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President's Column

Alon Orlitsky

2016 is a landmark year for our society. On April 30th, a fleeting two months from now, we will celebrate the 100th birthday anniversary of a visionary engineer and mathematician who changed the way we store, communicate, analyze, and most importantly, think about information—the father of information theory, Claude Shannon.

Most fields of study emerge after extended periods from the melding of diverse ideas and complementary thoughts of numerous contributors. Yet information theory was born in a bang. It is the brainchild of a single mind that foresaw the impending information age and envisioned a theory so broad that it covered many of the ensuing information technologies, yet so coherent that it stood out for its simplicity, elegance, and beauty.

In the seven decades since Shannon introduced his groundbreaking ideas, information theorists have profoundly deepened our understanding of the theory and extended its reach to a wide range of topics and disciplines. Even more importantly, they turned theoretical insights into technological paradigms, and transformed abstract theorems into efficient algorithms that power every computer and communication device manufactured today.

But we've only just begun. Be it quantum-, cloud-, or neural-computing; bio-engineering, -statistics, or -informatics; and data-storage, -analytics, or -science; new information technologies spring up at an ever accelerating pace. Each presents a new set of challenges and calls for solutions grounded by and built upon information-theoretic foundations. A fundamental, comprehensive, and actionable theory of information is even more essential and critical today than it ever was before.

It is against this formidable backdrop that I humbly assume our society's presidency. Being part of such a distinguished group of researchers and engineers, I know that the real work will be done by you. My modest hope for my brief year at the helm is to help our community members reach their full potential, and I will try to do so in three very information-theoretic ways: **increase communication from, to, and within our community.** Specifically, I would like to enhance the ways we inform others of our great research, help us find exciting new topics to work on, and facilitate collaborations on information-related research.

Over the next three "columns", I will elaborate on our plans in these three domains. Parts of the plan are still "in formation", so if you are willing to help, with ideas or deeds, please do write me at alon@ucsd.edu. Meanwhile, let me start with some of our outreach initiatives and events for the Shannon Centennial year.

Centennials: Throughout the year we will facilitate worldwide "Shannon Days", outreach events introducing general audiences to Shannon and information theory. We have created educational materials that can be easily used at Shannon days and have set aside funds to help support them. If you may be willing to organize such an event, please visit http://inform.epfl.ch/index.php?form=Shannon.

Birthday: We are working with Google on commemorating Shannon's 100th birthday. We are not at liberty to disclose specific details, but suffice it to say we are hoping for an "April Surprise".

Documentary: We are in the process of producing an hour-long documentary celebrating Shannon's legacy and the achievements of information theory. Filming started in January with interviews of some of Shannon's family and old-time colleagues and friends. We hope to finish the documentary within a year and will update you on the progress of this exciting project.

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From the Editor

Michael Langberg

Dear colleagues,

In the first issue of 2016 we open with Alon Orlitsky's first column as the IT society president. Please join me in warmly welcoming Alon and in wishing him and our community a fruitful and prosperous year.

In this issue you will find a collection of articles including technical contributions, reflections, reports, and announcements. We start with the intriguing article "Community detection and the stochastic block model" by Emmanuel Abbe that surveys recent progress in the field of community detection (i.e., clustering) from an information theoretic perspective. The article summarizes (parts of) the tutorial on Information Theory and Machine Learning given by Emmanuel and Martin Wainwright at ISIT 2015 in Hong Kong. We then turn to the enlightening thoughts of Aaron B. Wagner on the pros and cons of various teaching methodologies for Information Theory in the exposition "Teaching Source Coding and Teaching Channel Coding". I greatly thank the authors for their significant efforts in preparing these excellent contributions.

We continue with several exciting announcements of recent award winners from our community. These awards are among the most prestigious awards of the IEEE, AAES, and NAE. The IEEE Richard W. Hamming Medal: Abbas El Gamal; the IEEE Medal of Honor: G. David Forney; the IEEE Eric E. Sumner Award: Shuo-Yen Robert Li, Raymond W. Yeung, and Ning Cai; the IEEE Alexander Graham Bell Medal: Roberto Padovani; the AAES John Fritz Medal: H. Vincent Poor; the IEEE Jack S. Kilby Signal Processing Medal: Louis L. Scharf; the NAE Charles Stark Draper Prize for Engineering: Andrew J. Viterbi; a Bell Labs Prize: Georg Böcherer, Patrick Schulte, and Fabian Steiner; and a list of recent elevations of Information Society members to the grade of IEEE fellow. Congratulations to all! As a community, we are all honored.

The issue continues with an annual recognition of the IT Transactions Editor in Chief in our new column "Moments" which captures the day to day life in our society (please consider sharing such moments with me to appear in future newsletter issues). This is followed by Tony Ephremides's Historian's column; Sol Golomb's Puzzle column; the "Students' Corner" column with the thoughts of Caltech student Parham Noorzad in his article "A Challenge for Beginning Researchers" on the dilemmas students face in their first steps in theoretical research; the column "From the field" in which Balasubramanian Paramasivan describes the exciting inauguration of the Information Theory Society Madras Chapter at the National Engineering College, Kovilpatti, Tamilnadu, India; a

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Community Detection and the Stochastic Block Model

*Emmanuel Abbe**

Abstract

This note surveys some of the recent developments on community detection and the stochastic block model. It describes the fundamental limits of community detection for various recovery requirements, the connections with information theory, and some of the algorithms that emerged in the quest of the thresholds. A few open problems are also discussed. Part of this material was covered in our ISIT 2015 Tutorial with M. Wainwright on Information Theory and Machine Learning.

1 Introduction

The basic task of community detection (or clustering) consists in partitioning the vertices of a graph into clusters that are more densely connected. More generally, community structures may also refer to groups of vertices that connect similarly to the rest of the graphs without having necessarily a higher inner density. In particular, diassortative communities refer to clusters that have higher external connectivity, in contrast to assortative communities. In addition, community detection may be performed on graphs where edges have labels, intensities, or hyper-edges, and communities may not always be well separated, due to overlaps. In the most general context, community detection refers to the problem of inferring similarity relationships among the items of a network by observing their local interactions.

Community detection is one of the central problems in network and data sciences. Virtually any data sets can be represented as a network of interacting items, and one of the first features of interest in such networks is to understand which items are "alike," i.e., communities. Solving this task reliably can provide major insight on understanding sociological behavior [25, 42], protein to protein interactions [16, 34], gene expressions [17, 29], recommendation systems [33, 43], medical prognosis [46], DNA folding [15], image segmentation [44] and the list goes on.

While the field of community detection (CD) has been expanding greatly since the 80's, with impressive developments at the algorithmic and applied level, a major part of it has remained for long more an art than a science. In particular, understanding which structures can be extracted, or which are artefacts of algorithms, or how accurate a given clustering may be, are far from being resolved.

The stochastic block model (SBM) has been used widely as a canonical model to study these questions. The SBM is arguably the simplest model of a graph with communities

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(see definitions in the next section), but like the discrete memoryless channel in coding theory, it provides already strong insights. In addition, the SBM has recently turned into more than a model for community detection. It provides generally a fertile ground for studying various central questions in machine learning, computer science and statistics: It is rich in phase transitions [20, 35, 41, 2, 5], allowing to study the interplay between statistical and computational barriers [48, 6], as well as the discrepancies between probabilstic and adversarial models [37], it serves as an ideal test bed for algorithms, such as SDPs [2, 8, 26, 7, 38], spectral methods [47, 35, 13, 49], belief propagation [31, 6], and it creates new synergies between statistical physics, discrete probability and information theory.

In the next section, we define the SBM and various recovery requirements that are studied for community detection, namely weak, partial and exact recovery. We then provide in Section 3 recent results that have established the fundamental limits for these recovery requirements. We further discuss in Section 4 the connections between information theory and community detection, and give a list of open problems in Section 5.

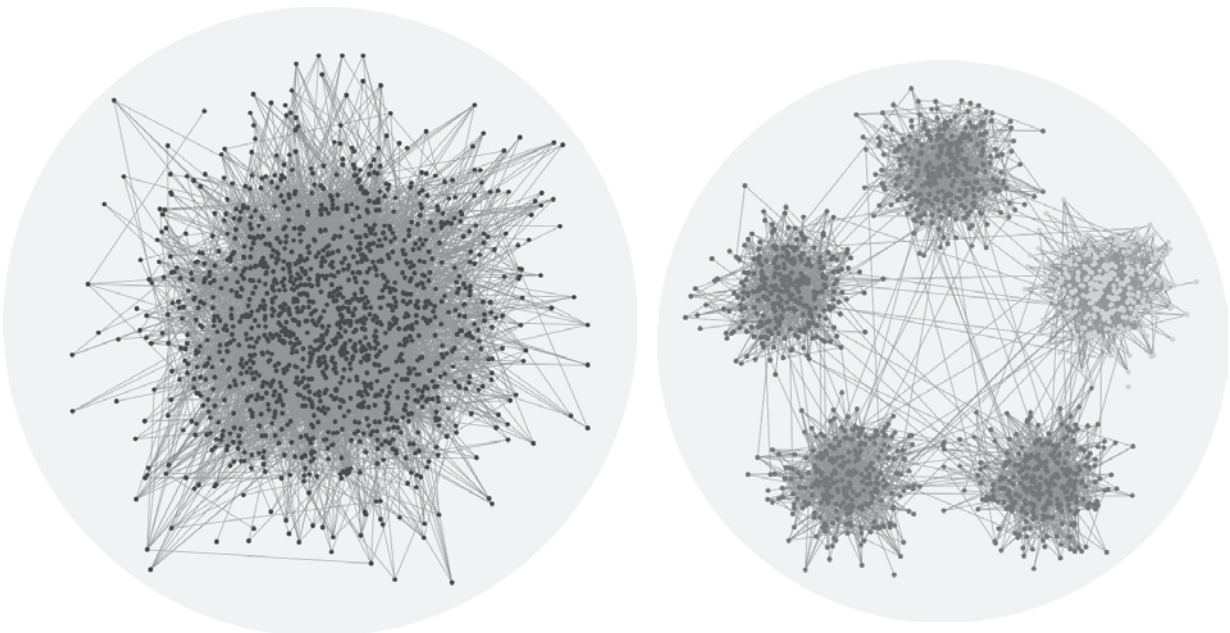


Figure 1: The above two graphs are the same graph re-organized and drawn from the SBM model with 1000 vertices, 5 balanced communities, within-cluster probability of 1/50 and across-cluster probability of 1/1000. The goal of community detection is to obtain the right graph (with the true communities) from the left graph (scrambled) up to some level of accuracy.

2 The stochastic block model

The stochastic block model (SBM) is widely employed as a canonical model for community detection. The history of the SBM is long, and we omit a comprehensive treatment here.

Interestingly, the model appeared independently in multiple scientific communities: the terminology SBM, which seems to have dominated in the recent years, comes from the machine learning and statistics literature [28], while the model is typically called the planted partition model in theoretical computer science [14, 22, 12], and the inhomogeneous random graphs model in the mathematics literature [11].

Definition 1. *Let n be a positive integer (the number of vertices), $p = (p_1, \dots, p_k)$ be a probability vector on $[k] := \{1, \dots, k\}$ (the relative sizes of the communities) and W be a $k \times k$ symmetric matrix with positive entries (the connectivity probabilities). The pair (X, G) is drawn under $\mathrm{SBM}(n, p, W)$, if X is an n-dimensional random vector with components valued in $[k]$ in proportions p (this means that X is either drawn uniformly at random with $\frac{1}{n}|\{v \in [n] : X_v = i\}| = p_i + o(1)$, or with i.i.d. components under p), and G is an n-vertex undirected graph where vertices i and j are connected with probability W_{X_i, X_j}, independently of other pairs of vertices.*

The goal of community detection is to recover the labels X by observing G, up to some level of accuracy.

Definition 2. *(i) The agreement between two community vectors $x, \hat{x} \in [k]^n$ is obtained by minimizing the Hamming distance between x and any relabelling of $\hat{x}$, i.e., any transformation of the components of $\hat{x}$ with a fixed permutation of $[k]$.*
(ii) An algorithm detects communities with accuracy $\alpha \in [0, 1]$, if it takes G drawn from $\mathrm{SBM}(n, p, W)$ and outputs a reconstruction $\hat{X}$ of X that has agreement α with probability $1 - o_n(1)$.

Note that the relabelling in first item above is needed to handle symmetric communities (see below), as it is impossible to recover the actual labels in this case, in contrast to the *partition* which is the object of interest. We now define specific recovery requirements.

Definition 3. *(i) Exact recovery is solvable in $\mathrm{SBM}(n, p, W)$ if there exists an algorithms with accuracy $\alpha = 1$. (ii) Strong recovery is solvable in $\mathrm{SBM}(n, p, W)$ if there exists an algorithms with accuracy $\alpha = 1 - o_n(1)$. (iii) Weak recovery (or detection) is solvable in $\mathrm{SBM}(n, u, V)$, where u is the uniform distribution on $[k]$ and V has constant value in and outside the diagonal, if there exists an algorithms with accuracy $\alpha = 1/k + \varepsilon$ for some $\varepsilon > 0$.*

In other words, exact recovery requires perfect reconstruction of the communities, strong recovery requires almost perfect reconstruction, and weak recovery requires to improve on what a random guess would provide (i.e., $1/k + o(1)$). The most general problem is to understand which accuracy $\alpha \in (0, 1)$ can be achieved in terms of the parameters p and W.

3 Results

3.1 Strong and exact recovery

Exact recovery for linear size communities has long been studied for the SBM [14, 22, 12, 45, 19, 36, 10, 47, 48], but it is only in the recent years that the fundamental limits were obtained [2, 40, 5]. Note that exact recovery requires the node degrees to be at least logarithmic; to see this, note that in the symmetric SBM with disconnected clusters, exact recovery

amounts to ask for connectivity in the Erdős-Rényi model, which has a phase transition in the logarithmic degree regime [23]. Interestingly, exact recovery has also a phase transition that extends the connectivity one, and is governed by an f-divergence reminiscent of Shannon's coding theorem:

Theorem 1. *[5] Exact recovery is solvable in* $\mathrm{SBM}(n, p, \log(n)Q/n)$ *if and only if*

$$J(p,Q) := \min_{1\le i<j\le k} D_+((\mathrm{diag}(p)Q)_i \| (\mathrm{diag}(p)Q)_j) \ge 1$$

where D_+ *is defined by*

$$D_+(\mu\|\nu) = \max_{t\in[0,1]} \sum_x \nu(x) f_t(\mu(x)/\nu(x)), \quad f_t(y) = 1 - t + ty - y^t, \tag{1}$$

Further, the threshold is efficiently achievable.

Theorem 1 gives an operational meaning to a new f-divergence, D_+, which we call the CH-divergenge in [5] as it generalizes both the Chernoff and Hellinger (or Rényi) divergences. The fundamental limit for data clustering in SBMs is hence governed by the CH-divergence, similarly to the fundamental limit for data transmission in DMCs governed by the KL-divergence. If the columns of $\mathrm{diag}(p)Q$ are "different" enough, where difference is measured in D_+, then one can separate the communities. This is analog to the channel coding theorem, showing that when the output's distributions are different enough in KL-divergence, the codewords can be separated.

To prove the converse, namely, that exact recovery is information-theoretically impossible if $J(p,Q) < 1$, we show that Maximum A-Posteriori (MAP) decoding fails if there exist $i \neq j$ such that $D_+((\mathrm{diag}(p)Q)_i \| (\mathrm{diag}(p)Q)_j) < 1$. This is shown using the following reduction to a *genie-aided community detection problem.* Assume that a genie reveals all the vertices' labels except for a single vertex $v \in [n]$. Then classifying v requires solving an hypothesis test between the k hypotheses corresponding to the k communities, based on the connections that v has with each of the k communities. Here our key result is that, if d_v denotes the vector whose i-th component gives the number of neighbors that v has in community i, d_v is a approximately a multi-variate Poisson random vector with mean $(\mathrm{diag}(p)Q)_{X_v}$ and covariance $\mathrm{diag}((\mathrm{diag}(p)Q)_{X_v})$, and MAP decoding fails with probability roughly given by

$$n^{-\min_{i<j} D_+((\mathrm{diag}(p)Q)_i \| (\mathrm{diag}(p)Q)_j)}. \tag{2}$$

While this is vanishing, it does so too slowly if $D_+((\mathrm{diag}(p)Q)_i \| (\mathrm{diag}(p)Q)_j) < 1$ to prevent that at least one of the $\Theta(n)$ vertices in communities i or j gets misclassified with such a genie-aided test, and thus the non-genie-aided MAP decoder also fails in that case.

To prove that $J(p,Q) > 1$ is an achievable region (and efficiently achievable), we use an efficient algorithm based on a two-round procedure. We start with a "graph-splitting", i.e., we split our original graph into two subgraphs (complement to each other, but essentially independent due to the sparsity of the original graph). On the first graph, whose average degree is taken to be diverging by sub-logarithmic, we run an algorithm that obtains strong recovery. We refer to the next section for the type of algorithms that allows to achieve this. This shows in particular that strong recovery is achievable efficiently as long as the

average degrees of the vertices are diverging, i.e., $W = \omega(1)Q/n$. Then we enhance this preliminary clustering by using the left over graph, "cleaning up" the strong clustering into an exact clustering with local improvements based on the hypothesis test described above. If $D_+((\mathrm{diag}(p)Q)_i \| (\mathrm{diag}(p)Q)_j) > 1$ for all $i < j$, the vertices that were misclassified in part 1 can be re-classified correctly with high probability, even though our genie gives now only an approximate clustering. Further, if the algorithm for part 1 is efficient, the whole algorithm is efficient since the local improvement part is only linear in n. Our algorithm 'degree-profiling' has in fact an overall complexity of $O(n^{1+\varepsilon})$, for any $\varepsilon > 0$.

3.2 Weak recovery

Weak recovery was introduced in [18, 20]. Note that weak recovery is investigated in SBMs where vertices have constant expected degree, as otherwise the problem can easily be solved by exploiting the degree variations. The following conjecture was established first in [20] from deep but non-rigorous statistical physics arguments, and is responsible in part for the resurged interest in the fundamental study of the SBM:

Conjecture 1. *[20, 39] Denote by* $\mathrm{SBM}(n, k, a, b)$ *the symmetric sparse SBM, i.e., the model* $\mathrm{SBM}(n, p, W)$ *where* p *is uniform on* $[k]$ *and* $W_{i,j}$ *is* a/n *if* $i = j$ *and* b/n *otherwise. Define* $\mathrm{SNR} = \frac{(a-b)^2}{k(a+(k-1)b)}$*, then*

(i) irrespective of k*, if* $\mathrm{SNR} > 1$ *(the Kesten-Stigum threshold), it is possible to detect communities in polynomial time;*

(ii) if $k \geq 5$*, it is possible to detect communities information-theoretically for some* SNR *strictly below 1.*

We have recently proved this conjecture in [3]. For the case of $k = 2$, it was already proved in [35, 41] that the KS threshold can be achieved efficiently. However, for $k = 2$, no information-computation gap takes place as shown with a tight converse in [39].

The terminology 'KS threshold' comes from the reconstruction problem on trees. A transmitter broadcasts a uniform bit to some relays, which themselves forward the received bits to other relays, etc. The number of relays (or offspring) at each generation may be a constant c, or Poisson distributed of mean c. Each relay is assumed to transmit with an independent BSC of parameter ε. The receiver gets to see all the bits at the leaves. For what values of c and ε could the receiver reconstruct the original bit when the tree depth diverges? The unorthodox part is that we are interested in recovering the bit weakly, i.e., with probability away from $1/2$, and not tending to 1 as usual in information theory. This problem was first solved in [30] for binary symmetric channels and constant offspring, showing that weak recovery is possible if and only if $c > 1/(1-2\varepsilon)^2$, i.e., the KS threshold. It was later solved for the Poisson case in [24]. This implies a converse for weak recovery in the 2-community SBM [39], using a genie-aided argument and the fact that a node's neighborhood in the sparse SBM is tree-like (in particular $c = (a+b)/2$, $\varepsilon = b/(a+b)$, and the KS threshold reads $(a-b)^2 > 2(a+b)$).

Note that the KS threshold raises an interesting challenge for community detection algorithms, as standard clustering methods fail to detect communities down the KS threshold. This includes spectral methods based on the adjacency matrix or Laplacians [18, 31] or

SDPs [38]. For standard spectral methods, a first issue is that the fluctuations in the node degrees produce high-degree nodes that disrupt the eigenvectors from concentrating on the clusters. One possibility is to trim such high-degree nodes, throwing away some information, but this does not suffice to get the KS threshold.

The first efficient algorithms that managed to achieve the KS threshold for $k = 2$ were based on counting self-avoiding walks (entry (i, j) counts the number of self-avoiding walks of moderate size between vertices i and j) [35], and weighted non-backtracking walks between vertices [41]:

Theorem 2. *For $k = 2$,*

1. *[35, 41] Weak recovery is solvable efficiently if* SNR > 1 *(i.e., KS threshold is efficiently achievable for $k = 2$);*

2. *[39] Weak recovery is information-theoretically not solvable if* SNR ≤ 1.

It was also shown in [13] that for SBMs with multiple but slightly asymmetrical communities, the KS threshold can be achieved using a spectral method with the matrix of non-backtracking walks between directed edges (each edge is replaced with two directed edges and entry (e, f) is one if and only if edge e follows edge f) [13]. However, [13] does not resolve Conjecture 1 for $k \geq 3$.

We proved Conjecture 1 for arbitrary k using a message passing algorithm:

Theorem 3. *[3] Conjecture 1 holds for all $k \geq 2$. In particular*

1. *Weak recovery is solvable in $O(n \log n)$ if* SNR > 1 *with Acyclic Belief Propagation (ABP), a belief propagation algorithm that is linearized and exploits cycles;*

2. *Weak recovery is information-theoretically solvable for some* SNR *strictly below* 1 *if $k \geq 5$ with Typicality Sampling, a non-efficient algorithm that samples uniformly at random a clustering having the typical proportion of edges inside and across clusters.*

The fact that BP with a random initialization could achieve the KS threshold for arbitrary k was believed to take place [20], but handling random initialization and cycles stood has a challenge. Interestingly, our ABP algorithm is also closely related to the non-backtracking operator from [31], but it improves on the complexity of spectral methods due to the message-passing implementation.

The information-theoretic (IT) bound is characterized in [3] at the extremal regimes of a and b. For $a = 0$, it is shown that weak recovery is information-theoretically solvable if $b > ck \ln k + o_k(1)$, $c \in [1, 2]$. Thus the information-computation gap — defined as the gap between the KS threshold and the IT bound — is large since the KS threshold reads $b > k(k - 1)$. The behaviour of the IT bound is also characterized for b close to 0. Similar though weaker results were also recently posted in [9]. Note also that the information-computation gap concerns the gap between the KS threshold and what is achieved information-theoretically, which is the gap between the information-theoretic and computational thresholds only under non-formal evidences [20]. Showing formally that no algorithms can succeed below the KS threshold would naturally require novel techniques and major progress on deep complexity theory questions.

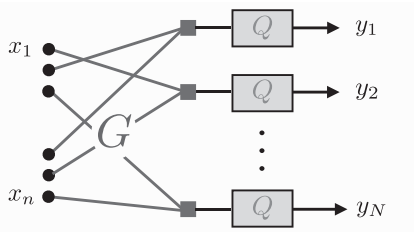
4 Information theory and community detection

Community detection has natural connections with information theory at various levels. Exact recovery is closely related to the decoding of graph-based codes on memoryless channels, and to f-divergences. Weak recovery relates naturally to the broadcasting problem on trees. In the next section, we also mention how partial recovery is connected to information-estimation measures. More generally, community detection pairs well with information theory as it can be viewed as a decoding problem on a noisy channel: the community labels are the input to a black-box channel that provides local and noisy interactions of the inputs. This view point was further developed in [4], with the notion of graphical channels:

Definition 4. *[4] Let $V = [n]$ and $G = (V, E(G))$ be a hypergraph with $N = |E(G)|$. Let $\mathcal{X}$ and $\mathcal{Y}$ be two finite sets called respectively the input and output alphabets, and $Q(\cdot|\cdot)$ be a channel from $\mathcal{X}^k$ to $\mathcal{Y}$ called the kernel. To each vertex in V, assign a vertex-variable in $\mathcal{X}$, and to each edge in $E(G)$, assign an edge-variable in $\mathcal{Y}$. Let y_I denote the edge-variable attached to edge I, and $x[I]$ denote the k node-variables adjacent to I. We define a graphical channel with graph G and kernel Q as the channel $P(\cdot|\cdot)$ given by*

$$P(y|x) \equiv \prod_{I \in E(G)} Q(y_I|x[I])$$

$$x \in \mathcal{X}^V, y \in \mathcal{Y}^{E(G)}$$



The above departs significantly from a traditionally encoded channel when considering low order edges (e.g., $k = 2, 3$) and G uniform or complete (the closest would be a special LDGM code [32]). As discussed in [5], exact recovery in the SBM is verbatim a decoding problem on such a channel with an LDGM code of right-degree 2.

Community detection has a strong connection with information theory since $\mathcal{X}$ is typically discrete (as the goal is to obtain 'clusters' on the data), which is not common for other applications in machine learning where the real-valued nature of the channel is important.[1] Graphical channels allow also to capture many extensions of the SBM, such as non-overlapping communities, edge-labeled or non-pairwise interactions. This can be further extended to problems such as topic modelling or ranking, with new notions of recovery. Ubiquitous to all these models are two quantities: a measure on how "rich" the observation graph G is (e.g., the node degrees in the SBM), and a measure on how "noisy" the connectivity kernel Q is (e.g., the CH-divergence for exact recovery). These are not the usual notions of rates and capacity in information theory, but they are the relevant ones here. These also make the problems novel and interesting. By understanding various instances of such models, the hope is to build a general theory for the fundamental limits in machine learning and data science problems, inspired by information theory.

[1] Compressed sensing or topic modelling rely instead heavily on real-valued channels.

5 Open problems

The establishment of fundamental limits for community detection in the SBM have appeared in the recent years. There is therefore a long list of open problems and directions to pursue, both related to the SBM and to similar models in machine learning. We provide here a partial list:

- *Exact recovery for sub-linear communities.* Theorem 1 gives a comprehensive result for exact recovery in the case of linear-size communities, i.e., when the entries of p and its dimension k do not scale with n. If $k = o(\log(n))$ and the communities are balanced, most of the current techniques apply. However new phenomena seem to take place beyond that, with again gaps between information and computational thresholds. In [48], some of this is captured by looking at coarse regimes of the parameters. Finer scale regimes may reveal further interesting directions to explore concerning the discrepancies of information and computation barriers.

- *Partial recovery.* Between weak and exact recovery, *how much* can we hope to recover about the communities? What are the fundamental tradeoffs between the SNR and the distortion/accuracy of detection algorithms? Is there a *rate-distortion theory* of CD? Recently, we were able to answer this question in [21] for the special case where the SNR is constant while the average degrees diverge at the same rate. In particular the mutual information and I-MMSE formula [27] allow to estimate the SNR-distortion curve sharply. The finite SNR regime with constant node degrees, or the case with multiple (asymmetric) communities remain open.

- *The information-computation gap.* Can we locate the exact information-theoretic threshold for weak recovery when $k \geq 3$? Can we strengthen the evidences that the KS threshol is the computational threshold?

- *Beyond the SBM.* How do previous results generalize to other graphical channels [4, 1]?

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Teaching Source Coding and Teaching Channel Coding

Aaron B. Wagner

Many electrical engineering programs offer an information theory course of the following form. The course covers the fundamental limits of channel coding (capacity), lossless compression (entropy), and lossy compression (the rate-distortion function). The course typically covers some network extensions of these point-to-point results. In all cases the emphasis is on i.i.d. models and known distributions, and favors common mathematical methodologies, such as typicality and binning, over engineering considerations. Cornell University, where the author is based, had such a course for many years, which he taught on a number of occasions.

Such a course certainly has many virtues. It provides students with a broad exposure to the field of information theory. It

provides them the mathematical tools necessary to immediately begin reading research papers in most areas of the field. And it highlights the connections between different areas of information theory, drawing attention to the symmetry between channel coding and source coding and how they form an optimal pairing under the separation theorem.

Such a course also has a number of limitations, however. A course that touches on so many different problems inevitably cannot cover any of them in much depth. In particular, the emphasis on fundamental limits leaves little time to discuss *schemes* that achieve those limits. There is no time, and the students are not equipped, for design projects to be included in the course. The restriction to i.i.d. sources leaves a sizable gulf between the mathematical models considered and the physical processes they are intended to model. In the experience of the author, students often emerge from such a class with a capacity for solving certain kinds of math problems but with little understanding of how to design a communication or compression system. This emphasis on theory over design also dissuades a sizable contingent of engineering students, who might otherwise be interested in the topic, from enrolling in the course.

Several years ago, the School of Electrical and Computer Engineering (ECE) at Cornell sought to address these limitations by dividing the existing, annual information theory course into two biennial courses, one devoted exclusively to source coding and the other devoted exclusively to channel coding. Since each course is only covering "half" of the field, there is ample time to discuss practical schemes and modeling concerns. There is even time for design projects.

The source coding course covers the entropy limit for lossless compression along with a detailed examination of two practical schemes: arithmetic coding and the Lempel-Ziv compressor. Both schemes are shown to achieve the entropy rate universally over the class of all stationary sources in the large-blocklength limit. The course also covers the rate-distortion function limit to lossy compression along with a detailed examination of how this limit can be nearly achieved universally for stationary Gaussian sources via the application of an appropriate transform followed by entropy-coded uniform quantization.

The schedule allows for two projects, one on lossless compression and one on lossy compression. For the lossless project, the students are given a large text file, typically a concatenation of several English-language novels, and asked to write a Python script that outputs the file and whose compiled bytecode is as short as possible. For the lossy project, the students are given a short audio clip and asked to write a Python script that outputs a WAV file within a certain mean-square error of the original recording, again with the aim of minimizing the size of the compiled bytecode. In both cases, there is a prize for the student that achieves the most compression.

The channel coding course covers the capacity theorem for discrete memoryless channels, stationary Gaussian channels, and a wide array of wireless channels. The emphasis of the wireless unit is on deriving insight into the design of signaling schemes through capacity studies. Wireless courses often use capacity studies to glean insight into signaling schemes, but there is typically insufficient time to properly develop the concept of capacity in such courses, limiting the effectiveness of this approach.

The channel coding course also has ample time to discuss practical codes. Recent offerings of this course have included a unit on modern coding theory and the capacity-achieving capabilities of certain iterative codes. Like the source coding course, this course has included an open-ended design project, in which the students are asked to design the best code they can for a particular channel. Again there is a prize.

This split-course offering does have some disadvantages. The source-channel separation theorem, arguably the most important of Shannon's theorems, cannot be covered at a mathematical level in either course. Also, Ph.D. students aiming to work on channel coding problems might enter the program during a year in which the source coding course is offered, or vice versa. But the experience of the author is that the advantages of this approach outweigh the disadvantages. Most students have so internalized the notion of source-channel separation that they fail to appreciate the significance of the separation theorem when it is shown to them. Students who take the compression course can learn channel coding easily through self-study if they wish to begin reading channel-coding papers immediately. Ph.D. students benefit overall from learning information theory more deeply—two semesters instead of one. The design projects make the courses of interest to a broader array of students, including advanced undergraduate and professional masters students. The design projects also cement concepts in students' minds that often remain woolly when only explicated in theoretical form, as multiple students have expressed thankfully in their end-of-semester reviews.

A full-semester course on information-theoretic data compression is certainly atypical; the few schools that offer a dedicated data compression course tend to focus more on quantization theory than on Shannon's rate-distortion theorem. Yet source coding is poised to become more of a focal point for information theory research in the future, considering the untapped potential it offers for improvements in multimedia compression and its connection to learning. As such, students are well-served by such a course. Likewise, students are well-served by a course that combines the practical and theoretical aspects of communication. Cornell ECE is currently in the process of merging the channel-coding information theory course with its long-lived course on coding theory. Channel capacity arguably should be paired with coding theory, not compression.

The Cornell versions of these two courses are still very much evolving, and anyone interested in discussing this approach to teaching information theory or in implementing such a split at their institution is invited to contact the author.

Awards

Congratulations to the members of our community that have recently received the most prestigious awards of the IEEE, AAES, and NAE. The IEEE Richard W. Hamming Medal: **Abbas El Gamal**; the IEEE Medal of Honor: **G. David Forney**; the IEEE Eric E. Sumner Award: **Shuo-Yen Robert Li, Raymond W. Yeung, and Ning Cai;** the IEEE Alexander Graham Bell Medal: **Roberto Padovani**; the AAES John Fritz Medal: **H. Vincent Poor**; the IEEE Jack S. Kilby Signal Processing Medal: **Louis L. Scharf**; and the NAE Charles Stark Draper Prize for Engineering: **Andrew J. Viterbi.** More details below.

We are all honored as a community!

IEEE Richard W. Hamming Medal: Abbas El Gamal

The IEEE Richard W. Hamming Medal is awarded for exceptional contributions to information sciences, systems, and technology, sponsored by Qualcomm, Inc., to **Abbas El Gamal (**Professor and Department Chair, Department of Electrical Engineering, Stanford University) "for contributions to network multi-user information theory and for wide ranging impact on programmable circuit architectures."

Professor El Gamal joins fellow Shannon Award winners Irving S. Reed, Elwyn R. Berlekamp, Jorma J. Rissanen, Jacob Ziv, Thomas M. Cover, Solomon Golomb, Peter Elias, Jack K. Wolf, Neil J.A. Sloane, Sergio Verdú, Toby Berger, Robert Calderbank, and Imre Csiszár in receiving this honor.

IEEE Medal of Honor: G. David Forney, Jr.

The IEEE Medal of Honor is awarded for an exceptional contribution or an extraordinary career in IEEE fields of interest, sponsored by the IEEE Foundation, to **G. David Forney, Jr.** (Adjunct Professor, Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology) "for pioneering contributions to the theory of error-correcting codes and the development of reliable high- speed data communications."

Professor Forney is the fifth Shannon Award winner to receive this honor, after Claude Shannon, Robert Gallager, Andrew J. Viterbi, and Tom Kailath.

2016 IEEE Eric E. Sumner Award: Shuo-Yen Robert Li, Raymond W. Yeung, and Ning Cai

The IEEE Eric E. Sumner Award was established by the IEEE Board of Directors in 1995 and is presented to an individual or team for outstanding contributions to communications technology.

The pioneering contributions of Shuo-Yen Robert Li, Raymond W. Yeung, and Ning Cai to network coding have laid the foundation of the field. Their seminal work on linear network coding has changed the landscape of the information technology by demonstrating an improvement of transmission rates over traditional routing techniques in communication networks. Linear network coding has become one of the fastest-growing areas in communication theory. It is now being actively investigated for applications to mobile/wireless, network infrastructure and protocols, cloud storage, content distribution networks, and video streaming.

IEEE Alexander Graham Bell Medal: Roberto Padovani

The IEEE Alexander Graham Bell Medal is awarded for exceptional contributions to the advancement of communications sciences and engineering, sponsored by Bell Labs, Alcatel-Lucent, to **Roberto Padovani** (Executive Vice President and Fellow, Qualcomm Technologies) "for innovations enabling efficient, wideband, wireless access to the Internet, that is central to all third-generation cellular networks."

American Association of Engineering Societies (AAES) John Fritz Medal: H. Vincent Poor

Vince Poor will receive the 2016 John Fritz Medal of the American Association of Engineering Societies, "for outstanding contributions to the fields of modern communications and signal processing through their development, application and dissemination." The John Fritz Medal, which is one of the oldest American awards in engineering, is presented annually for scientific or industrial achievement in any field of pure or applied science. Former recipients include Alexander Graham Bell and Guglielmo Marconi, and in more recent times, Claude Shannon and Andrew Viterbi. The award will be presented at the National Academy of Engineering on April 18, 2016.

IEEE Jack S. Kilby Signal Processing Medal: Louis Scharf

The IEEE Jack S. Kilby Signal Processing Medal is awarded for outstanding achievements in signal processing, sponsored by Texas Instruments, Inc., to **Louis L. Scharf** (Professor, Department of Electrical and Computer Engineering, Colorado State University) "for pioneering and sustained contributions to statistical signal processing and its practice."

2016 Charles Stark Draper Prize for Engineering: Andrew J. Viterbi.

The National Academy of Engineering (NAE) annually honors engineers whose work has changed lives, benefited society, and enhanced the education of the future leaders of engineering. The NAE is proud to recognize these pillars of the engineering profession for their innovations, and congratulates the 2016 NAE Draper Prize recipient for his extraordinary work.

The 2016 Charles Stark Draper Prize for Engineering is awarded to **Dr. Andrew J. Viterbi** "for development of the Viterbi algorithm, its transformational impact on digital wireless communications, and its significant applications in speech recognition and synthesis and in bioinformatics."

Coding Team Wins a Bell Labs Prize

Three young information theorists won a Bell Labs Prize in December 2015, tied for third place in a global competition that included over 250 submitted ideas. Georg Böcherer, Patrick Schulte, and Fabian Steiner from the Technical University of Munich (TUM) showed how their RateX architecture and distribution matcher can be used to approach the Shannon limit in the Future X Network. The RateX architecture layers three essential functions for the first time: shaping, coding, and modulation, in that order, within the physical layer of the Open Systems Interconnection model. This is a universal method that enhances flexibility and reduces costs in the engineering of wireless, wireline, optical fiber, and satellite systems.

Fabian Steiner, Georg Böcherer, and Patrick Schulte with the statue of Claude Shannon at Bell Labs in Murray Hill, NJ

A key to closing the shaping gap to capacity was to invent a fixed-to-fixed length distribution matcher that puts out constant-composition symbol sequences by using a novel adaptive arithmetic coding algorithm. The first experimental studies with optical fiber and wireline DSL systems confirm the performance predicted by theory. Because RateX adapts easily to the actual channel, it is well suited for the short-range wireless links that will be a ubiquitous feature of the 5G "Internet of Things" as for the world's long-haul fiber-optic backbones.

Georg Böcherer is a postdoctoral researcher who is completing his Habilitation in the Department of Electrical and Computer Engineering at TUM. Patrick Schulte and Fabian Steiner are doctoral candidates who began working with Böcherer as master's students. The three shared equally in the prize, a personal award of $25,000 from Alcatel-Lucent Bell Labs (now Nokia Bell Labs). The other prizes awarded went to professors at Carnegie Mellon University and the University of California, San Diego.

The coding team's research was supported by the German Federal Ministry of Education and Research in the framework of an Alexander von Humboldt Professorship and by the TUM Institute for Advanced Study.

For more information, please see http://www.tum.de/en/about-tum/news/press-releases/short/article/32802/

From the Editor *continued from page 2*

report on the Munich Workshop on Information Theory of Optical Fiber (MIO 2015) by Luca Barletta, Tobias Fehenberger, Gerhard Kramer, and Mansoor Yousefi; a report on the 2015 JTG/IEEE IT Society Summer School by Navin Kashyap and Rajesh Sundaresan; and the IEEE Information Theory Society Board of Governors meeting minutes from their meeting in ISIT 2015 (Hong Kong). We then review a number of upcoming events and nomination deadlines including a series of workshops/seminars/events for The Shannon Centenary. Many thanks to all the contributors for their efforts!

With sadness, we conclude this issue with a tribute to a prominent member of our community Moshe Zakai (1926-2015) who passed away on November 27, 2015, in his hometown Haifa. Thanks to Eddy Mayer Wolf, Ofer Zeitouni, and Jacob Ziv for preparing the tribute.

Please help to make the newsletter as interesting and informative as possible by sharing 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, in such, broaden the influence of our society. Any ideas along this line will also 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: April 10, 2016 for the June 2016 issue. July 10, 2016 for the September 2016 issue.

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

2016 Newly Elevated Fellows

Congratulations to the members of our community that have been recently elevated to the grade of IEEE fellow!

Faramarz Fekri
Georgia Institute of Technology, Atlanta, GA, USA
for contributions to coding theory and its applications

Christina Fragouli
UCLA-University of California-Los Angeles, Los Angeles, CA, USA
for contributions to network coding

Lizhong Zheng
MIT-Massachusetts Institute of Technology, MA, USA
for contributions to the theory of multiple antenna communication

Ozgur Akan
Koc University, Dept of EEE, Rumelifeneri Campus, Istanbul, Turkey
for contributions to wireless sensor networks

Petar Popovski
Aalborg University, Aalborg, Denmark
for contributions to network coding and multiple access methods in wireless communications

Sundeep Rangan
NYU Polytechnic School of Eng. ECE Dept., Brooklyn, NY, USA
for contributions to orthogonal frequency division multiple access cellular communication systems

Osvaldo Simeone
New Jersey Institute of Technology, Newark, NJ, USA
for contributions to cooperative cellular systems and cognitive radio networks

John Thompson
University of Edinburgh, School of Engineering & Electronics, Edinburgh, United Kingdom
for contributions to multiple antenna and multi-hop wireless communications

Sennur Ulukus
University of Maryland, Dept of ECE, College Park, MD, USA
for contributions to characterizing performance limits of wireless networks

Zhengdao Wang
Iowa State University, Ames, IA, USA
for contributions to multicarrier communications and performance analysis of wireless systems

Kaikit Wong
University College London, Department of EEE, Torrington Place, London, United Kingdom
for contributions to multiuser communication systems

Jinhong Yuan
University of New South Wales, School of Elec Eng & Telecommunications, Sydney, New South Wales, Australia
for contributions to multi-antenna wireless communication technologies

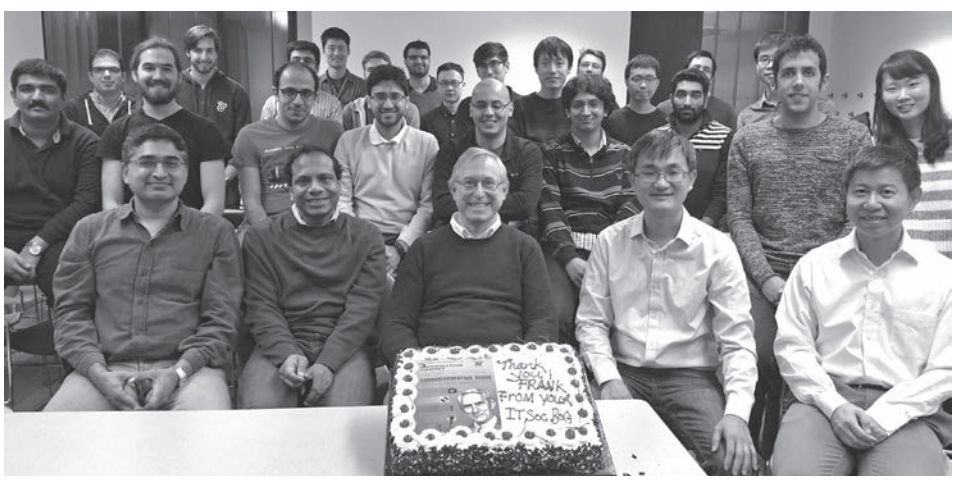
Liang-Liang Xie
Universiy of Waterloo, Waterloo, ON, Canada
for contributions to fundamental limits of feedback control systems and wireless networks

Erik Larsson
Linkoping University, ISY, Campus Valla Linkoping, Sweden
for contributions to the technology of multi-antenna wireless communications

Lie Liang Yang
University of Southampton, School of ECS, Mountbatten, Southampton, United Kingdom
for contributions to multicarrier communications and wireless transceivers

Moments

Frank Kschischang (center) receives his third and final cake from the IEEE Information Theory Society Board of Governors (ITSoc BoG) for his service as the Editor-in-Chief of the Transactions. The text on the cake says: "Thank you! Frank. From Your ITSoc BoG." The photo is taken with colleagues and students at the University of Toronto.



The Historian's Column

Anthony Ephremides

Have you reflected on how language is evolving today? Many purists find this evolution objectionable, if not intolerable. It is present in every day's discourse but also in scientific and technical materials. Consider some examples. On a recent newscast the announcer was talking about expected "precip" levels or poor "viz". My colleagues at the University (including myself, of course) are referred to as "Profs". In fact, the staff in my department addresses me as "Dr. E". The scandal of deflated foot balls became known as "deflategate". Topless bathing suits are known as "monokinis". The suffix "thon" is appended to any word that is to be associated with long, protracted duration (like "telethon", "talkathon", "walkathon", "cookathon" etc.). My Word editor does not recognize any of these words, as I am writing this. And, of course, I am not even touching "tweet-speak", like "R u 4 our team?" This is not language. It is a disease! It is called Chirpes and it is untweetable (sorry about that).

But it goes much further. The College of Cardiology of the George Washington University is actually officially referred to as "The Heart House". Most of us are in EE departments. Injured people go for "rehab" sessions. An Attorney from the (hypothetical) prestigious law-firm of Dickerson, Fitsimmons, and Carruthers is just a Lawyer, or, worse, a "paralegal". Once, a member of the Board of Directors of the IEEE (here we go again), referred to the term colloquium as a "collegium"! Stores like Abercrombie and Fitch, Woodward and Lothrop, Bloomingdale's, and Saks Fifth Avenue are being replaced by "Dick's", "Michael's", "Kohl's", and "Target". Television has become TV a long time ago, and Air Conditioning is established as just AC. One cannot fight those anymore. Your car joints lubrication is done by "Jiffy Lube". Hopefully, "sauce Hollandaise" will not become "Dutch sauce", one day.

In the technical domain, I recall that at an early time Tom Cover had drawn the distinction between "Hertz", that he had called "jargon", and "cycles-per-second" that he submitted was the proper scientific term. I am not insisting on "binary digits" since "bits" has won the battle since almost the inception of the concept. And calling photocopying just "Xeroxing" is an accepted incorrect substitution. But once you are on a slippery slope, there is no stopping. Today, we deal with enormous volumes of data (someone had said that we are "data-rich" but "information-poor", but that is another story) and we have chosen the name "Big Data" for that. If the intent is to compress ruthlessly everything down to the entropy and give up florid language, sophistication, and aesthetic idiom, let us at least preserve some inventiveness in our simplifications and avoid childish, or, worse, caveman's terms. Consider, for example, the "Internet of Things"! Things? Can't we think of a term at least from the vocabulary of secondary school, like "objects"? And you know what is coming next? It is "Internet of Everything"! You read that right. And I have also heard about "The Internet of Me"! Comrades, this is not to be believed! Soon we are bound to hear a talk with the title "…Whatever"!

So, why is this happening? Is it laziness, aversion for complexity, the attractiveness of the least common denominator, or is it a latent reincarnation of information compression? If it is the latter, we should at least be aware of the risks when "editing down" becomes "butchery". As we know from Information Theory, casual compression can lead to distortion. I recall the preposterous example from high school, where the question was "Name the four evangelists" and the answer that emerged was "The three evangelists are the following two: Marcus"!

Compression, even when done properly, has its downside. It destroys beauty. Simplicity can be beautiful, but complexity, in the right hands, has a superior level of beauty. In fact, to many people, complexity is a necessary condition in good Art (though far from necessary in good Science).

I recall some decades ago listening to a lecture by Professor Cattermole, a true British gentleman, although not too well known for his technical work, which had spell-binding beauty even though, all he was talking about was...the properties of the Poisson Process! It was not just the erudition and the sound of the refined accent. It was the careful choice of descriptive words, the correct grammar and syntax, and the colorful intonation that synthesized a pleasurable and informative narrative. And, yes, you can argue that he could have done away with it by simply saying that the Poisson Process is a point process with intervals between points that are i.i.d. and exponential.

Or, consider what crime against humanity would be an attempt to compress Hamlet's monologue? How can "a pound of flesh" in the bloody context of medieval England be changed to a "kilo of meat"? Look at any passage from a great piece of literature and you will see that you could compress it and "flatten" it to the point where the meaning will still be clearly perceived but all its beauty will be gone. It would be like 240 bits/sec speech.

The consequences of the "…whatever" trend can be truly horrific (albeit, at the same time, entertaining). A student wrote the following in his exam, in which two random variables were given to be jointly Gaussian: "if by Gaussian, we mean, like, independent…." And he went on in the same vein. Another student, asked, regarding the definition of "optimal solution", whether optimal is "something that can't be beat"! And a waiter, who wanted to know whether I wanted an egg on my steak, simply asked "…egg"? Or when the Microsoft software engineers choose how to interface with the users when their programs malfunction and decide on nothing more informative than "….an error occurred"! Or when a student announces to his parents that he has MS and he means a Master's degree and NOT Multiple Sclerosis.

Perhaps the proliferation of hand-held devices has contributed to this deterioration. Dealing with "untethered" machines gave us a feeling of freedom and opened up so many conveniences and useful applications. At the same time, however, it caused ourselves to become "tethered" to these devices. I have seen even motorcyclists

glued on their I-phones as they navigate in heavy traffic. Such stress also leads to compression (sometimes not limited to words but to body parts as well).

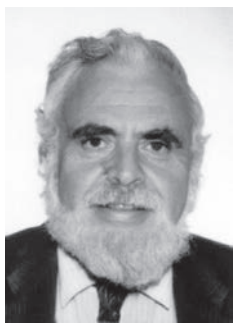
Language is the instrument of communication. It is like a channel in Information Theory. The input is our thoughts and concepts and the output is whatever the language we use conveys to the receiver. How do we combat noise in a communication channel? We add redundancy. So, language should be redundant. And since we are humans and not machines, we have additional weaknesses, like a need for beauty, humor, innuendo, creativity, entertainment, and…yes, art! So, isn't it worth the effort to keep this instrument well-tuned? Shouldn't we resist the slide towards…."machine-speak"? As Information Theorists we must lead the way instead of leaving it to the linguists to do the job…for LOL!

Ooops! Even I, Brutus?

Erratum: In my previous column I inadvertently changed Claude Shannon's actual birthdate. The correct date is April 30, 1916.

GOLOMB'S PUZZLE COLUMN™

Simple Counting Problems



Solomon W. Golomb

1) How many of the integers from one to one million are neither perfect squares nor perfect cubes?

2) Suppose you have 20 coins, of which 10 are mutually distinct, and the other 10 are identical to each other but different from the first 10. From this collection of 20 coins, how many different-looking assortments of 10 coins are possible? (The order of an assortment does not matter.)

3) If 6^z divides $2^{16} \cdot 3^{24}$, what is the largest possible value of the whole number z?

4) How many of the integers from one to one thousand are divisible by neither 7 nor 11 nor 13?

5) The grocery store has a special this week of 6 fruit for $1.00, where you may pick any assortment of peaches, plums, or pears totaling six. Regarding fruit of the same kind as identical, how many different assortments of six fruit are possible? (Order doesn't matter).

6) In how many ways can a set of n distinct objects be partitioned into two non-empty subsets where which subset is which does not matter?

GOLOMB'S PUZZLE COLUMN™

Numerical Oddities Solutions

Solomon W. Golomb

1) $3!\,5! = 6!$, $\quad 6!\,7! = 10!$.

2) $4! + 1 = 25 = 5^2$, $\quad 5! + 1 = 121 = 11^2$, $\quad 7! + 1 = 5041 = 71^2$.

3) a) $3^2 - 2^3 = 9 - 8 = 1$.
b) $3^3 - 5^2 = 27 - 25 = 2$.
c) $2^7 - 5^3 = 128 - 125 = 3$.
d) $5^3 - 11^2 = 125 - 121 = 4$.
e) $13^3 - 3^7 = 2197 - 2187 = 10$.
f) $2 \cdot 5^2 - 7^2 = 50 - 49 = 1$.
g) $3^5 - 2 \cdot 11^2 = 243 - 242 = 1$.

4) $2^5 + 1 = 33$, $\quad 6^5 + 1 = 7777$.

5) $\binom{14}{6} = 3003$, $\binom{14}{5} = 2002$, $\binom{14}{4} = 1001$.

6) $\binom{14}{6} = 3003 = \binom{15}{5}$. (This is the only solution with $n < 100$.)

7) $\binom{90}{0} + \binom{90}{1} + \binom{90}{2} = 1 + 90 + 4005 = 4096 = 2^{12}$.

8) $\binom{23}{0} + \binom{23}{1} + \binom{23}{2} + \binom{23}{3} = 1 + 23 + 253 + 1771 = 2048 = 2^{11}$.

9) $(2^8 - 1) + (3^9 - 1) = 255 + 19,682 = 19,937$, a known "Mersenne exponent."

10) The smallest solution has $n = 2183$ and $k = 17$. Thus $S = \{2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200\}$. The nine even elements all have the factor 2 in common. Of the eight odd elements, 3 is a common factor of {**2187, 2193, 2199**}; 5 is a common factor of {**2185, 2195**}; 7 is a common factor of {**2191,** 2198}; 11 is a common factor of {**2189**, 2200}; and 13 is a common factor of {2184, **2197**}.

From the Predisent *continued from page 1*

Website: We are curating a repository of Shannon information and resources. Over the next few months you can watch our progress at http://claudeshannon.info. If you have thoughts or suggestions, or are willing to help, please let us know.

As with all cerebral enterprises, our society's work is undertaken by many devoted volunteers who work assiduously on our behalf and all they get is a measly thank-you paragraph. Let me mention a few related to this column and year. The Shannon Centennial Committee members Christina Fragouli, Michelle Effros, Rudi Urbanke, Lav Varshnay, and Sergio Verdu, have labored on the Shannon events. This year, Stark Draper, aka sky scraper, succeeds Edmund Yeh as Mr. Secretary, and Emanuele Viterbo replaces Elza Erkip as conference committee chair, alias travel agent in chief. Elza herself becomes our new 2nd VP, while Rudi Urbanke transitions to 1st VP and gets groomed for top dog. I thank them all for their great work and look forward to benefiting from their thoughtfulness, creativity, and enthusiasm for years to come.

Last, but absolutely not least, I would like to thank our recent presidents whose seminal technical contributions and lifelong devotion to information theory have changed the society and inspired many amongst us. Junior past president Michelle Effros, senior past president Abbas El Gamal, and Gerhard Kramer who concludes a five-year tour of dedication through the society's presidential ranks. Please join me in congratulating and thanking them for a job admirably done!

Students' Corner

From Idea to Proof: A Challenge for Beginning Researchers

Parham Noorzad
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While published results in information theory are expected to be completely rigorous, rarely do research projects start that way. For the beginning researcher, making the transition from a complete lack of rigor to a state where everything is carefully proved is quite a challenge.

At first glance, the existence of a trade-off becomes clear. If one stays in an inexact state for a long time while obtaining more results, one risks building a "house of cards". In this case, a simple mistake in an intermediary result may break down the entire proof. On the other hand, too much emphasis on rigor in the early stages of research stifles creativity. The main reason is that rarely is the proof of a result obtained in the linear fashion that it is presented. Usually proofs emerge as a collection of results that may have been proved at different times, and for different purposes. Thus at least in the early stage, obtaining such proofs require one to be flexible in assuming various statements are true.

Maintaining this balance is especially difficult for new graduate students, for whom the thesis is the first long-term research project, despite the occasional formal checks (e.g., the candidacy exam). Depending on their previous experiences, students may fall into one of these two groups. One group are students who decline to make any statements that they are not completely sure of, while the second group are more inclined to take "intuitively true" to be the same as "true".

One approach to this problem that is emphasized in our group is to "write often". As we demonstrate, writing frequently helps both groups of students. First, writing allows one to figure out what is known to be true, and what seems to be true. It helps the researcher differentiate between proofs and evidence. Second, it helps the researcher to step back and think about the main questions. In many cases, problems that originally seem very important, once formalized, may not be as crucial as they seemed. In such a case, writing often provides one with the opportunity to pivot and move into new directions, making it less likely to miss the forest for the trees.

Some may argue that writing takes too much time or that it is rather boring to write down trivial results. While writing is rather time-consuming, the cost of fixing a long proof that is incorrect is usually much higher, if at all possible. With regards to writing down results that seem obvious, one can argue that writing such results should not be avoided for a simple reason. If it is the case that a result is in fact obvious, it should not be too difficult to write up the proof. On the other hand, if it turns out that a simple proof does not exist, then the result is not obvious, and thus important to consider.

Finally, one may wonder how often one should write. One can come up with different standards, but one approach that has worked for me has been to write up any result which has not been already published but I believe to be true. Others may be more satisfied by writing on a daily or weekly basis, where time determines when to write rather than new results. Either way, any strategy that guarantees one spends a sufficient amount of time thinking both rigorously and in big-picture terms works fine.

From the Field: The New Madras Chapter

In TamilNadu, India more than 570 Engineering Colleges function under Anna University. Among those 570 Engineering colleges, 270 colleges have an IEEE Student Branch. These colleges have several society student branch chapters like the IEEE Computer Society Student Branch Chapter, the Communication Society Student Branch Chapter, and the Power Engineering Society Student Branch Chapter. In this region many research scholars and students do research work on information coding and processing. It will be more useful and meaningful when there is a platform to encompass an interaction between research scholars and students to promote research activities in the field of information theory. To implement the same, we have submitted the Information Theory Society petition on 24-03-2015 to the IEEE and our petition was positively approved by the IEEE officials on 18-09-2015 with its geo code CH10754 to reach our goal.

I am very happy to enlighten that the Information Theory Society (ITS) Madras Chapter was successfully inaugurated at National Engineering College [NEC], Kovilpatti, Tamilnadu, India on 21-11-2015 at 11.00am by the Honorable IEEE Madras Section Chair Dr. N. R. Alamelu. She inaugurated the society in a successful manner in the august presence of Dr. Kn. K. S. K. Chockalingam, Director, NEC, Dr. S. Shanmugavel, Principal, NEC , Dr. M. A. Atmanand Chair Elect, IEEE Madras Section and Thiru. H. R. Mohan, Vice Chair, IEEE Madras Section. Dr. B. Pramasisvan, Chair, Information Theory Society Madras Chapter introduced the ITS office bearers to the gathering. Many Society Chairs of IEEE Madras Section and Execom Members graced the function with their valuable presence.

Many learned professors and researchers are willing and ready to deliver technical talks, guest lectures and to organize workshops. Also we are in the process of publishing good quality news letters in the area of information theory and processing. We request all the Information Theory Society officials to extend their kind support and guidance for the developmental activities of the

Release of plaque during the launching ceremony of the Information Theory Society Madras Chapter. From Left to Right: Dr. B. Paramasivan, Dr. M. A. Atmanand, Dr. N. R. Alamelu, Dr. Kn. K. S. K. Chockalingam, Dr. S. Shanmugavel, and Thiru. H. R. Mohan.

Information Theory Society Madras Chapter. We are confident that with the support and guidance of eminent researchers we can make our society thrive.

With kind regards
Dr. B. Paramasivan
IEEE Senior Member

Chair – Information Theory Society Madras Chapter
Execom Member- IEEE Madras Section
Prof&Head/CSE
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Report on the Munich Workshop on Information Theory of Optical Fiber (MIO 2015)

Organizers

Luca Barletta, Tobias Fehenberger, Gerhard Kramer, Mansoor Yousefi

The Institute for Advanced Studies (IAS) and the Institute for Communications Engineering (LNT) at the Technical University of Munich (TUM) organized a Munich Workshop on Information Theory of Optical Fiber (MIO 2015) on December 7–8, 2015. The technical program included talks by leading researchers from around the world. On Monday, December 7, the speakers were René-Jean Essiambre (TUM-IAS Rudolf Diesel Fellow), Cristian Antonelli, Mansoor Yousefi, Sander Wahls, Henning Bülow, Yves Jaouen, Erik Agrell, and Marco Secondini. On Tuesday, the speakers were Mark Shtaif, Meir Feder, Magnus Karlsson,

Delegation from Baden-Württemberg enjoying lunch

Group photo of MIO 2015 participants

Roland Ryf, Tobias Fehenberger, and Gerhard Kramer. The talk topics included space-division multiplexing, solitons, capacity calculations, coding, and shaping. Doctoral students, postdocs, and professors from academic and industrial institutions presented posters. Over 100 persons attended the event.

The social program included lunches, coffee, chocolate, and meeting St. Nicholas. On Monday there was a dinner at the Salvator Keller of Paulaner am Nockherberg, which was opened to the public by Paulaner monks in 1780. On Tuesday after the workshop there was a guided tour of the Alte Pinakothek on the topic "Art has always been contemporary—the Old Masters seen in a new light".

Funding for the workshop was provided by TUM-IAS, TUM-LNT, and the Alexander von Humboldt Foundation. The program, presentations, posters, theme song, and photos are available at the web address https://www.lnt.ei.tum.de/en/events/munich-workshop-on-information-theory-of-optical-fiber-2015/

Report on the 2015 JTG/IEEE IT Society Summer School

by Navin Kashyap and Rajesh Sundaresan

The 2015 Joint Telematics Group / IEEE Information Theory Society Summer School on Signal Processing, Communications and Networks was held at the Indian Institute of Science (IISc), Bangalore, during July 20–23, 2015. The summer school was followed by a one-day workshop on July 24, in which sixteen early-career researchers from within the Indian research community in communications, information theory and networks were invited to present their work.

A few words about the history of this Summer School are in order here. The Summer School series started in 2009 as an initiative of the Joint Telematics Group (JTG), and was intended as a venue to cover contemporary research topics in signal processing, communications, information theory, and networks that could be accessed by students and young researchers from all over India. The JTG itself is a loose body of experts in "telematics" (an umbrella term, perhaps out of fashion now, that covers telecommunications, vehicular technologies and networks) drawn from the various Indian Institutes of Technology (IITs) and IISc. JTG Summer Schools have been held annually since 2009. The IEEE Information Theory Society's involvement as a financial and technical co-sponsor started with the 2014 edition of the school, which was held in IIT Madras.

The format of the summer school has remained the same since its first edition in 2009. The school comprises two short courses, each given by a leading expert on some topic within the broad realm of communications, signal processing, information theory and networks. Each course consists of eight hours of lectures and additional time for questions and discussions, over a span of four days. One course is scheduled in the mornings and the other in the afternoons, with a lunch break in between. The daily program also includes a few short talks given by PhD students on their research topics.

The two short courses comprising the 2015 Summer School were taught by Yihong Wu from the University of Illinois at Urbana-Champaign and Gerhard Kramer from the Technical University of Munich. Yihong's lectures were on information-theoretic methods in high-dimensional statistics, while Gerhard lectured on multi-terminal communication theory. Interspersed among these lectures were eight short talks by PhD students from IIT Bombay, IIT Madras and IISc.

Yihong Wu brought out the interplay between information theory and statistics in his high-energy lectures. He illustrated how techniques rooted in information theory play a key role in understanding the fundamental limits of high-dimensional statistical problems. He covered Fano's inequality, Le Cam's methods, metric entropy and volume methods, and their applications to sparse linear regression, estimation of high-dimensional matrices, principal component analysis, and community detection.

Gerhard Kramer began with an excellent overview of the basic information theoretic quantities, and followed it up with one of the clearest expositions of typicality and mismatched typicality. He then discussed the basic point-to-point coding theorems and followed it up with an overview

of results on multiaccess, broadcast, interference and other multiterminal systems.

The lectures were very well received by the audience comprising students and faculty from various Indian engineering colleges and institutes, including the IITs, the Tata Institute of Fundamental Research (TIFR) and IISc. The number of registration requests far exceeded the capacity (120) of the venue, so we had to close registrations quite early. The registered participants included about 80 students and 50 others, including faculty. We had to arrange some extra seating to accommodate the large audience on the first day. However, as was to be expected, the audience numbers dropped beyond the first day. Those who stayed for the duration of the school benefited immensely from the opportunity to interact with the speakers during the discussion sessions and lunch/coffee breaks.

The one-day workshop following the short courses was an innovation tried out for the first time at a JTG Summer School. This was intended as an opportunity for early-career researchers from the IITs and TIFR to present their recent research to the wider research community in India and abroad (the latter being represented by Yihong and Gerhard). The half-hour talks given by the sixteen invited speakers covered the areas of signal processing, coding, communication theory, networking, network optimization, and information theory. The success of this workshop will hopefully engender more such events in the future.

Generous funding from the IEEE Information Theory Society made it possible for us to support the travel and local accommodation of students coming from outside Bangalore. We would like to take this opportunity to thank the IT Society for their support.

Further information about the Summer School, including lecture notes and video recordings of Yihong and Gerhard's lectures, are available on the school's website: http://www.ece.iisc.ernet.in/~jtg/2015/

Preparations for the 2016 JTG / IEEE IT Society Summer School are well underway.

IEEE Information Theory Society Board of Governors Meeting Minutes

Convention Centre (HKCEC), Hong Kong, China, 06.14.2015, 1 PM–5 PM Edmund Yeh

Present: Michelle Effros, Alon Orlitsky, Ruediger Urbanke, Gerhard Kramer, Frank Kschischang, Helmut Bölcskei,, Edmund Yeh, Aylin Yener, Vincent Poor, Daniela Tuninetti, Anand Sarwate, Emanuele Viterbo, Stephen Hanly, Elza Erkip, Wei Yu, Vijay Kumar, Alex Vardy, Vitaly Skachek.

The meeting was called to order at 1 PM Hong Kong Time by Information Theory Society (ITSoc) President, Michelle Effros.

1) **Motion:** Vote to approve the minutes from the February 2015 BoG meeting. Motion was passed.

2) **Motion:** Vote to approve the meeting agenda. Motion was passed.

3) Michelle presented the President's Report, and gave the State of the Society. During 2014–2015, a half-time Society administrator position was proposed and approved. The

administrator will provide support and continuity for various Society functions. Michelle welcomed Matt LaFleur, who filled the position and started on May 26, 2015. Michelle then covered Society finances. The surplus from 2014 exceeds projections, which creates opportunities for expenditure. Several proposals will be presented at this BoG meeting. The Treasurer's report will provide further details. Moving on to broader outreach activities, an Ad Hoc committee has been formed to coordinate the activities. A focus are the Shannon Day celebrations. A documentary is being planned and a filmmaker has been contacted. Proposals have been submitted to the U.S. and Swiss National Science Foundations for financial support for the documentary. The committee is also exploring materials and lectures for generating interest in information theory among children. As an example, Michelle will give a lecture to high school students in Hong Kong about information theory. The Broader Outreach committee's report will provide further details. Michelle then discussed future ISITs. Two decisions will be made at the present BoG meeting, regarding the locations of ISIT 2018 and ISIT 2019. There is a wealth of opportunities to consider. There will also be a discussion of the decision mechanism for future ISITs. The Conference Committee report will provide further details.

4) Daniela Tuninetti presented the Treasurer's Report. Daniela first pointed out that budget actuals for 2014 are better than expected. The surplus for 2014 is now $281.7k, largely resulting from low expenses. Using the 50% rule and accounting for 2015 initiatives already undertaken (India School $11.5k, South African School $5.5k, Shannons centennial $35k), there is currently still $118k left to spend before the end of 2015. Daniela asked for other ideas for 2015 50%-rule initiatives. Christina Fragouli has proposed an initiative for Shannon's Centennial, and Anand Sarwate has proposed an initiative for hosting the ISIT website on ItSoc.org. Daniela suggested that it is possible to donate a portion of the possible initiative spending to the IEEE Foundation Account for Shannons Centennial. It is also possible to apply to spend beyond our 50%-rule. IEEE-TAB has $1M for initiatives in 2015; proposals due end of June.

   Daniela then presented a brief analysis of the Society finances. In 2014, periodicals accounted for 60% of revenue, 59% of expenses; conferences: 38% of revenue, 35% of expenses; membership: 2% of revenue, 5% of expenses. Thus, most of the Society revenue comes from the Transactions, whereas for other societies conference income is more significant. Daniela presented the first pass 2016 budget, covering the membership, periodicals, conferences, and committees categories. For 2016, Daniela pointed out that the Society may have $60k for new initiatives, which may be continuations of 2015 initiatives, for up to three years.

   Motion: Vote to move the amounts allocated for the 2015 Indian School and South African School from the 2015 initiatives fund (from the 50% rule) to the 2015 regular budget. Motion was passed.

   Motion: Vote to donate the remaining 2015 initiatives funds to the IEEE Foundation Account for Shannons Centennial. Motion was passed.

5) Gerhard Kramer presented the report of the Nominations and Appointments (N&A) Committee. Gerhard presented the slate of candidates for the BoG members election. The list includes Jeff Andrews, Matthieu Bloch, Todd Coleman, Sueli Costa, Suhas Diggavi, Stark Draper, Albert Guillen i Fabregas, Dongning Guo, Pierre Moulin, Krishna Narayana, Henry Pfister, Emina Soljanin, Yossef Steinberg, and Pascal Vontobel.

   Motion: Vote to approve the slate of candidates for the BoG members election. Motion was passed.

   Gerhard proceeded to First and Second Vice President and President nominations. Elza Erkip and Emina Soljanin were nominated for Second VP.

   Motion: Vote to approve the nominations of Elza Erkip and Emina Soljanin for Second Vice President. Motion was passed.

   Ruediger Urbanke was nominated for First VP.

   Motion: Vote to approve the nomination of Ruediger Urbanke for First Vice President. Motion was passed.

   Alon Orlitsky was nominated for President.

   Motion: Vote to approve the nomination of Alon Orlitsky for President. Motion was passed.

6) Alon Orlitsky presented the Awards Committee Report. Alon first discussed the ComSoc/IT Paper Award. Five papers were nominated for 2015. The joint committee considered three finalists. The award was given to M. Maddah-Ali and D. Tse, "Completely Stale Transmitter Channel State Information is Still Very Useful." *IEEE Transactions on Information Theory*, Volume 58, Number 7, pp. 4418–4431, July 2012.

   Alon commented that papers from the IT community have dominated the ComSoc/IT Paper Award in recent years. This may be discouraging to ComSoc authors.

   Alon next discussed the 2015 Jack Keil Wolf ISIT Student Paper Award. The ISIT TPC Subcommittee and two independent members chose five finalists. These papers will be presented at the semi-plenary sessions on Tuesday and Wednesday. Alon raised the issue of whether the award should be limited to student-only papers. Presently, all finalists have faculty as a co-author.

   Alon then discussed the IT Society Paper Award. The Awards Committee members for the IT Society Paper Award are: Alexei Ashikhmin, Stephan ten Brink, Giuseppe Caire, Tracey Ho, Michael Honig, Navin Kashyap, Yingbin Liang, Ertem Tuncel, and Ruediger Urbanke.

   Eight papers were nominated for the 2015 IT Society Paper Award. After multiple rounds of review, two finalists were selected. The Committee recommends the following paper for the IT Society Paper Award:

Tamo, I. and Barg, A., "A Family of Optimal Locally Recoverable Codes," *IEEE Transactions on Information Theory*, Volume 60, Number 8, pp. 4661–4676, August 2014.

Motion: Vote to approve the Awards Committee Report. Motion was passed.

Motion: Vote to approve the awarding of the 2015 IT Society Paper Award to the recommended paper by I. Tamo and A. Barg. Motion was passed.

Alon raised the issue whether the window for IT Society Paper Award nominations should be extended beyond two years.

7) Ruediger Urbanke presented the Membership and Chapters Committee report. The committee members include Negar Kiyavash, Joerg Kliewer, Paul Siegel, and Sriram Vishwanath.

Ruediger summarized the recent activities of the Student Committee, which includes Deniz Gunduz and Osvaldo Simeone. Ruediger then reported on the Outreach Subcommittee, which is co-chaired by Aaron Wagner and Joerg Kliewer, with Tara Javidi, Michele Wigger and Bobak Nazer as members. The Sub-committee co-organized (with the Student Committee) the panel discussion "101 Reasons to Study IT" with panelists Ubli Mitra, Emina Soljanin, and Andrea Montanari, at ITA 2015. The event had 50 attendees. At ISIT 2015, activities include a panel discussion "99 Biggest Career Mistakes and How to Avoid Them" with panelists Alex Dimakis, Elza Erkip, Madhu Sudan, and Ruediger Urbanke. The event will be videotaped and placed on the ITSoc website. This will be followed by the traditional ISIT mentoring get-together reception.

Ruediger gave an update on the mentoring program. There are currently 34 mentoring pairs (up from 31 last year). Some problems include relatively few new applications despite advertising efforts, challenges in making pairings work effectively, and the lack of mentors. Some ideas in addressing the problems include better coordination of the program with conference activities, specific activities for mentors and their mentees, and team mentoring (a team of two mentors for a group of up to six mentees). These ideas are currently in the brainstorming phase and will be presented to the BoG formally at the next meeting.

Ruediger presented the recent activities of WITHITS. At ITA 2015, WITHITS held a lunch meeting. At Allerton 2014, promotional videos of research by some of our members were shot and placed on http://www.itsoc.org/withits/media-resources. At ISIT 2014, WITHITS orgaznied an interactive presentation and discussion section titled "Climate Change: What Conditions Help Women Thrive in STEM Areas?" In an interactive setting, WITHITS will present some statistics pertaining to recruitment and retention of women in STEM areas and discuss the role of climate change as a possible strategy to improve the status quo. For ISIT 2016, Natasha Devroye and Lalitha Sankar have kindly agreed to run a surprise WITHITS event. For Allerton 2016, WITHITS plans a meeting to create an archive for useful resources.

Ruediger continued with the Distinguished Lecturer Program. Last year, there were two requests for Distinguished Lecturer visits. The Distinguished Lecturers for 2014–2015 are Erdal Arikan, Giuseppe Caire, Pascal Vontobel, Frans Willems, and Tracey Ho. The Distinguished Lecturers for 2015–2016 are Suhas Diggavi, Babak Hassibi, Olgica Milenkovic, Ron Roth, and Martin Wainwright. Ruediger commented that there are still not enough requests for Distinguished Lecturer visits.

The Padovani Lecturer is chosen for being "distinguished and impactful in both academia and industry." The 2015 Padovani Lecturer is a distinguished member of the IT Society, Paul Siegel from UCSD. The Chapter of the Year Award for 2015 has been awarded to the Hong Kong chapter for its many conference, workshop, talks, schools and other student-related activities over the past year. Finally, Ruediger reviewed the updated chapters and membership information.

Ruediger mentioned a proposal which requires all IT School attendees to be IT Society members. The current IT Society membership of 3300 is a small percentage of the IEEE total membership of 500,000. This proposal could be one way of increasing membership numbers.

A discussion followed. It was pointed out that all IEEE members should be accorded similar treatment. Requiring school attendees to be IT Society members may create a barrier for other IEEE members. It was also pointed out that membership has recently grown by 4%, a development which may be due to differential pricing at IT conferences and schools.

Motion: Vote to require all IT School attendees to be IT Society members. Motion was passed.

8) Elza Erkip presented the Conference Committee Report. The first item was the presentations for the ISIT 2018 proposals. Babak Hassibi presented the proposal for ISIT 2018 in Los Angeles, CA. The dates are July 15–21, 2018. The general chairs are Salman Avestimehr, Giuseppe Caire, and Babak Hassibi. The TPC chairs are Young-Han Kim, Frederique Oggier, Greg Wornell, and Wei Yu. The venue is the JW Marriott LA Live. The registration fee for IEEE IT Society members (advance) is $875. The expected total cost is $569.6k, with a surplus of about 10%. Babak emphasized that Los Angeles is a major hub for IT activity, and an accessible, convenient and beautiful location, with many attractions as well as culinary and cultural diversity.

Mahesh Varanasi presented the proposal for ISIT 2018 in Vail, CO. The default choice for the dates is July 8–13, with the alternative dates being June 24–29. The general chairs are Ruediger Urbanke and Mahesh Varanasi. The TPC chairs are Syed Jafar, Andrea Montanari, and Chandra Nair. The venue is the Vail Cascade hotel. The registration fee for IEEE IT Society members (advance) is from $780 to $810. The expected total cost range from $494k to $589k. Vail is about 2 hours by car from the Denver airport, with a shuttle

service available between the two locations. Mahesh emphasized the beauty and intimate scale of the location, which may foster more interactions at the conference.

The presentations for the ISIT 2019 proposals followed. Vitaly Skachek presented the proposal for ISIT 2019 in Helsinki, Finland. The organizing committee are Marcus Greferath, Camilla Hollanti, Vitaly Skachek, and Olav Tirkkonen. The TPC chairs are Michael Gastpar, Muriel Medard, B. Sundar Rajan, and Aylin Yener. Possible venues are Messukeskus Helsinki, Expo and Convention Centre, Finlandia Talo Huset Hall, and Dipoli Center, Aalto University. The registration fee for IEEE IT Society members (advance) is from 730 to 800 euros. The conference will aim for a 11% surplus. Vitaly emphasized the low price level of the location and the high activity level in the communications area in Finland.

Emanuele Viterbo presented the proposal for ISIT 2019 in Melbourne, Australia. The proposed dates are June 16-21, 2019. The organizing committee are Emanuele Viterbo and Parastoo Sadeghi. The TPC chairs are Sundar Rajan, Michael Gastpar, and Emina Soljanin. The venue is the Melbourne Convention and Exhibition Centre. The registration fee for IEEE IT Society members (advance) is 950 Australian dollars or $732. The Melbourne Convention Bureau will provide guaranteed funding for the conference. Emanuele emphasized the multicultural, safe, and friendly nature of Melbourne, as well as the strong capabilities of the venue.

Al Hero presented the proposal for ISIT 2019 in Paris, France. The proposed dates are July 7-14, 2019. The organizing committee are Al Hero and Pablo Piantanida. The TPC chairs are Giuseppe Caire, Venu Veeravalli, Aaron Wagner, and Gilles Zemor. The venue is in the center of Paris: Maison de la Mutualite on the Left Bank. The registration fee for IEEE IT Society members (advance) is 750 euros. The total cost is estimated to be 608,278 euros, with a 10% surplus. Al emphasized the high accessibility, strong attraction of Paris, as well as the vibrant IT community in the city.

A discussion followed on whether ISIT should lower registration fees given the current surplus in the IT Society budget.

Motion: Vote to approve the proposal for ISIT 2018 from Vail, Colorado. Motion was passed.

Motion: Vote to approve the proposal for ISIT 2019 from Paris, France. Motion was passed.

Elza next presented the ITW 2016 budget. The budget surplus is 8.24% for 180 participants. The early registration fee $586 ($880 residential) for the three-day conference. A comparison was made to previous ITW budgets. The conference committee recommends BoG approval of the budget.

Motion: Vote to approve the budget for ITW 2016. Motion was passed.

Next, Elza moved to discuss technical co-sponsorship of Allerton 2015, CISS 2016, and ISITA 2016. The conference committee recommends BoG approval in all three cases.

Motion: To approve technical co-sponsorship for Allerton 2015. Motion was passed.

Motion: To approve technical co-sponsorship for CISS 2016. Motion was passed.

Motion: To approve technical co-sponsorship for ISITA 2016. Motion was passed.

Elza next discussed a funding request from The Institute Henri Poincare's Thematic Program on the Nexus of Information and Computation Theories, to be held in Paris from January 25–April 1, 2016. The funds would come from the IEEE surplus. A vote on this request will be taken later.

Elza gave a highlight of the discussion items for the October BoG. The items include the ISIT approval process, technical co-sponsorship fees, as well as ISIT and ITW statistics.

Finally, Elza gave an update on the ISIT 2015 budget. The organizers have offered to refund the registration fees of attendees from Korea. This may affect the budget surplus.

9) Anand Sarwate presented the Online Committee Report. The Online Committee members are Anand Sarwate, Matthieu Bloch, Adriaan J. de Lind van Wijngaarden, Stefan Moser, and J. Nicholas Laneman. Anand mentioned that a previous large expenditure ($40k) went towards infrastructure/database upgrades and "behind the scenes" improvements, as well as adding functionality for video support. The current budget covers only "necessary" upgrades and bug fixes. The Committee is currently planning major priorities as opposed to "as needed" items.

   Anand pointed out that the overall goal of the Online Committee is to generate and organize more content for itsoc.org that is member-generated and "outward-facing." This includes increasing the use of the site by "non-core" members and non-members, using the Shannon celebration as a springboard for organizing content, and soliciting tutorials, outreach resources, and other materials to help disseminate and share research and educational materials. Possible major initiatives include: (1) redesign of the ITSOC site: a major overhaul would change the look and feel of the site and modernize it; (2) customizable conference sites: developing an easier mechanism for making sub-sites for conferences, thus giving more control to organizers and taking that cost away from CMS; (3) security and software upgrades: partly maintenance and partly making this easier to update in the future. Web upgrade options (including costs) are as follows: major redesign with a new look and feel for the site ($17550–$39000), improved user management and contact with custom interfaces for users in groups/categories ($31500–$52500), and correspondence with better email lists ($9000–$22500).

   The Online Committee requests $45k to implement a major revision of the website and better communication. This would be in addition to the currently budgeted amount of $20k.

   Motion: To approve $45k for redesigning the ITSoc website and correspondence. Motion was passed.

A discussion followed. It was proposed that previous schools and workshops be archived on IT website. It was suggested that the project could request money from the IEEE $1 million fund. However, this is only possible if the 50% initiative fund is first exhausted.

10) Aylin Yener presented the Schools Subcommittee report. The current members are the committee are Alex Dimakis, Stark Draper, Michael Gastpar, Gerhard Kramer, Young-Han Kim, and Aylin Yener. The school subcommittee has the continuing goal of helping and facilitating the organization of summer/winter schools of information theory over the world. The committee aims to reach out to potential organizers, help with the preparation of the school proposals and recommendations to the BoG. The following Information Theory Schools are taking place in different parts of the globe in different parts of this year: (1) North American School of Information Theory (NASIT), August 2015; (2) South African School, August 2015; (3) Indian School (JTG/IEEE), July 2015; (4) East Asia (Hong Kong) School, June 2015; (5) European School of Information Theory (ESIT), April 2015.

Some brief updates. UCSD is organizing NASIT this year. The organization is on track with advertising emails sent. The society support level for NASIT is 20k. The East Asia (Hong Kong) School has applied and acquired substantial funding from the Croucher Foundation. Hence they no longer need the 15k support the BoG approved for them last year.

Jasper Goseling presented the report on the 2015 IEEE European School of Information Theory, which took place in April 20–24, 2015, in Zandvoort, The Netherlands. The organizing committee are Jasper Goseling (University of Twente), Tanya Ignatenko (Eindhoven University of Technology), Jos Weber (Delft University of Technology), and Frans Willems (Eindhoven University of Technology). The program included tutorial lectures by Stephan ten Brink, Imre Csiszar, Richard Durbin, Young-Han Kim, Michael Langberg, and Stephanie Wehner, poster sessions by students, and presentations on applications and entrepreneurial aspects of Information Theory. There were 89 students and postdoc participants (a record number for ESIT). The school ended with a small surplus.

The school committee has received two proposals so far for 2016: NASIT from Duke and the Australian School of Information Theory from Melbourne.

Gerhard Kramer presented the proposal for the 2016 NASIT at Duke University. The organizers are Henry Pfister, Rob Calderbank, Galen Reeves, Dror Baron, and Matthieu Bloch. The school is to take place June 7–10, 2016 in Durham, NC. The program consists of five two-hour lectures and three poster sessions. Lecture topic ideas include sharp thresholds for boolean functions, advances in random coding bounds, information theory and concentration, and fundamental limits of MIMO. The estimated total cost is $46k. The organizers request funding support at $20k from ITSoc.

Motion: To approve funding at $20k for the 2016 North American School of Information Theory at Duke University in Durham, NC. Motion was passed.

Emanuele Viterbo presented the proposal for the 2016 Australian School of Information Theory at Monash

University in Melbourne. The school will take place January 17–19, 2016. The general chairs are Emanuele Viterbo and Jamie Evans. The program consists of four lectures and an early-career development session. The target attendance is 50 students. The IEEE Australian Communication Theory Workshop (AusCTW) will be held immediately following the IT School from January 20–22, 2016, at the same venue. The school requests ITSoc funding at $15k. This amount will be used to support speaker travel to Australia as well as scholarships to students with financial need.

Motion: To approve funding at $15k for the 2016 Australian School of Information Theory at Monash University in Melbourne. Motion was passed.

11) Frank Kschischang presented the Editor-in-Chief (EiC) Report. Frank expressed thanks to the support of the Executive Editorial Board members, the Peer Review Support Specialist, the Senior Editor, and the Information Director. He reviewed the Associate Editor retirements since July 2014. Giuseppe Durisi, the former Publications Editor, retired in August 2014. The Publications Editor role is now terminated, as the only task in the post-Pareja era is paper-scheduling, which requires approximately 10 minutes per month using IEEE's POPP (Publishing Operations Production Portal) tool. This task is now performed by the EiC.

Frank reviewed the Editorial Board status as of June 2015. The Board currently consists of 45 Associate Editors (AEs). Some further expansion of the Editorial Board is planned. Particular needs exist in compressive sensing and statistics.

The EiC requests approval of the appointment of Xiaohu Tang as Associate Editor for Sequences, and the appointment of Helmut Bolcskei as Associate Editor *pro tempore*.

Motion: To approve the appointment of Xiaohu Tang as Associate Editor for Sequences, and the appointment of Helmut Bolcskei as Associate Editor *pro tempore*. Motion was passed.

Frank then presented some statistics. The number of papers submitted to the Transactions appears to have increased (about 10%) over the past year. The page budget for the Transactions in 2015 was 8500 pages. The actual page count until July was 4120. Frank presented the acceptance and rejection rates in the past 12 months, in overall terms and by editorial area. The fast rejection rate (decision taking fewer than 30 days) is about 15%. Excluding decisions made within 30 days, the median time to first decision is 174 days (the overall median is 157 days). The first decision is reached within one year in 89% of cases. Outliers among Associate Editors are a concern. Frank and Lisa Jess are monitoring this, and sending reminders when appropriate. Some

aggressive action (re-assignment of papers) was taken in July 2014 in one case. One current AE is struggling. Some papers were recently re-assigned to other AEs, including our new AE pro tem.

Frank mentioned that there have been eleven appeal cases since January 2014. Nine have been decided (upholding AE decision in all cases). Two are currently in progress. In one case, the author appealed to the IEEE, with the outcome that the author was allowed to re-submit and receive another set of independent reviews, currently in progress.

Frank requested feedback on the editorial board structure. The EiC job is heavy (requiring one to two days per week on average). There are two models for splitting the job. In the Area Editors model, six area editors are appointed, each managing 7-8 editors. This model has been adopted by *IEEE Trans. on Automatic Control*, *IEEE Trans. on Communications*, *IEEE Trans. on Wireless Communications*. The model was proposed by the 2006 Transactions review committee chaired by A. Vardy, and by the 2011 Transactions review committee chaired by A. El Gamal. In the Shift Register model, the current EiC job is split into two: the EiC, and the "past-EiC." The EiC is responsible for day-to-day paper handling, dealing with authors, reporting to the BoG, and interacting with ScholarOne. The Past-EiC is responsible for production of issues, handling appeals and certificates of appreciation, and interacting with the IEEE Production Portal. Together, both people invite new AEs, write reports, etc.

Finally, Frank discussed the possibility of organizing a special IT Transactions issue for the Shannon Centenary. The idea is to reprint some of the prize-winning or key papers from recent years. Feedback is sought on this suggestion.

12) Helmut Bolcskei presented the report of the External Nominations Committee (ENC). The members are Michelle Effros, Andrea Goldsmith, J. Nicholas Laneman, Paul H. Siegel, and Sergio Verdu. The committee is responsible for nominating ITSoc members for IEEE medals (e.g. Bell, Hamming, Founders), paper awards (Baker and Fink), IEEE Field Awards (e.g. Sumner, Kirchmayer, Fourier), and other major awards: Marconi, BBVA, Dobrushin, Queen Elizabeth, Japan Prize. Helmut mentioned some challenges faced by the committee, including the difficulty of getting people to nominate, the long queues associated with most major awards, lobbying university presidents to put forward nominations for major awards, mechanisms for exchanging information between the IT paper award committee and the ENC, and defining how the information from one year is passed on to the next.

13) Christina Fragouli presented the report of the Broader Outreach/Shannon Centennial Committee. The Committee members are Michelle Effros, Sergio Verdu, Ruediger Urbanke, and Christina Fragouli (with help from Greg Wornell, Emre Telatar, Daniela Tuninetti, Alon Orlitsky, Muriel Medard and others). The main goal is public outreach. Activities include a documentary, centennial celebrations, IEEE milestone, web presence, etc.

The planned film on Shannon has a director/producer Mark Levinson (producer of the award-winning documentary "Particle Fever"), with co-producer Sergio Verdu, and area expertise consultant Tonia Barber. The selection of the executive producers is still in discussion. The approximate budget for the film is $650,000 (estimate by Mark Levinson). The IT Society has granted $25,000 for the film (to be used for first steps such as script). An NSF proposal has been submitted, which requests $300,000 through the IEEE Foundation. Another proposal will be submitted to the Swiss NSF, requesting $50,000. The remaining funds will come from private donors, industry, other IEEE Societies and Foundations (such as the Sloan Foundation).

The IEEE Foundation Account for Solicitation for Charitable Gifts for Claude Shannon's 100th Birthday Celebration is being coordinated by Michelle Effros and Daniela Tuninetti. Steps for its approval include: (1) seeking permission to solicit donations (IEEE BoD approved on May 28), (2) requesting establishment and management of fund (IEEE Foundation meeting on June 19) and (3) review by IEEE Finance Committee (June 18). The Centennial activities will target local communities and the university population. Several universities have expressed interest. The Committee will approach more and encourage volunteer institutions. Materials and ideas will be collected and shared. $10k will be allocated for the IT Society for logo/website/poster design, and commemorative gifts.

The meeting was adjourned at 5:35 PM.

Shannon Centenary

The Shannon Centenary, 2016, marks the life and influence of Claude Shannon on the hundredth anniversary of his birth on 30 April 1916. Shannon is best known for developing the mathematical foundations of communication (establishing the field of information theory) [1], data compression [2], digital computers [3], cryptography [4], circuit complexity [5], flow networks [6], and juggling [7], as well as laying foundations of artificial intelligence [8, 9] and human–computer interaction [10].

Planned events around the world include the following:

- Australian School of Information Theory, Monash University, Melbourne, Australia, 18–19 January 2016.
- Boole Shannon Lecture Series, Massachusetts Institute of Technology, USA.
- Shannon Year@UMD, University of Maryland, 2016
- Bombay Information Theory Seminars (BITS), IIT Bombay and TIFR Mumbai, India, 1–3 January 2016.
- Boole/Shannon Exhibit, Museum of Science, Boston, MA, USA, 1–30 April 2016.
- Benelux Shannon Centenary, TU Eindhoven, Netherlands, 13 April 2016.
- First Shannon Conference on the Future of the Information Age, Bell Labs, Murray Hill, NJ, USA, 28–29 April 2016.
- Claude Shannon Web Exhibit, Bell Labs, Murray Hill, NJ, USA, 30 April 2016.
- Claude Elwood Shannon 100th Birthday Celebration at the Heinz-Nixdorf Museum, Paderborn, Germany, 3–4 May 2016. Claude Shannon Exhibit, MIT Museum, USA, 1 June - 31 July 2016.
- Claude Shannon Exhibit, MIT Museum, USA, 1 June–31 July 2016.
- Shannon Symposium, Institute for Advanced Study, Princeton, NJ, USA, 16 Nov 2016.

If you are interested in organizing a Shannon Centennial outreach event (see http://www.itsoc.org/resources/Shannon-Centenary/), please send an email to christina.fragouli@ucla.edu, to find out about resources and support we can provide. Many thanks to all who already volunteered! The centennial committee.

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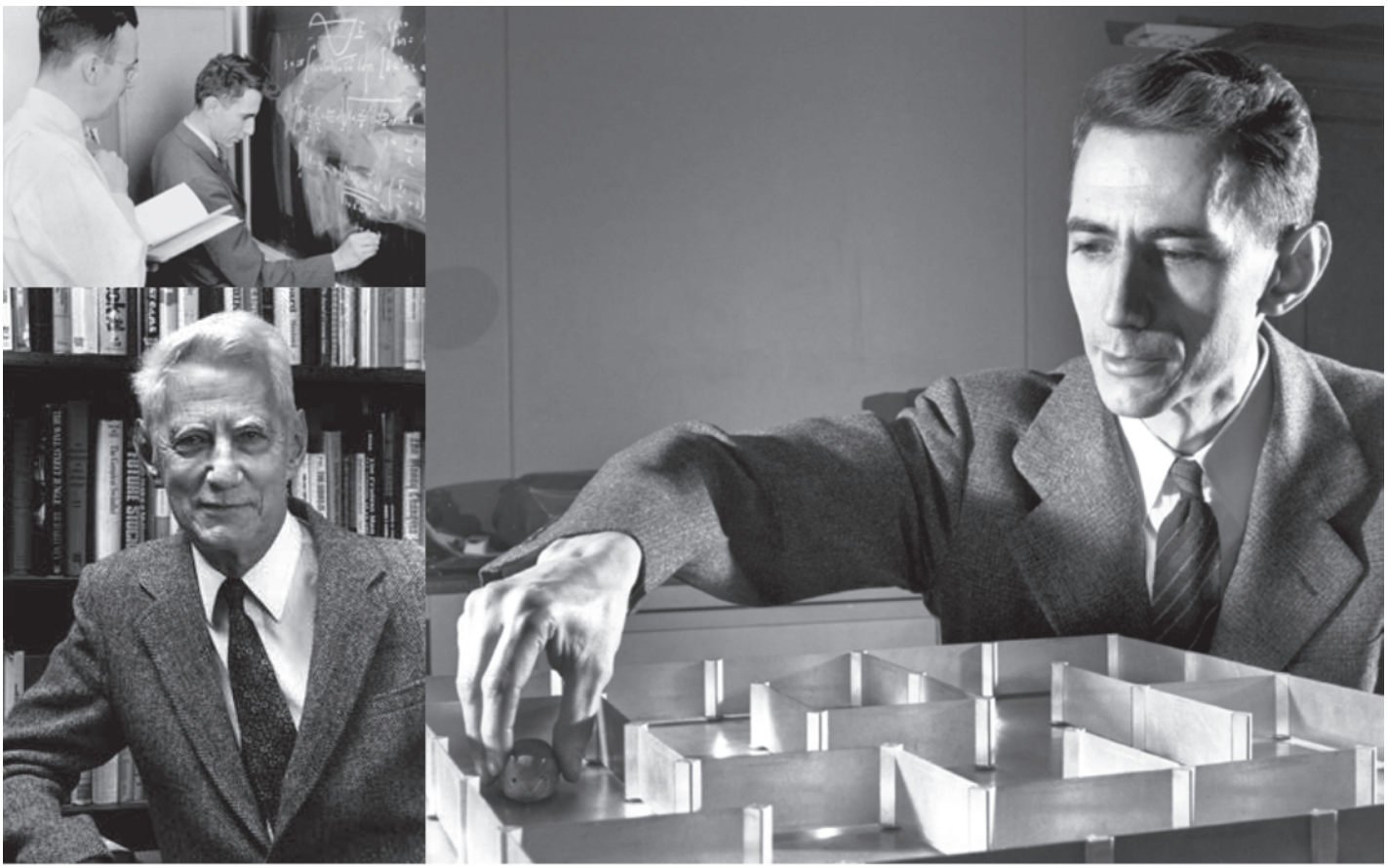


First Shannon Conference on the Future of the Information Age

HOSTED BY BELL LABS TO CELEBRATE CLAUDE SHANNON'S CENTENNIAL AND THE CONTINUED IMPACT OF INFORMATION THEORY IN OUR SOCIETY

DATE: **April 28-29, 2016**
LOCATION: **Murray Hill, New Jersey**
ATTENDEES: **250 leaders, visionaries and researchers from industry, academia and Bell Labs**

We are at the dawn of a new digital era, where everyone and everything will be digitally connected and controllable, allowing an unprecedented level of automation and consequently the ability to 'create time'. The extent of disruption to human existence will be such that this will likely be viewed as the 6th technological revolution of the modern era. This revolution will result in a massive change in the global techno-economic fabric, with a wholesale shift towards a new global-local paradigm, where any digital 'good' is accessible, anywhere. Furthermore, with the emergence of ever more sophisticated 3D printing techniques, physical goods will be able to be locally recreated on demand anywhere, at any time. In tandem, these phenomena will drive the 'virtualization of existence'.

The net effect will be to remove all significance of location and create a new real-time, global-digital+local-physical economy, the like of which has never been seen before in human history. The magnitude of change will be comparable in the departure from the past - and impact on the future - to the agricultural revolution 12 millennia ago, the industrial revolution 2 centuries ago. This revolution is rooted in the dawn of the Information Age, characterized by the shift from industrial activity to an information-based economy, based on emergence of digital computing and digital transmission techniques, which were in turn based largely on the information theoretic concepts defined by Claude Elwood Shannon.

Bell Labs
Alcatel·Lucent

First Shannon Conference on the Future of the Information Age

April 28-29, 2016, Murray Hill, New Jersey

In 2016, Bell Labs will celebrate the centennial of Shannon's birthday – April 30th, 1916 – by hosting a unique 2-day conference focusing on a discussion of the future digital information economy and the impact of information theory on society today and in the digital future. This special event will celebrate Shannon's life and influence and commemorate his profound impact with the creation of new Bell Labs Shannon Visionary Awards that will be presented at the event.

Day One will consist of a set of keynote talks and fireside conversations with leaders and visionaries in the Information Society, with a provocative but informed discussion of our digital past, present and future, in the classic Bell Labs tradition. There will be personal recollections of Shannon, as well as an exhibit of previously unreleased Shannon memorabilia. Bell Labs researchers will also showcase some of their latest innovations based on new applications of information theory to multiple domains, from social graphs to wireless beamforming and novel future optical transmission systems.

Day Two will comprise a series of leading technical presentations outlining the latest work that is building upon Shannon's work not only in the traditional area of communication, but also progressively in such disparate areas as bioinformatics, economic systems, social networks, etc. Day Two will also include a student competition in novel information theoretic tools and applications.

Day One - April 28

Morning session

Keynote Talks and Awards

Talks on the Future Information Society by global luminaries and visionaries who will be recognized with Bell Labs Shannon Visionary Awards

Afternoon session

Remembering Shannon and His Work

A series of fireside chats with invited speakers:

- Elwyn Berlekamp
- Robert Gallager
- Leonard Kleinrock
- Sergio Verdu
- Andrew Viterbi

Tour of Exhibit of Shannon's early papers and Bell Labs memorabilia

Bell Labs demonstrations of Future Information Society Technologies

Gala Dinner

Day Two - April 29

Technical symposium on information theory in communication, bioinformatics, economics and social systems.

Invited speakers include:

- Emmanuel Abbe
- David Forney
- Gerhard Kramer
- Vince Poor
- Muriel Medard
- Shlomo Shamai
- Amin Shokrollahi
- Christopher Sims
- Emre Telatar
- David Tse
- Rudiger Urbanke

In his groundbreaking paper, "A Mathematical Theory of Communication" (Bell System Technical Journal, July and October, 1948) Claude Shannon laid the formal foundation of a quantitative science of digital information. This theory grew, in part, out of the field of statistical mechanics, where the notion of entropy had been introduced as a measure of disorder in large configurations of atoms and molecules in random physical systems. Shannon's seminal work showed how entropy, appropriately redefined and applied, provided the mathematical means to measure the information content of signals and systems. Immediate areas of application were the quantification of the capacity limits of communication in noisy channels, and shortly afterwards the limits of data compression and reliable storage. Shannon's formal foundations were broadened subsequently to many other application areas, including cryptography, natural language processing, statistical inference, neurobiology and more recently to evolution, ecology, quantum computing, linguistics, pattern recognition and progressively to many areas of what we now call data analytics.

Claude Elwood Shannon 100th Birthday Celebration

At the Heinz Nixdorf Museum in Paderborn, Germany, May 3-4, 2016

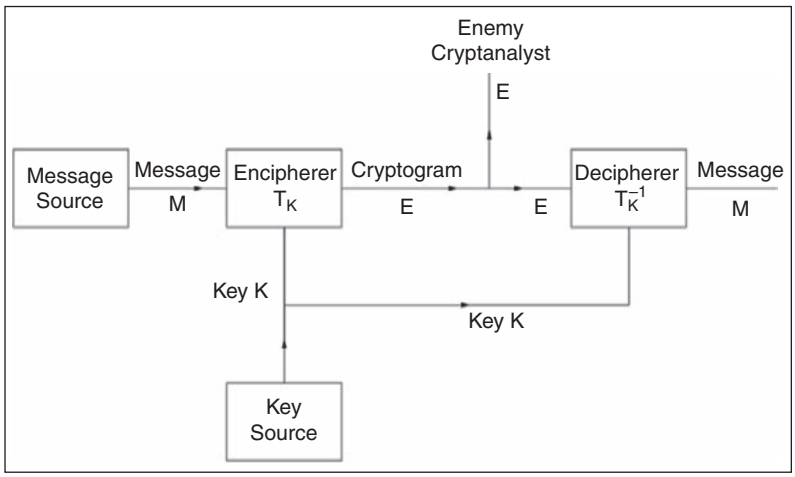
Organizers

Han Vinck, TUM Institute for Communications Engineering, German Information Theory Society Section Chapter

The German Information Theory Society Section Chapter, together with Prof. Han Vinck and the Institute for Communications Engineering (LNT), is organizing a Claude Elwood Shannon 100th Birthday Celebration at the Heinz Nixdorf Museum in Paderborn, Germany on May 3–4, 2016.

The program will feature talks on Shannon's work, including his 1948 paper, cryptography, multi-user information theory, computation, genetics, and coding.

The preliminary program is available at http://www.lnt.ei.tum.de/en/events/claude-elwood-shannons-100th-birthday-celebration/



In Memoriam: Moshe Zakai (1926–2015)

We are deeply saddened by the loss of a dear friend. Moshe Zakai was an extraordinarily talented man who made a major difference in the life and career of those who collaborated with him as well as many of his students. Born in 1926 in Sokólka, Poland, Zakai came to Israel (then Palestine) as a child and passed away on November 27, 2015, in his hometown Haifa.

The advanced status of statistical communication theory and Information Theory in Israel stems historically from the fact that about a century ago, long before the 1948 establishment of the state of Israel, the Technion in Haifa and the Hebrew University in Jerusalem were founded. The Electrical Engineering department at the Technion excelled in classical power engineering and electromagnetic theory.

After the establishment of the State of Israel in 1948 there was an urgent need to quickly develop a technical leadership at the scientific department of the ministry of defence. This led to adopting an innovative policy of encouraging and financially supporting young promising engineers to get a Ph.D. from first league universities abroad. Moshe Zakai was one of the first to benefit from this policy.

From 1956 to 1958 Zakai did graduate work at the University of Illinois and was awarded the PhD in Electrical Engineering. He then returned to the scientific department as head of the communication research group. He encouraged Jacob Ziv, who showed interest in the newly established Information Theory, and later Israel Bar-David, who was interested in radar problems, to use the same program and go to MIT for their D.Sc. degres.

In 1965 Moshe Zakai and Israel Cederbaum, an expert on graph theory and networks, migrated from the scientific department to the Technion EE department; they were later joined by Jacob Ziv and Israel Bar-David. This migration, initiated and led by Cederbaum and Zakai, completely renovated the department, turning the Technion into an advanced academic center excelling in Statistical Communication, Information Theory, Computer Engineering and Probability Theory.

Moshe Zakai was a strong proponent of exploiting modern advanced mathematical tools in the study of communication and radar theory. Motivated by his interests in these topics, he became deeply interested in stochastic differential equations. Soon, together with Eugene Wong, he realized that there was a serious obstacle in applying Itô's theory: white noise is not physical, and Itô's solution was not continuous in the input (in the sense that driving a stochastic differential equation with an approximation of white noise does not yield a solution that is close to Itô's solution).

Together, Wong and Zakai, in a ground-breaking 1965 paper, showed how to resolve this problem: an extra term (now called the *Wong-Zakai correction*) has to be added to the "physical" equation, and with this correction term continuity is restored. This observation now opened the door to rigorous applications of Itô calculus in communication and control on the one hand, and to new developments in the theory of stochastic processes on the other. To some extent, one could interpret Martin Hairer's recent theory of regularity structures (for which he received the Fields medal in 2014) as a suitable way to introduce Wong-Zakai corrections in the setup of nonlinear stochastic *partial* differential equations.

Another topic to which Zakai made a seminal contribution is the theory of nonlinear filtering. Filtering deals with extracting a signal from a noisy observation of it, by computing the conditional distribution of the signal given the observations. In the setup of Gaussian processes, the problem was solved in the 40s by Wiener and Kolmogorov (It is worthwhile to note that Wiener was motivated by control applications, stemming from the WWII effort.) Later, Kalman devised a recursive filter that computed the optimal (linear) filter; Kalman's filter was a crucial element in the development of modern control, radar and communication systems. However, it did not perform well in non-Gaussian situations, where one needed to evaluate the optimal *nonlinear* filter.

The mid 60's saw a flurry of activity in addressing this challenge, and various representations of the optimal filter were derived. However, none of those could be computed effectively, as it required solving an infinite system of coupled stochastic differential equations. Zakai's major insight in his fundamental 1969 paper was to realize that by focusing on an un-normalized version of the conditional density, one could obtain a single bilinear stochastic partial differential equation (the *Zakai Equation*), from which the filter could be easily computed (and which reduces to the Kalman filter in the Gaussian case). Zakai's equation has been the basis for all progress in filtering theory; in particular, modern approaches to compute the filter using genetic algorithms ("particle filters") effectively compute the solution to Zakai's equation.

Already early in his career, and motivated by communication and radar applications, Zakai derived with Jacob Ziv the *Ziv-Zakai* bound on parameter estimation error, exploiting some information theoretic tools in the process. Later, they extended these to the filtering setup. Zakai returned to this problem throughout his career, each time applying new tools. In particular, he derived with his student Ben-Zion Bobrovsky bounds on the filtering problem based on an infinite dimensional extension of the Cramer-Rao bound, and later, with his students Eddy Mayer-Wolf and Ofer Zeitouni, he used ideas from Malliavin's calculus to improve on those.

After a foray with Eugene Wong into the study of multi-parameter stochastic processes, Zakai completed in the last two decades of his professional life his transition to a full time probabilist, working on the Malliavin calculus and its application in the study of changes of measure. In a nutshell, the Malliavin calculus (introduced by Malliavin in 1979) studies the smoothness of the law of Wiener functionals, and in particular of solutions to Itô's equations with respect to perturbations of the driving white noise. Malliavin's original motivation was to give a probabilistic proof of Hörmander's criterion for the regularity of solutions of parabolic partial differential equations. Zakai was one of a handful of probabilists who started working on Malliavin's calculus shortly after its introduction. Very early on, he introduced a different, more geometric, approach, summarized in his influential 1985 paper. He then embarked with Süleyman Üstünel and others on a program to apply these ideas to the study of anticipative changes of measures on Wiener space. Their joint book from 2000 summarizes the theory and is the standard reference for the study of transformations on Wiener space.

Zakai continued his research program well into retirement. In 2005, using Malliavin's calculus as a working tool, Zakai came back to his information theoretic roots and extended the Guo-Shamai-Verdu relations between information, filtering and smoothing in the general Gaussian channel to the abstract Wiener space setup, in a way closing the loop between his early and later research interests.

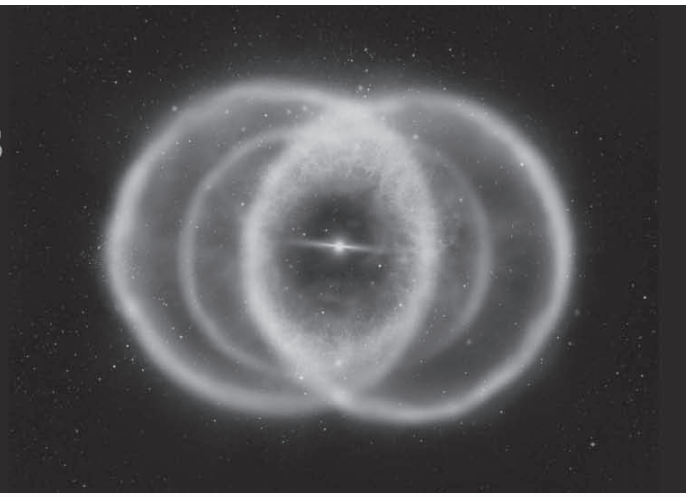
Zakai's work was recognized by many awards, including the IEEE control society prize and Israel's Rothschild prize. He was a Fellow of the IEEE, Fellow of the Institute of Mathematical Statistics, foreign member of the US National Academy of Engineering and a member of the Israel Academy of Sciences and Humanities. He was a strong proponent of employing sophisticated mathematical tools in engineering, and his influence in that direction helped shape the revolution in EE departments worldwide in the 60s and 70s. His voice and mentorship will be sorely missed by his many colleagues, students and friends.

Eddy Mayer Wolf, Ofer Zeitouni, and Jacob Ziv

Nexus of Information and Computation Theories

Institut Henri Poincaré
Spring 2016 Thematic Program
http://csnexus.info

January 25 - April 1, 2016
Paris, France



About the Program

Recently, a number of advances in the theory of computation have been made by using information-theoretic arguments. Conversely, some of the most exciting ongoing work in information theory has focused on problems with a computational component. The primary goal of this three-month IHP thematic program is to explore the rich interplay between information theory and the theory of computation, and ultimately create new connections and collaborations between both scientific communities.

- **Core of the Program:** eight weeks, split across four major themes (see below for details).
- **Central Workshop (February 29 - March 4):** broadly spanning the interface between CS and IT.
- **Tutorial Week (January 25 - 29) at CIRM (Marseille):** designed for students, but all are welcome.

Registration

Researchers and students who are considering attending any part of the program **must register on the website as soon as possible.** Registration is free but mandatory given the limited number of places. During the registration process, one can choose amongst the thematic weeks and/or the central workshop.

Program Organizers

Mark Braverman (Princeton)
Bobak Nazer (Boston University)
Anup Rao (University of Washington)
Aslan Tchamkerten (Telecom Paristech)

About IHP

The Henri Poincare Institute (IHP) is a research institute dedicated to mathematics and theoretical physics. Each quarter, the institute hosts a thematic program that brings together researchers from a particular discipline to foster the exchange of ideas.

ihp Institut Henri Poincaré

Theme Organizers

Distributed Computation (February 1 - 12)
Péter Gàcs (Boston Univeristy)
János Körner (Sapienza University of Rome)
Leonard Schulman (Caltech)

Fundamental Inequalities (February 15 - 26)
Kasper Green Larsen (Aarhus University)
Babak Hassibi (Caltech)
Iordanis Kerenidis (University Paris Diderot 7)
Raymond Yeung (Chinese University of Hong Kong)

Inference Problems (March 7 - 18)
Amit Chakrabarty (Dartmouth College)
Andrew McGregor (UMass Amherst)
Henry Pfister (Duke University)
Devavrat Shah (MIT)
David Woodruff (IBM)

Secrecy and Privacy (March 21 - April 1)
Prakash Narayan (University of Maryland)
Aaron Roth (University of Pennsylvania)
Anand Sarwate (Rutgers University)
Vinod Vaikuntanathan (MIT)
Salil Vadhan (Harvard University)

Call for participation
2016 European School of Information Theory

April 4-8, 2016, Gothenburg, Sweden

The European School of Information Theory (ESIT) is an annual educational event, organized by the IEEE Information Theory Society, for graduate students from institutes throughout Europe and beyond. The objective of the school is to provide the students with the opportunity (i) to learn from distinguished lecturers by attending long-format (3 hour) tutorials, (ii) to present their own work to obtain feedback and to start up collaborations, (iii) to hear about applications of information theory in industry, and (iv) to participate in a stimulating and inviting forum of scientists.

This year topics include wireless networks, distributed-storage systems, fiber-optical systems, modern coding theory, and nonasymptotic Shannon theory. Tutorial lectures will be given by

- Gerhard Kramer
Technical University of Munich, Germany
- Frank R. Kschischang
University of Toronto, Canada
- Vijay Kumar
IISc Bangalore, India
- Yury Polyanskiy
Massachusetts Institute of Technology, MA, USA
- Henry D. Pfister
Duke University, NC, USA
- Emanuele Viterbo
Monash University, Australia

Applications of information theory in industry will be covered in a dedicated session. Finally, poster sessions will give the opportunity to the attendees to present their scientific work, obtain feedback, and initiate novel collaborations in a largely informal setting.

The venue of the school is the Department of Signals and Systems, Chalmers University of Technology, Hörsalsvägen 9-11, Gothenburg, Sweden.

The organizing committee consists of Fredrik Brännström, Giuseppe Durisi, and Alexandre Graell i Amat, all from Chalmers University of Technology.

The registration fee includes social program, meals, and accommodation in two-bed rooms, if desired. Since the number of rooms is limited, accommodation will be provided on a first come, first served basis. Early-bird registration deadline is February 2, 2016. Registration fee will be higher for late registrations. The registration form can be accessed via the school's website.

Further information: http://www.itsoc.org/conferences/schools/european-school-2016

Contact: Dr. Giuseppe Durisi, durisi@chalmers.se, +46 31 772 18 02
Department of Signals and Systems, Chalmers University of Technology, Gothenburg, Sweden

CALL FOR PAPERS

2016 IEEE Radar Conference

Enabling Technologies for Advances in Radar

www.radarconf16.org

IEEE

Key Dates

Paper Summaries Due: 14 November 2015
Notification of Acceptance: 04 January 2016
Paper Submission Due: 05 February 2016
2016 Radar Conference: May 2 – 6, 2016
Loews Philadelphia Hotel, 1200 Market Street, Philadelphia, Pennsylvania, USA

Guide to Paper Submissions

Authors are required to submit a three to four page (inclusive of figures) summary. Electronic submission is required in Adobe pdf format. The cover page must include the title, names of authors (with the contact author identified), organizational affiliation, address, telephone and fax numbers, and email addresses. Authors are permitted to indicate paper suitability for a poster format presentation. Student papers (two to four pages) are also strongly encouraged to be submitted.

All papers must be electronically submitted to the Technical Program Chairman at the *radarconf16.org* web site (available to upload not later than 90 days before the deadline). The deadline for submission of summaries is 14 November 2015. Authors will be notified of acceptance by 4 January 2016, and will receive instructions and forms for publication at that time. Authors will be limited to orally presenting at most two papers at the conference. Your electronically submitted papers in final form will be required by 5 February 2016. They are limited to six pages inclusive of text, figures, and tables. If applicable, government approval for publication as an *unclassified, public-release* paper will also be required with the final paper submission.

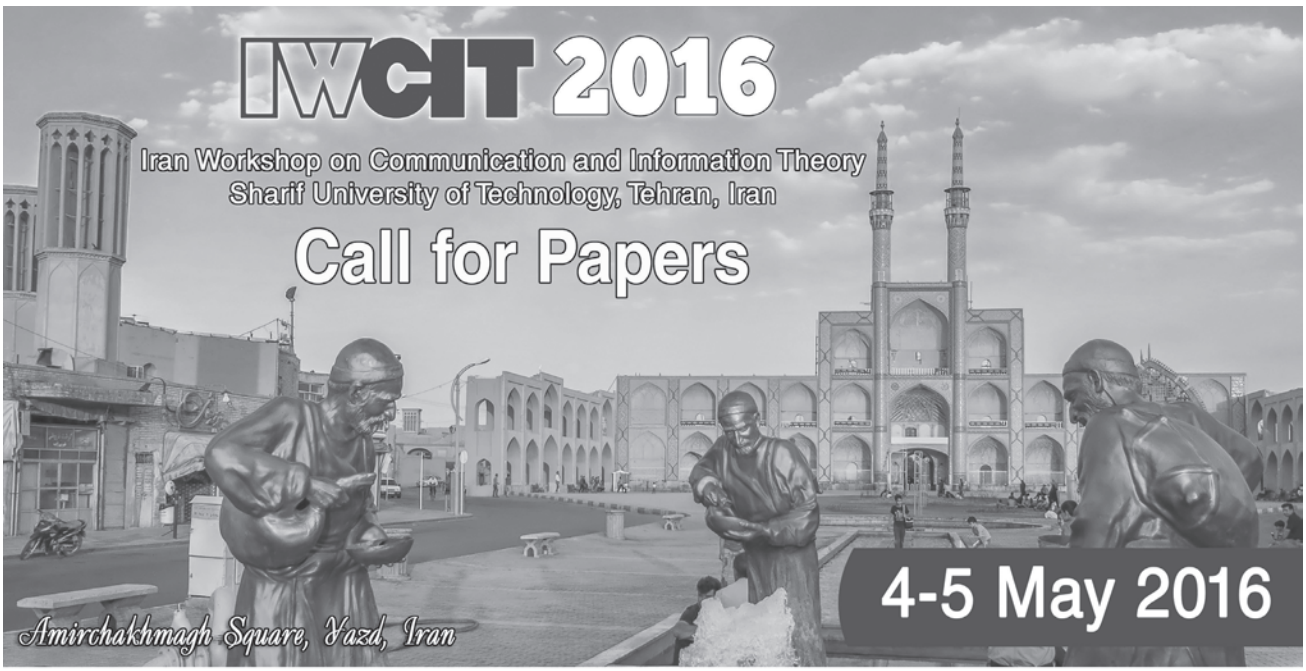
Main tracks

A list of topics within these tracks is on the web site <*www.radarconf16.org*>.

Authors can indicae preference for a track.

Component & Subsystem Development
Radar Signal & Data Processing
Antenna Technolog
Phenomenology
Radar Systems
Emerging Technologies

Technical Program Chair
David J. Farina
Lockheed Martin MST
djfarina@radarconf16.org



The fourth Iran Workshop on Communication and Information Theory will take place at Sharif University of Technology, on May 4th and May 5th 2016, Tehran, Iran. Interested authors are encouraged to submit their original and previously unpublished contributions to the following fields. This conference highly appreciates interdisciplinary related research not necessarily included below.

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

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

Coding Theory
- Compressed sensing
- Data compression
- Network coding

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

Important Dates:
- **Paper Submission: January 11th, 2016**
- **Notification of Acceptance: March 15th, 2016**
- **Camera Ready Submission: April 15th, 2016**

General Chairs:
- Aref, M. R.
Sharif University of Technology
- Sharafat, A. R.
Tarbiat Modares University

Technical Program Chair:
- Salehi, J. A.
Sharif University of Technology

Executive Chairs:
- Gohari, A.
Sharif University of Technology
- Seyfe, B.
Shahed University

Contact Us :
- Email:
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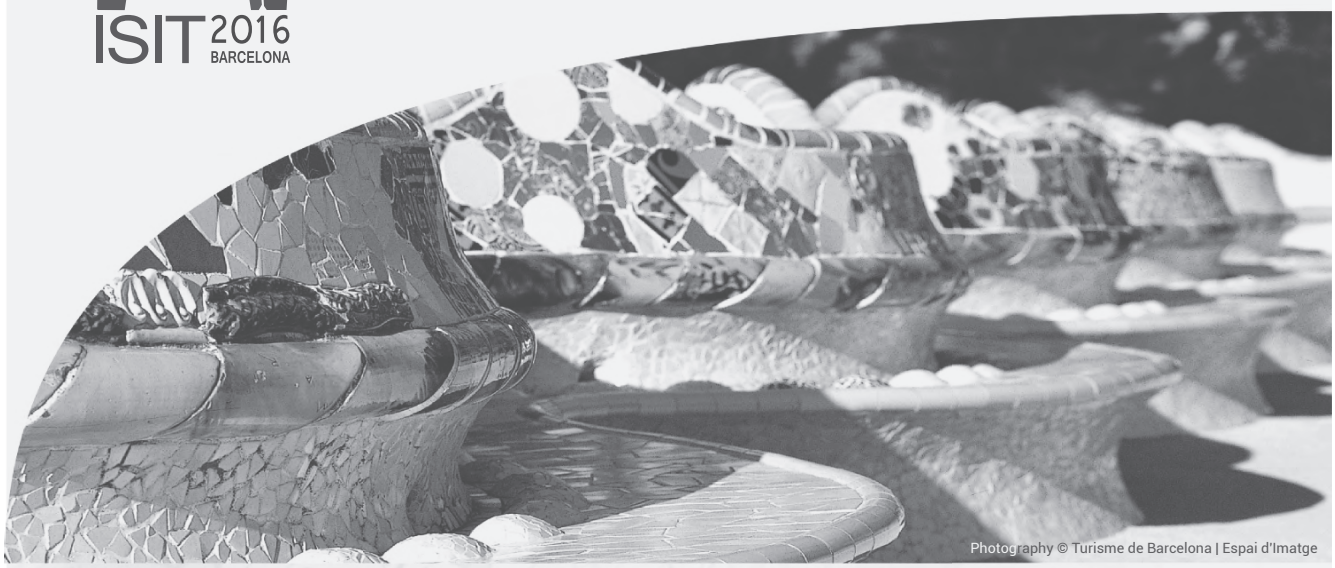
- Address:
Secretariat of IWCIT 2016 Room 503 Dept. of Electrical Engineering Sharif University of Techology Tehran, Iran
Tel : +98 21 66165910

IEEE IRAN SECTION

WWW . IWCIT . ORG

2016 IEEE International Symposium on Information Theory

Barcelona, Spain | July 10-15, 2016



Call for papers

The 2016 IEEE International Symposium on Information Theory will take place in Barcelona, Spain, from July 10 to 15, 2016. A lively city, known for its style, architecture, culture, gastronomy and nightlife, Barcelona is one of the top tourist destinations in Europe. Interested authors are encouraged to submit previously unpublished contributions from a broad range of topics related to information theory, including but not limited to the following areas:

Topics

Big Data Analytics
Coding for Communication and Storage
Coding Theory
Communication Theory
Complexity and Computation Theory
Compressed Sensing and Sparsity
Cryptography and Security
Detection and Estimation
Emerging Applications of IT
Information Theory and Statistics
Information Theory in Biology
Network Coding and Applications
Network Information Theory
Pattern Recognition and Learning
Physical Layer Security
Quantum Information and Coding Theory
Sequences
Shannon Theory
Signal Processing
Source Coding and Data Compression
Wireless Communication and Networks

Researchers working in emerging fields of information theory or on novel applications of information theory are especially encouraged to submit original findings.

The submitted work and the published version are limited to 5 pages in the standard IEEE conference format. Submitted papers should be of sufficient detail to allow for review by experts in the field. Authors should refrain from submitting multiple papers on the same topic.

Information about when and where papers can be submitted will be posted on the conference web page. The paper submission deadline is January 24, 2016, at 11:59 PM, Eastern Time (New York, USA). Acceptance notifications will be sent out by April 3, 2016.

We look forward to your participation in ISIT in the centennial year of Claude Shannon's birth.

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Alfonso Martinez
Sergio Verdú

TPC Co-Chairs
Venkat Anantharam
Ioannis Kontoyiannis
Yossef Steinberg
Pascal Vontobel

Finance
Stefan Moser

Publications
Tobias Koch

http://www.isit2016.org/

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Secretary
Ken-ichi Iwata Univ. of Fukui

ISITA2016

October 30–November 2, 2016

Monterey, California, USA

The **International Symposium on Information Theory and Its Applications (ISITA)** is a leading conference on information theory. Since its inception in 1990, ISITA has been an exciting forum for interdisciplinary interaction, gathering leading researchers to discuss topics of common interest in the field of information theory. In 2016, the biennial ISITA will be held October 30–November 2 at the Hyatt Regency Monterey Hotel in Monterey, California, USA.

Call for Papers

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

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

Paper Submission

Authors should submit papers according to the guidelines which will later appear on the conference website:

http://www.isita2016.org/

This link points to the permanent site http://www.isita.ieice.org/2016/. Accepted papers will appear in the symposium proceedings. To be published in IEEE *Xplore*, an author of an accepted paper must register and present the paper. IEEE does not guarantee inclusion in IEEE *Xplore*.

Schedule

Paper submission deadline **April 7, 2016**

Acceptance notification **June 30, 2016**

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

The Asilomar Conference on Signals, Systems, and Computers will be held from November 6 to 9, 2016 in nearby Pacific Grove, California.

Financial Support
The Telecommunications Advancement Foundation

Sponsor
Research Society of Information Theory and Its Applications, Engineering Sciences Society, IEICE

Technical Co-Sponsor
IEEE Information Theory Society

Photo: Flickr/Raghuvara Ravikumar

The 2016 IEEE Information Theory Workshop will take place from the 11th to the 14th September 2016 at Robinson College, Cambridge, United Kingdom.

Founded in 1209, the University of Cambridge is a collegiate university consisting of 31 constituent colleges. ITW 2016 will take place at Robinson College, the youngest of the Cambridge colleges founded in 1979, offering modern dedicated conference facilities in a cosy residential setup and easy access to the sights and attractions in central Cambridge that lie within a ten-minute walk of the college.

Plenary Speakers

Yonina Eldar, *Technion—Israel Institute of Technology*
Andrew Blake, *Microsoft Research Cambridge*
Thomas Strohmer, *University of California, Davis*

Call for Papers

The 2016 IEEE Information Theory Workshop welcomes original technical contributions in all areas of information theory. The agenda includes both invited and contributed sessions, with a particular emphasis on the interface between:

- Information Theory, Statistics and Machine Learning
- Information Theory and Compressed Sensing
- Information Theory and Radar

Paper Submission

Authors are invited to submit previously unpublished papers, not exceeding five pages, according to the directions that will appear on the conference website: ***http://sigproc.eng.cam.ac.uk/ITW2016***
The ITW proceedings will be published by the IEEE and will be available on IEEE Xplore.

Schedule

Paper Submission Deadline: 13th March 2016
Acceptance Notification: 12th June 2016
Final Paper Submission: 31st July 2016

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Deniz Gündüz, *Imperial College London*
David MacKay, *University of Cambridge*
Jossy Sayir, *University of Cambridge*

TPC Co-Chairs

Helmut Bölcskei, *ETH Zurich*
Robert Calderbank, *Duke University*
Miguel Rodrigues, *University College London*

Financial Chair

Ramji Venkataramanan, *University of Cambridge*

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Publicity Chair

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UNIVERSITY OF CAMBRIDGE IEEE

sigproc.eng.cam.ac.uk/ITW2016

CALL FOR PAPERS

IEEE Journal on Selected Areas in Communications

Channel Modeling, Coding and Signal Processing for Novel Physical Memory Devices and Systems

Advancements in the theoretical foundations from 70 plus years of signal, information and communication theories have been used with phenomenal success in data storage systems starting from punch cards to today's sophisticated memory devices. However, existing approaches designed for simpler channels do not meet the needs of new storage technologies where the data must be packed densely in two and higher dimensions with various read, write and media conditions. This requires a fundamental understanding into the channel characterization under adverse physical constraints, information-theoretic limits for storage and practical ways for getting to the storage limits by novel signal processing and coding techniques.

At the device level, recent advances in data storage technologies, such as 3D non-volatile memories (NVM), shingled and two-dimensional magnetic recording (SMR and TDMR) and energy-assisted magnetic recording (HAMR) are bound to transform the storage industry in the next few years. These technologies require the information to be stored and accessed in higher dimensions. Also, emerging technologies such as STT RAMs, phase change memories, memristors etc. are bound to transform the future of data storage. At the system level, we need new architectures catering to high throughput and better energy efficiencies with lower cost for realizing and integrating the Silicon architectures into the memory hierarchy.

The possible topics include, but are not limited to:

- Novel aspects of read, write and media characterization for emerging physical memories
- Channel modeling for emerging storage technologies such as STT RAMs, memristors etc.
- Analysis of novel recording paradigms and performance evaluation
- Information theoretic limits for storage over new physical memory channels
- Practical coding methods cognizant of underlying physical constraints
- Innovative signal processing algorithms for analog front end, synchronization, equalization and detection for emerging storage technologies
- Architecture and design of coding and signal processing subsystems for new non-volatile memories, magnetic and optical memories
- Practical coding methods cognizant of underlying physical constraints, parallelizable coding algorithms for higher throughput

Original, previously unpublished research articles will be considered. Authors should follow the IEEE J-SAC manuscript format described in the Information for Authors, which can be found at

http://www.comsoc.org/jsac/author-information

Prospective authors are requested to e-mail their manuscripts to one of the Guest Editors according to the following timetable (tentative, to be discussed with the Editor in Chief):

Manuscript submission: April 15, 2016 — Acceptance notification: June 15, 2016

Final manuscript: July 8, 2016 — Publication: Third quarter of 2016

GUEST EDITORS:

Shayan Garani Srinivasa (IISc), Tong Zhang (RPI), Ravi Motwani (Intel Corporation), Haralampos Pozidis (IBM Zurich) and Bane Vasić (UA), Muriel Medard (Editor-in-Chief)

Post-Doctoral Postions, Center For Science of Information

Howard University, Center For Science of Information

Description: Postdoctoral position in machine learning and information sciences in the Department of Computer Science, Howard University and the Center for Science of Information (CSoI), a National Science Foundation Science and Technology Center
Location: Department of Computer Science, Howard University
PI: Mugizi Rwebangira

A postdoctoral position is available to work on machine learning and information science at Howard University. The projects will involve developing novel machine learning algorithms with a particular focus on semi-supervised classification, active learning, transfer learning and related ideas. The potential candidate will have a strong background in algorithms, statistics and machine learning theory and be conversant with the latest developments. The project will provide excellent training to postdoctoral fellows in the areas of machine learning, statistics and algorithms. In addition to this primary project, the postdoctoral research fellow will also have opportunities to contribute to ongoing research projects in natural language processing and computational biology.

Howard University is a partner in the Center for Science of Information based at Purdue University. The mission of the Center for Science of Information is to advance science and technology through a new quantitative understanding of the representation, communication, and processing of information in biological, physical, social, and engineered systems. Regarding the research group, we are a dynamic group working on machine learning and its applications. We are committed to developing technologies that have significant potential to make an impact and disseminating these results. The laboratory currently has 4 graduate students and on average 5-8 undergraduate researchers. The successful candidate is expected to serve in a leadership role with respect to education and mentoring of graduate and undergraduate students and participate as needed in CSoI related activities.

Qualifications: Applicants should have a Ph. D degree, a strong publication record and excellent oral and written communication skills.

How To Apply: Interested applicants should submit a current CV with a list of three references here https://www.soihub.org/news-events.php?id=681

The position will remain open until filled.

The Center for Science of Information (CSoI) is committed to diversity and equality of opportunity. Applications from women, minorities, and persons with disabilities are especially encouraged. For questions regarding the submission of your application, please contact Kelly Andronicos, Director of Diversity, Center for Science of Information (kandroni@purdue.edu)

Purdue University, Center For Science of Information

Description: The Center for Science of Information (CSoI) at Purdue University, www.soihub.org , seeks a Postdoctoral Researcher, starting immediately. The selected candidate will work with Purdue Profs. W. Szpankowski and A. Grama on problems in the analysis of algorithms, models and methods in data sciences, and information theory. Additionally, the candidate is expected to participate in relevant Center-related activities including education and research activities. The appointment will be for a period of 12 months, renewable by mutual agreement for another year. Shorter periods may also be considered.

The mission of the Center for Science of Information is to advance science and technology through a new quantitative understanding of the representation, communication, and processing of information in biological, physical, social, and engineered systems.

Qualifications: Applicants should have a Ph. D degree, a strong publication record and excellent oral and written communication skills.

How To Apply: Interested applicants should submit a current CV and a one-page research statement.

https://www.soihub.org/news-events.php?id=680

The position will remain open until filled.

The Center for Science of Information (CSoI) is committed to diversity and equality of opportunity. Applications from women, minorities, and persons with disabilities are especially encouraged. For questions regarding the submission of your application, please contact Kelly Andronicos, Director of Diversity, Center for Science of Information (kandroni@purdue.edu)

Call for Nominations

(ordered by deadline date)

• IEEE Information Theory Society Claude E. Shannon Award

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

NOMINATION PROCEDURE: Nominations and letters of endorsement must be submitted by **March 1, 2016**. All nominations should be submitted using the online nomination forms. Please see http://www.itsoc.org/shannon-award for details.

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

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

NOMINATION PROCEDURE: Nominations and letters of endorsement must be submitted by **March 1, 2016**. All nominations should be submitted using the online nomination forms. Please see http://www.itsoc.org/wyner-award for details.

• IEEE Fellow Program

Do you have a colleague who is a senior member of IEEE and is deserving of election to IEEE Fellow status? If so, please submit a nomination on his or her behalf to the IEEE Fellow Committee. The deadline for nominations is **March 1 2016**.

IEEE Fellow status is granted to a person with an extraordinary record of accomplishments. The honor is conferred by the IEEE Board of Directors, and the total number of Fellow recommendations in any one year is limited to 0.1% of the IEEE voting membership. For further details on the nomination process please consult: http://www.ieee.org/web/membership/fellows/index.html

• IEEE Information Theory Society Paper Award

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

NOMINATION PROCEDURE: Nominations and letters of endorsement must be submitted by **March 15, 2016**. All nominations should be submitted using the online nomination forms. Please see http://www.itsoc.org/honors/information-theory-paper-award/itsoc-paper-award-nomination-form for details. Please include a statement outlining the paper's contributions.

• IEEE Information Theory Society James L. Massey Research & Teaching Award for Young Scholars

The purpose of this award is to recognize outstanding achievement in research and teaching by young scholars in the Information Theory community. The award winner must be 40 years old or younger and a member of the IEEE Information Theory Society on January 1st of the year nominated.

NOMINATION PROCEDURE: Nominations and supporting materials must be submitted by **April 30, 2016**. All nominations should be submitted using the online nomination forms. Please see http://www.itsoc.org/honors/massey-award/nomination-form for details.

• IEEE Information Theory Society Board of Governors

The Board of Governors (BoG) is the governing body of the IEEE Information Theory Society. The Nomination and Appointments Committee welcomes suggestions for candidates for the BoG. Individual voting members of the Society eligible to vote in the election for the Board may nominate Society Members by written petition provided such nominations are made by **April 1st, 2016**. Prior to submission of a nomination petition, the petitioner shall have determined that the nominee named in the petition is eligible and willing to serve, if elected; evidence of such willingness to serve shall be submitted with the petition. Please send nominations to Matt LaFleur, IEEE Technical Community Program Coordinator, m.lafleur@ieee.org

• IEEE Awards

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

Conference Calendar

DATE	CONFERENCE	LOCATION	WEB PAGE	DUE DATE
January 25–April 1, 2016	**IHP Thematic Program on the Nexus of Information and Computation Theories.**	Paris, France	http://csnexus.info	—
March 2-4, 2016	**2016 International Zurich Seminar on Communications.**	Zurich, Switzerland	http://www.izs.ethz.ch	—
March 16–18, 2016	**50th Annual Conference on Information Sciences and Systems.**	Princeton University	http://ee-ciss.princeton.edu	Passed
April 4–8, 2016	**The European School of Information Theory (ESIT)**	Gothenburg Sweden	http://www.itsoc.org/conferences/schools/european-school-2016	—
May 2–6, 2016	**IEEE Radar Conference: Enabling Technologies for Advances in Radar.**	Philadelphia, Pennsylvania, USA.	http://radarconf16.org/#/	Passed
May 4–5, 2016	**4rd Iran Workshop on Communication and Information Theory (IWCIT).**	Sharif University of Technology, Tehran, Iran.	http://www.iwcit.org	Passed
May 9–13, 2016	**14th International Symposium on Modeling and Optimization in Mobile, Ad-Hoc, and Wireless Networks (WiOpt)**	Arizona State University, Tempe, Arizona, USA	http://www.wi-opt.org	Passed
July 3–6, 2016	**The 17th IEEE International Workshop on Signal Processing Advances in Wireless Communications.**	Edinburgh, UK	http://www.spawc2016.org.uk	Passed
July 10–15, 2016	**2016 IEEE International Symposium on Information Theory.**	Barcelona, Spain	http://www.isit2016.org	Passed
September 11–14, 2016	**Information Theory Workshop (ITW)**	Cambridge, UK	http://sigproc.eng.cam.ac.uk/ITW2016	13 March, 2016
October 30–November 2, 2016	**The International Symposium on** Information Theory and Its **Applications (ISITA).**	Monterey, California	http://www.isita2016.org/	April 7, 2016

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