcommittee recently conducted an online survey, which found that only 15% of the participants in the mentoring program felt that the program was working well and over 60% recommended that the program be changed in some way.

After some deliberation, the subcommittee decided to focus its energies more on creating time and space for mentoring to occur rather than assigning mentors to mentees and relying on them to handle the logistics of mentoring. This decision was partly founded on the recognition that society members can be quite busy and might like help in arranging mentoring activities. But it was also founded on the insight that successful young professionals generally synthesize advice from several people rather than relying on a single mentor. The subcommittee therefore decided to work towards helping younger members of the society develop a mentoring network.

At both ISIT 2016 and ISIT 2017, the subcommittee organized a large mentoring event with simultaneous round-table discussions in which two designated "mentors" lead a discussion and share their expertise. This setup allows the attendees to either stay at one of the tables for a deep dive or to move from table to table to discuss different facets of their career.

For example, for ISIT 2017 in Aachen, Germany, the event had the following lineup of round tables and table leaders:

ISIT 2017 mentoring event (photo by Bobak Nazer)

- Navigating the academic job market (Hessam Mahdavifar and Jing Yang)
- Industry or academia? (Urs Niesen and Mohammad Ali Maddah-Ali)
- Navigating the tenure and promotion process (Michèle Wigger and Osvaldo Simeone)
- The postdoc experience (Yanina Shkel and Lele Wang)
- Life after tenure (Roy Yates and Aylin Yener)
- Funding your research (Salman Avestimehr and Deniz Gunduz)
- Effective teaching techniques (Henry Pfister and Stark Draper)
- Branching into allied fields (Anand Sarwate and Kannan Ramchandran)
- Effective paper writing (Sennur Ulukus and Vincent Y. F. Tan)
- Writing your book (Raymond Yeung and Ruediger Urbanke)
- Creating your mentoring network (The Outreach Subcommittee)

This list of topics at ISIT 2016 was similar. The subcommittee plans to repeat this at forthcoming ISITs so that society members can rely on receiving guidance on these topics in the future. The subcommittee hopes that over time the round table attendees will form a loose mentoring network on the specific topics they are interested in. In the future, the subcommittee will also provide similar discussion groups on the team-based discussion platform Slack which will support the group mentoring approach.

The IEEE Information Theory Society Outreach Subcommittee:

Joerg Kliewer, co-chair
Aaron Wagner, co-chair
Tara Javidi
Bobak Nazer
Vincent Y. F. Tan

Recent Publications

IEEE Transactions on Information Theory

Table of content for volumes 63(6), 63(7), 63(8)

Vol. 63(6): Jun. 2017.

Vol. 63(7): Jul. 2017.

Foundations and Trends® in Networking

Volume 11, Issue 3–4
Duality of the Max-Plus and Min-Plus Network Calculus
Jörg Liebeherr

Volume 11, Issue 1–2
Opportunistic Routing in Wireless Networks
Tara Javidi and Eric Van Buhler

Foundations and Trends® in Communications and Information Theory

Volume 13, Issue 4
Redundancy of Lossless Data Compression for Known Sources by Analytic Methods
Michael Drmota and Wojciech Szpankowski

Foundations and Trends® in Theoretical Computer Science

Volume 12, Issue 3–4
Hashing, Load Balancing and Multiple Choice
Udi Wieder (VMware Research, USA)

Problems of Information Transmission

Volume 53, Issue 2, April 2017

Entropy of a stationary process and entropy of a shift transformation in its sample space
B. M. Gurevich
Pages 103–113

Generalized error-locating codes with component codes over the same alphabet
I. V. Zhilin, V. V. Zyablov
Pages 114–135

MDS codes in Doob graphs
E. A. Bespalov, D. S. Krotov
Pages 136–154

Fast discrete Fourier transform on local fields of positive characteristic
S. F. Lukomskii, A. M. Vodolazov
Pages 155–163

Spaceability for sets of bandlimited input functions and stable linear time-invariant systems with finite time blowup behavior
H. Boche, U. J. Mönich
Pages 164–182

Fast protocols for leader election and spanning tree construction in a distributed network
M. N. Vyalyi, I. M. Khuziev
Pages 183–201

The 10th International Workshop on Coding and Cryptography
WCC 2017
Saint-Petersburg, Russia, September 18–22, 2017

`http://wcc2017.suai.ru/`

ANNOUNCEMENT AND CALL FOR PAPERS

Organizing committee:
- Pierre Loidreau (**co-chair**, DGA, U. Rennes 1, France)
- Evgeny Krouk (**co-chair**, SUAI, Russia)
- Veronika Prokhorova (SUAI, Russia)
- Evgeny Bakin (SUAI, Russia)

Local organization:
- Oksana Novikova
- Maria Shelest

Invited Speakers:
- Alexander Barg (U. Maryland, USA)
- Claude Carlet (U. Paris 8 and Paris 13, France)
- Camilla Hollanti (Aalto U., Finland)
- Grigory Kabatiansky (Skoltech and IITP RAS, Moscow, Russia)
- Patric Östergård (Aalto U., Finland)

This is the tenth in the series of biannual workshops Coding and Cryptography. It is organized by INRIA, SUAI and Skoltech and will be held in the main building of SUAI (http://suai.ru/), Saint-Petersburg, Russia.

Conference Themes. Our aim is to bring together researchers in all aspects of coding theory, cryptography and related areas, theoretical or applied.

Topics include, but are not limited to:
- coding theory: error-correcting codes, decoding algorithms, related combinatorial problems;
- algorithmic aspects of cryptology: symmetric cryptology, public-key cryptography, cryptanalysis;
- discrete mathematics and algorithmic tools related to these two areas, such as: Boolean functions, sequences, finite fields, related algebraic systems.

Submissions. Those wishing to contribute a talk are invited to submit a 6-10 page extended abstract, before April 6, 2017 (23:59 Greenwich). The submission server is now open, information on the submission process is available at http://wcc2017.suai.ru/submission.html.

Full papers. After the conference, authors of accepted abstracts will be invited to submit a full paper for the proceedings to appear as a special issue of the journal "Designs Codes and Cryptography". Contributions will be thoroughly refereed.

Important dates (for extended abstracts)**:**
- **Submission by April 6, 2017**
- **Notification by May 24, 2017**
- **Final version by June 26, 2017**

Program committee:
- Daniel Augot (**co-chair**, INRIA, France)
- Delphine Boucher (U. Rennes 1, France)
- Lilya Budaghyan (U. Bergen, Norway)
- Eimear Byrne (UC Dublin, Ireland)
- Pascale Charpin (INRIA, France)
- Alain Couvreur (INRIA, France)
- Ilia Dumer (UC Riverside, USA)
- Tuvi Etzion (CSD Technion, Israel)
- Markus Grassl (MPL Erlangen, Germany)
- Tor Helleseth (U. Bergen, Norway)
- Thomas Honold (U. Zhejiang, China)
- Thomas Johansson (Lund U., Sweden)
- Gohar Khyureghan (U. Magdeburg, Germany)
- Ivan Landjev (NBU Sofia, Bulgaria)
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- Ryutaroh Matsumoto (Tokyo Tech., Japan)
- Gary McGuire (UC Dublin, Ireland)
- Sihem Mesnager (U. Paris 8 and Paris 13, France)
- Marine Minier (INSA-Lyon, France)
- Kaisa Nyberg (AU Helsinki, Finland)
- Ayoub Otmani (U. Rouen-Normandie, France)
- Ferruh Ozbudak (METU Ankara, Turkey)
- Kevin Phelps (AU Auburn, USA)
- Alexander Pott (U. Magdeburg, Germany)
- Josep Rifa (UA Barcelona, Spain)
- Palash Sarkar (ISI Kolkata, India)
- Natalia Shekhunova (SUAI St.Petersburg, Russia)
- Vladimir Sidorenko (TU Munich, Germany)
- Faina I. Solov'eva (**co-chair**, IM Sobolev, Russia)
- Jean-Pierre Tillich (INRIA, France)
- Alev Topuzoğlu (Sabanci U. Istanbul, Turkey)
- Peter Trifonov (PU St.Petersburg, Russia)
- Michail Tsfasman (CNRS and IITP RAS, Marseille, France)
- Serge Vladuts (Aix-Marseille U. and IITP RAS, France)
- Arne Winterhof (Austrian Acad. of Sc., Linz)
- Gilles Zémor (U. Bordeaux, France)
- Victor Zinoviev (IITP RAS, Moscow, Russia)
- Victor Zyablov (IITP RAS, Moscow, Russia)

55th Allerton Conference

Call for Papers: Due July 10, 2017

Manuscripts can be submitted during June 16-July 10, 2017 with the submission deadline of July 10th being firm. Please follow the instructions at allerton.csl.illinois.edu.

CONFERENCE CO-CHAIRS: **Naira Hovakimyan & Negar Kiyavash**

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 and uploaded as final manuscripts 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.

IMPORTANT DATES - 2017

JULY 10 — Submission Deadline

AUGUST 7 — Acceptance Date *Authors will be notified of acceptance via e-mail by August 7, 2017, at which time they will also be sent detailed instructions for the preparation of their papers for the Conference Proceedings.*

AFTER AUGUST 7 — Registration Opens

OCTOBER 3-6 — Conference Dates

OCTOBER 3 — Opening Tutorial Lectures
Coordinated Science Lab, University of Illinois at Urbana-Champaign

OCTOBER 4-6 — Conference Sessions (Plenary Lecture October 6)
University of Illinois Allerton Park & Retreat Center: The Allerton House is located twenty-six miles southwest of the Urbana-Champaign campus of the University of Illinois 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.

OCTOBER 8 — Final Paper Deadline *Final versions of papers that are presented at the conference must be submitted electronically in order to appear in the Conference Proceedings and IEEE Xplore.*

All speaker information will be added when confirmed.

PAPERS PRESENTING ORIGINAL RESEARCH ARE SOLICITED IN THE AREAS OF:

· Biological information systems
· Coding techniques & applications
· Coding theory
· Data storage
· Information theory
· Multiuser detection & estimation
· Network information theory
· Sensor networks in communications
· Wireless communication systems
· Intrusion/anomaly detection & diagnosis
· Network coding
· Network games & algorithms
· Performance analysis
· Pricing & congestion control
· Reliability, security & trust
· Decentralized control systems
· Robust & nonlinear control
· Adaptive control & automation
· Robotics
· Distributed & large-scale systems
· Complex networked systems
· Optimization
· Dynamic games
· Machine learning & learning theory
· Signal models & representations
· Signal acquisition, coding, & retrieval
· Detection & estimation
· Learning & inference
· Statistical signal processing
· Sensor networks
· Data analytics

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ALLERTON CONFERENCE

NSF Workshop on Low-Latency Wireless Random-Access

November 2-3, 2017

Dates:
Nov 2-3, 2017

Location:
MIT/LIDS
Grier Room 34-401
50 Vassar Street
Cambridge, MA, USA

Contact:
iot2017-info@mit.edu

This workshop brings together experts from industry and academia to discuss the challenges and solutions for the problem of multiple-access in wireless communication and Internet-of-Things.

Current radio-access networks (RANs) are designed with the aim of maximizing data-stream throughput for a few active users. The next generation RANs will need to service massive numbers of infrequently communicating sensors (machine-type communication, MTC, or Internet-of-Things). Most present systems employ centralized resource allocation, orthogonalizing the access but incurring large control-layer overhead. Presently, there is a strong demand for a new solution in both the unlicensed spectrum [low-power wide-area networks (LP-WANs)] and the licensed spectrum (5G). This workshop is dedicated to exploring the state-of-the-art in research on this topic.

Registration deadline: September 15, 2017
Register at http://iot2017.mit.edu

PROGRAM COMMITTEE: Yury Polyanskiy (MIT) & Sergio Verdú (Princeton)

CONFIRMED SPEAKERS:

Giuseppe Caire, Technical University of Berlin
Mérouane Debbah, Huawei
Dariush Divsalar, NASA Jet Propulsion Laboratory
Giuseppe Durisi, Chalmers University of Technology
Uri Erez, Tel-Aviv University
Meir Feder, Tel-Aviv University
Christophe Fourtet, SigFox
Alexey Frolov, SkolTech
Albert Guillén i Fàbregas, Universitat Pompeu Fabra
Dongning Guo, Northwestern University
Dave Kjendal, Senet Co.
Tobias Koch, Universidad Carlos III de Madrid

Victoria Kostina, CalTech
Junyi Li, Qualcomm
Gianluigi Liva, German Aerospace Center
Krishna Narayanan, Texas A&M University
Or Ordentlich, Hebrew University
Yury Polyanskiy, MIT
H. Vincent Poor, Princeton University
Petar Popovski Aalborg University
Slawomir Stanczak, Fraunhofer HHI
Vincent Tan, National University of Singapore
Gonzalo Vazquez Vilar, Universidad Carlos III de Madrid
Wei Yu, University of Toronto
Peiying Zhu, Huawei

Hosted by the Laboratory for Information and Decision Systems (LIDS)

Center for Science of Information
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2017 IEEE Information Theory Workshop

Kaohsiung Exhibition Center, Kaohsiung, Taiwan / **November 6–10, 2017**

http://www.itw2017.org

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National Chiao-Tung University
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The 2017 IEEE Information Theory Workshop will take place in Kaohsiung, Taiwan, from November 6 to 10, 2017. Based at the southern tip of the island and facing the Taiwan Strait, Kaohsiung is the second largest city in Taiwan and is one of the major seaports in Asia. Love-River cruises, night markets, delicious seafood, and day tours out into nature or to historic Tainan are some of the many attractions awaiting you in Southern Taiwan. Situated directly by the waterfront, the Kaohsiung Exhibition Center (KEC) serves as workshop venue. It is a brand-new and multi-functional facility, designed by an international, pro-environment team of architects and built in the shape reminding of a billowing sail. The workshop participants will have an unforgettable experience visiting and enjoying some of the most dazzling attractions in Kaohsiung.

Call for Papers

Interested authors are encouraged to submit previously unpublished contributions in all areas of information theory with special emphasis on the following :

- **Information Theory for Content Distribution**
  – Distributed data storage
  – Peer-to-peer network coded broadcasting
  – Coded caching for wireless and wireline transmissions
  – Delay-constrained communications

- **Information Theory and Biology**
  – Information theory and intercellular communications
  – Information theory and neuroscience
  – Information-theoretical analysis of biologically-inspired
    communication systems

- **Information Theory and Quantum Communications**
  – Quantum information
  – Quantum computation
  – Quantum cryptography

- **Information Theory and Coding for Memories**
  – New coding techniques for non-volatile memory channels
  – Coding and signal processing for dense memory
  – Multi-dimensional coding for storage channels

Paper Submission

Paper submission guidelines will be posted on the workshop's website : **http://www.itw2017.org**

Poster

The technical program will feature a poster session. Details about poster submissions will be announced on the workshop's website by late July, 2017.

Important Dates

Paper submission deadline : **May 7, 2017**
Acceptance notification : **July 21, 2017**

Call For Papers

General Chairs
Warren Gross
McGill Univ.

Kostas Plataniotis
Univ. of Toronto

Technical Program Chairs
Z. Jane Wang
Univ. of British Columbia

Costas Kotropoulos
Univ. of Thessaloniki

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Tsinghua Univ., China

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Simon Fraser University

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André Morin
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Chair**
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Univ. of British Columbia

IEEE GlobalSIP ◆ IEEE

**5th IEEE Global Conference on Signal
and Information Processing**
November 14–16, 2017, Montreal, Canada

IEEE Signal Processing Society

http://2017.ieeeglobalsip.org/

Call for Papers

The 5th IEEE Global Conference on Signal and Information Processing (GlobalSIP) will be held in Montreal, Quebec, Canada on November 14-16, 2017. GlobalSIP, as a new flagship IEEE Signal Processing Society conference, focuses on signal and information processing with an emphasis on up-and-coming signal processing themes. The conference features world-class plenary speeches, distinguished Symposium talks, tutorials, exhibits, oral and poster sessions, and panels. GlobalSIP is comprised of co-located General Symposium and symposia selected based on responses to the call-for-symposia proposals. Featured symposia include:

- General symposium
- Sparse SP and deep learning
- Graph signal processing
- Distributed optimization and resource management over networks
- Control & information theoretic approaches to privacy and security
- SP for interference cancellation and full-duplex communication systems
- SP for Accelerating Deep Learning
- SP for Smart Cities & IoTs
- SP & ML in large medical datasets

- Big Data Analytics for IoT Healthcare
- Advanced Bio-SP for Rehabilitation and Assistive Systems
- Deep Learning for Intelligent Multimedia
- Knowledge-based Multimedia Computing
- Stochastic & approximate computing for signal processing and machine learning
- Signal and information processing (SIP) for smart grid infrastructure
- SIP for Healthcare Engineering
- SIP for Finance and Business

Prospective authors are invited to submit full-length papers (up to 4 pages for technical content, an optional 5th page containing only references) and extended abstracts (up to 2 pages, for paper-less industry presentations and Ongoing Work presentations). Manuscripts should be original and written in accordance with the standard IEEE 2-column paper template. Accepted full-length papers will be indexed on IEEE Xplore. Accepted abstracts will not be indexed in IEEE Xplore, however the abstracts and/or the presentations will be included in the IEEE SPS SigPort. Accepted papers and abstracts will be scheduled in lecture and poster sessions.

Conference Highlights

- Plenary Talks within the general symposium and Distinguished Symposium Presentations/Talks within the 16 thematic symposia surveying emerging topics in SIP
- Panel discussions on funding opportunities, trends and targeted topics
- Enhanced industry program: paperless industry presentations, panels, demos and exhibitions
- Exciting student program: Ongoing Work tracks, Student-Industry Luncheon, 3MT competition
- Great venue with vibrant cultural, educational, and scientific identity, combining the modern buzz of a North American city and a specific European charm

Important Dates:
- May 15, 2017 : Paper submission due
- June 30, 2017 : Final acceptance decisions notifications sent to all authors
- July 22, 2017 : Camera-ready papers due

Call for Papers

2018 International Zurich Seminar on

Information and Communication

February 21 – 23, 2018

The 2018 International Zurich Seminar on Information and Communication will be held at the Hotel Zürichberg in Zurich, Switzerland, from Wednesday, February 21, through Friday, February 23, 2018. High-quality original contributions of both applied and theoretical nature are solicited in the areas of:

Wireless Communication	Optical Communication
Information Theory	Fundamental Hardware Issues
Coding Theory and its Applications	Network Algorithms and Protocols
Detection and Estimation	Network Information Theory and Coding
Data Storage	Cryptography and Data Security

Invited speakers will account for roughly half the talks. In order to afford the opportunity to learn from and communicate with leading experts in areas beyond one's own specialty, no parallel sessions are anticipated. All papers should be presented with a wide audience in mind.

Papers will be reviewed on the basis of a manuscript (A4, not exceeding 5 pages) of sufficient detail to permit reasonable evaluation. Authors of accepted papers will be asked to produce a manuscript not exceeding 5 pages in A4 double column format that will be published in the Proceedings. Authors will be allowed twenty minutes for presentation.

The deadline for submission is **September 17, 2017**.

Additional information will be posted at

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http://www.izs.ethz.ch/
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We look forward to seeing you at IZS.

Amos Lapidoth and Stefan M. Moser, Co-Chairs.

Princeton University ✧ Department of Electrical Engineering

PRINCETON
March 21-23, 2018

52nd Annual Conference on Information Sciences and Systems

Call for Papers
52nd Annual Conference on Information Sciences and Systems
March 21, 22, & 23, 2018

Princeton University - Department of Electrical Engineering
and Technical Co-sponsorship with the
IEEE Information Theory Society

Authors are invited to submit previously unpublished papers describing theoretical advances, applications, and ideas in the fields of information sciences and systems including:

·Information Theory	·Coding Theory	·Image Processing
·Communications	·Signal Processing	·Machine Learning
·Statistical Inference	·Security and Privacy	·Energy Systems
·Networking	·Systems and Control	·Biological Systems

Electronic submissions of up to 6 pages (in Adobe PDF format) including 3-4 keywords must be submitted by **December 11, 2017**. Submissions should be of sufficient detail and length to permit careful reviewing. Authors will be notified of acceptance no later than **January 17, 2018**. Final manuscripts of accepted papers are to be submitted in PDF format no later than **January 31, 2018**. These are firm deadlines that will permit the distribution of Electronic Proceedings at the Conference. Accepted Papers will be allotted 20 minutes for presentation, and will be reproduced in full (up to 6 pages) in the conference proceedings. IEEE reserves the right to exclude a paper from post-conference distribution (e.g., removal from IEEE Xplore) if the paper is not presented by the author 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. H. Vincent Poor** **Prof. Sergio Verdú** Dept. of Electrical Engineering Princeton University Princeton, NJ 08544	**Paper submission deadline:** December 11, 2017 **Notification of acceptance:** January 17, 2018 **Final accepted manuscript due:** January 31, 2018

Conference Calendar

DATE	CONFERENCE	LOCATION	WEB PAGE	DUE DATE
September 18–22, 2017	**The Tenth International Workshop on Coding and Cryptography 2017**	Saint-Petersburg, Russia	http://wcc2017.suai.ru/	Passed
October 3–6, 2017	**55th Annual Allerton Conference on Communication, Control, and Computing**	University of Illinois at Urbana-Champaign	http://allerton.csl.illinois/.edu	Passed
October 9–11, 2017	**2017 IEEE CNS 4th Workshop on Physical-Layer Methods for Wireless Security**	Las Vegas, NV, USA	http://cns2017.ieee-cns.org/workshop/4th-workshop-physical-layer-methods-wireless-security-plmws	Passed
October 15–17, 2017	**58th Annual IEEE Symposium on Foundations of Computer Science (FOCS 2017)**	Berkeley, California, USA	http://focs17.simons.berkeley.edu/	Passed
November 2–3, 2017	**NSF Workshop on Low-Latency Wireless Random-Access**	Laboratory for Information and Decision Systems (LIDS), MIT, USA	https://iot2017.mit.edu/	Passed
November 6–10, 2017	**IEEE Information Theory Workshop**	Kaohsiung, Taiwan	http://www.itw2017.org/	Passed
November 14–16, 2017	**5th IEEE Global Conference on Signal and Information Processing (GlobalSIP)**	Montreal, Quebec, Canada	https://2017.ieeeglobalsip.org/Default.asp	Passed
December 4–8, 2017	**IEEE GLOBECOM**	Singapore	http://globecom2017.ieee-globecom.org/	Passed
February 21–23, 2018	**2018 International Zurich Seminar on Information and Communication**	Zurich, Switzerland	http://www.izs.ethz.ch/	September 17, 2017
March 21–23, 2018	**52nd Annual Conference on Information Sciences and Systems (CISS)**	Princeton University, USA	http://ee-ciss.princeton.edu/	December 11, 2018

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