

I dare say that there is no other IEEE society that is a more purely volunteer society than the Information Theory Society. Our society has no staff, and is basically run out of the back pockets of a large number of dedicated and highly responsible volunteers. Moreover, I believe that there is no other IEEE society in which the principal volunteers are so often the principal technical contributors to its field.

The IT Society has no Executive Committee, but the officers of the society form a tight-knit collaborative group who are in continual contact and serve somewhat as an executive committee. I wish to express here my deep gratitude to last year's officers—Steve McLaughlin, Dave Neuhoff, Marc Fossorier, Andrea Goldsmith, and above all Bixio Rimoldi—who helped me enormously in making a smooth transition to my new role. This year Frank Kschischang has started his climb up the officer pyramid. Other officers are Anant Sahai, Treasurer and João Barros, Secretary.

The volunteers who probably spend the most time on society affairs are the editors of the IT Transactions, led by Ezio Biglieri, Editor-in-Chief. The EiC must not only maintain the quality of the Transactions through his astute choice of effective Associate Editors, but is also responsible for the operational and financial aspects of our Transactions. In this the EiC is strongly assisted by Publications Editors Elza Erkip and Adriaan van Wijngaarden. The quality, timeliness, and financial condition of our Transactions remain superb, but Ezio is pushing hard for improvements in our submission-to-publication time, where we continue to lag.

The EiC also chairs the Publications Committee, which formulates policy for the Transactions and other publications. This committee has recently agreed that there is no good reason to continue to make a sharp distinction between Correspondence and regular papers, and has therefore recommended that the Correspondence section of the Transactions be phased out. It has also recommended discontinuing print publication of the annual Transactions index, which has been

superseded to a great extent by electronic tools; the index will still be available on-line.

Daniela Tuninetti, the Newsletter Editor, puts out this publication more or less single-handedly. She is responsible for obtaining a steady stream of interesting contributions, including the regular columns of our Historian, Tony Ephremides, and our Puzzle Master, Sol Golomb.

Beyond publications, the next largest activity of our society is our program of conferences and workshops. The Conference Committee is chaired by Alex Grant, and includes João Barros, Dan Costello, Tony Ephremides, Bruce Hajek, and Anant Sahai. The committee is responsible for stimulating, evaluating and guiding conference proposals. Our next four ISITs seem to be well in hand: Toronto (2008), Seoul (2009), Austin (2010), and



- Last but not least avoid clichés like the plague and seek viable alternatives

Now that you've had enough of that too, consider the witty responses to the solicitation of unlikely titles of papers and books under competition No. 4:

- "Techniques for Factoring Large Primes with Applications to Cryptography" (due to non-other than Sol Golomb),
- "Matrix Inversion using Roman Numerals",
- "An Algorithm for Compression using Lead Weights",
- "Error-producing Codes",
- "Research on Pole Placement at the University of Warsaw",
- "Installing Mufflers on Noisy Channels".

(all by D. Pitt and M. Robinson – anyone knows them?)

- "New Results – A Tutorial",
- "Estimation of Known Signals",
- "Crime-Detection Algorithms",

(sadly, by "yours truly"!)

Ahh! Those were the days.

Column 2008

In my previous column I made reference to Sergio Verdu's usage of "Fleischer's Lemma" in his Shannon Lecture, which was not due to

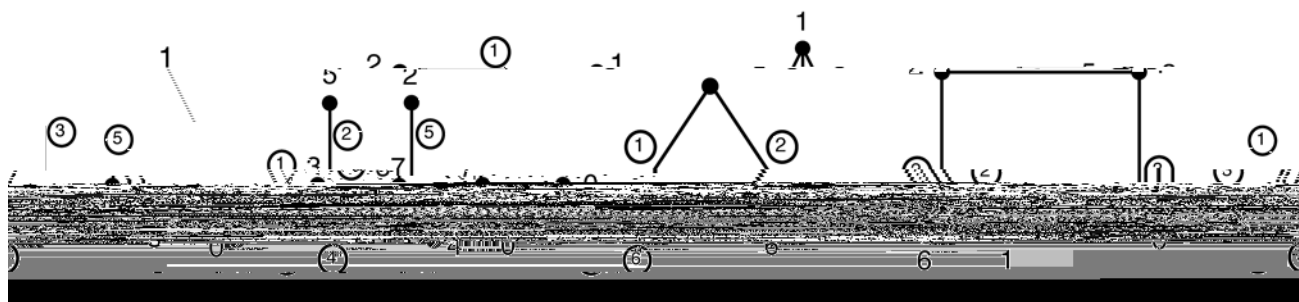


Solomon W. Golomb



We consider a simple connected graph, G , with n nodes (a.k.a. n vertices, or n nodes) and e edges (a.k.a. e edges). We seek to assign a subset of the positive integers from 0 to e to the n nodes in such a way that the e edges get the edge labels from 1 to e , where the label on an edge is the absolute value of the difference between the node numbers at its two endpoints. (Such a numbering of the nodes of G is called a graceful numbering, and if G has such a numbering, G is called a graceful graph.)

Here are some graceful numberings of some fairly small graphs.



(The edge labels are enclosed in circles.)

Problem 1. Find graceful numberings for each of the following graphs.



Problem 2. An Euler circuit on a connected graph is a path that traverses each edge of the graph exactly once and returns to the starting point. (Nodes of the graph may be visited more than once. Of the six graphs in Problem 1, C_3 and C_4 – and no others – have Euler circuits.) Prove the following Theorem: If G is a graph with e edges that has an Euler circuit, then G cannot be graceful if $e \equiv 1 \pmod{4}$ or if $e \equiv 2 \pmod{4}$.

Problem 3. As an application of the theorem in Problem 2, find the three (simple, connected) graphs on 5 nodes that have no graceful numberings.

Problem 4. The complete graph K_n is the graph with n nodes that has $e = \binom{n}{2}$ edges which connect each pair of nodes. Prove the following Theorem: For $n > 4$, K_n is not a graceful graph.

I. The Prime Number Theorem

Sometime before 300 BC someone showed that there are infinitely many prime numbers—we know this because a proof appears in Euclid's famous *Elements*. In modern notation, if we write $\pi(n)$ for the number of primes no greater than n , we can say that,

$$\pi(n) \rightarrow \infty \quad \text{as } n \rightarrow \infty \quad (1)$$

Here's a proof, based on the idea of an argument of Chaitin from

$M^2 \leq N \leq n$, or $M \leq \sqrt{n}$, and noting that the representation (6) is also unique, arguing as before we get,

$$\begin{aligned}
 \log n &= H(N) \\
 &= H(M Y_1 Y_2 \dots Y_{\ell(n)}) \\
 &\leq H(M) + H(Y_1) + H(Y_2) + \dots + H(Y_{\ell(n)}) \\
 &\leq \frac{1}{2} \log n +
 \end{aligned}$$

since for large n the summands in (9) behave like

$$\frac{\log n}{n} + o\left(\frac{1}{n}\right)$$

from (9) we get the heuristic estimate,

$$C(n) = \sum_{\leq n} \frac{\log n}{n} \approx \log n \quad \text{for large } n$$

It would certainly be nice to have an actual information-theoretic proof of Theorem 1 along those lines—Billingsley suggests so too—but the obvious strategy doesn't work, or at least I wasn't able to make it work. The problem is that the approximation of the distribution of the $\{X_i\}$ by independent geometrics is not accurate enough to turn the two " \approx " steps in (8) and (9) into rigorous bounds. That's the bad news. But there's also good news.

IV. A More Elementary Proof

As it turns out, it is possible to give an elementary information-theoretic proof of Theorem 1, albeit using somewhat different arguments from Billingsley's. Here's the more-beautiful-half of the proof; for the other half see [12].

For a $C(n)$ satisfying $C(n) \geq \log n$. The starting point is again

References

- [1] T.M. Apostol, *Introduction to Analytic Number Theory*. Springer-Verlag, New York, 1976.
- [2] P.T. Bateman and H.G. Diamond, *Advanced Topics in Probability*. Amer. Math. Monthly, vol. 103, no. 9, pp. 729–741, 1996.
- [3] P. Billingsley, *Ergodic Theory and Probability*. John Wiley & Sons Inc. New York, 1965.
- [4] P. Billingsley, “The probability theory of additive arithmetic functions,” *Ann. Probab.*, vol. 2, pp. 749–791, 1974.
- [5] H. Bohr, “Address of Professor Harold Bohr,” In *Proceedings of the International Congress of Mathematicians (Cambridge, 1950)*, vol. 1, pages 127–134, Amer. Math. Soc., Providence, RI, 1952.
- [6] G.J. Chaitin, “Toward a mathematical definition of ‘life’,” In *Maximum Entropy and Its Applications (Conf., Mass. Inst. Tech., Cambridge, Mass., 1978)*, pages 477–498. MIT Press, Cambridge, Mass., 1979.
- [7] P.L. Chebychev, “Mémoire sur les nombres premiers,” *J. de Math. Pures Appl.*, vol. 17, pp. 366–390, 1852.
- [8] P.L. Chebychev, “Sur la totalité des nombres premiers inférieurs à une limite donnée,” *J. de Math. Pures Appl.*, vol. 17, pp. 341–365, 1852.
- [9] T.M. Cover and J.A. Thomas, *Elements of Information Theory*. J. Wiley, New York, 1991.
- [10] H.G. Diamond, “Elementary methods in the study of the distribution of prime numbers,” *Bull. Aust. Math. Soc. (N.S.)*, vol. 7, no. 3, pp. 553–589, 1982.
- [11] M. Kac, *Statistical Independence in Probability, Analysis and Number Theory*. Published by the Mathematical Association of America. Distributed by John Wiley and Sons, Inc., New York, 1959.
- [12] I. Kontoyiannis, Some information-theoretic computations related to the distribution of prime numbers. *Preprint, available online*: <http://aps.arxiv.org/abs/0710.4076>, November 2007.
- [13] M. Li and P. Vitányi, *An Introduction to Kolmogorov Complexity and Its Applications*. Springer-Verlag, New York, second edition, 1997.

10.1109/2.2222

, 1970-9-41

10.1109/2.2222



dent website: <http://students.itsoc.org/>.

We are already well into April now, which means we are busy planning the events at the upcoming ISIT. As done every year, we are organizing two events: on Monday, July 7, we will have the research discussion round table and on Thursday, July 10, a panel discussion and committee meeting will be held. As every year, there will be IT Student Society T-shirts free for participants. Both events will be held at lunch time, so don't forget to bring your appetite along with your ideas! As always, please contact Lalitha Sankar if you would like to volunteer as a discussion leader at the round table discussion event. You can propose a round table research topic, or go with one already proposed. You can even throw in your ideas and comments about the student committee events in general. Graduate students and postdocs are both welcome. Don't be shy to volunteer; if you've been to any of the student committee meetings, you know that they are as informal and fun as they are informative!

An exciting new initiative worth mentioning here is the redesign of the student committee web page and the online content. Specifically, our aim is to move to a content management system from the static page that we have, in-line with the overall society-wide effort going on. We thank Anand Sarwate for volunteering to help with this major task, as well as J. Nicholas Laneman and the rest of the IT Web committee. We are at the beginning now and will have more to report on this issue in the near future.

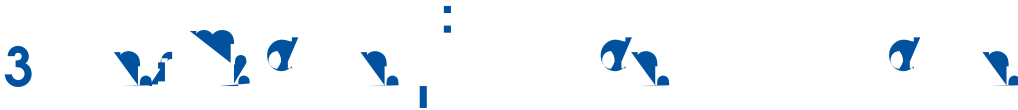
Last but not the least, a major student oriented initiative is the organization of an Annual School of Information Theory. The aim of the School of Information Theory is to bring together graduate students, postdoctoral researchers and senior researchers working on informa-

tion theory related problems in an interactive campus environment once a year. In doing so, we follow the tradition of the European Winter School on Coding and Information Theory and bring it to North America. All the student committee leaders have been and are currently heavily involved in this organization. Aylin Yener and Gerhard Kramer proposed the school last year and they have been working towards raising funds to cover the cost of the school (The school has no registration fee and we hope to be able to award travel grants from remaining funds after the school concludes), as well as the organization, with a lot of help from Ivana Maric and Sennur Ulukus in selection of applications and session organization, Lalitha Sankar and Brooke Shrader in publicizing the school and Nick Laneman for developing the web-site of the school, <http://school.itsoc.org/>.

The First Annual School of Information Theory will be held Sunday, June 1, to Thursday, June 5, 2008, at the University Park Campus of Penn State University, PA. There will be three courses held on June 2, 3, and June 4, by Professors Muriel Medard, David Tse and Toby Berger, respectively. There will also be a panel of senior researchers and a keynote lecture on June 4 and 5. Each student attending the school will give a short presentation and/or a poster.

The response to the call for participation of the school has been well above our expectations, despite the relatively short window of applications. We look forward to the school and will report back here our observations of this exciting event.

That's all from the Student Committee for now. As always, please feel free to contact us with any questions or comments you might have. We hope to involve more student volunteers, once again please e-mail lalitha@princeton.edu if you'd like to participate.



Ever since its inauguration in 2006, the Information Theory and Applications (ITA) centre at UC San Diego has made it an annual affair to hold a workshop. This enables eminent researchers to discuss the latest advances in information theory as well as its appli-

The 2007 Chinese Workshop on Information Theory was held at the South China University of Technology in Guangzhou, China, on December 14-16 2007, hosted by Gang Wei. This is the fourteenth workshop in the series sponsored by the Information Theory Chapter of Chinese Institute of Electronics. The program consisted of two days of technical sessions and forums on information theory related research and education activities in China. In his talk, past president of the IT Society Vijay Bhargava traced the progress of Information Theory in China from the early years. In particular, he mentioned the contributions of Xinmei Wang from Xidian University (who introduced, through a series of technical books, major discoveries in information theory to Chinese colleagues) and the research work presented by Chinese scholars at the 2007 IEEE Information Theory Workshop in Chengdu host-

ed by Pingzhi Fan of South-West Jiao Tong University. Following the conference banquet on 15 December, a meeting of the Chapter was held where it was decided to hold the 15th workshop in Beijing in 2009.

Guangzhou is a historical city that has seen rapid modernization. As the southern gateway to China, Guangdong has also taken up

G



Solomon W. Golomb

For simplicity, we denote the elements of the n -element set A_n by $\{1, 2, 3, \dots, n\}$. We define the cyclic permutation mapping $\sigma : A_n \rightarrow A_n$ by $\sigma(k) \equiv k + 1 \pmod{n}$.

Sirin Tekinay, Program Director for the Communications Program, and
Cyber-Enabled Discovery and Innovation Program



Dear reader,

This is the eleventh quarterly guest column in this series. I'm thrilled to see this space continue to serve its purpose of enabling our interaction on all that impact us as professionals in the communications community as I write about relevant NSF programs and news.

New a U o Pe ea

I continue to serve as the lead for the Cyber-Enabled Discovery and Innovation (CDI) [1] program is "mid-review-process" at the time of writing: a total of some thirteen hundred preliminary proposals were reviewed by multi-disciplinary panels run by teams of two to three NSF program officers mid-February. (This year, Valentine's Day was changed as CDI-Type II Panel Day 1) In the aftermath of these panels, the CDI Working Group and the extended team of panel moderators poured over all of the panel reports and converged relatively quickly on two hundred invitations for the full proposal stage. Full proposals are due on April 29. We will hold the full proposal review panels early in June. It is thrilling to think that mid-July we will have the first set of CDI Awards granted! Among the submitted, then invited proposals, our community is well represented. Also, many of you have volunteered, and served on the review panels. If you would like to volunteer to participate in the CDI review process, please let us know by registering on our reviewer database [2]. As we get ready for the second stage of the CDI review process, we are also busy planning for the 2009 cycle. The solicitation is back on the drawing boards, with its much anticipated budget increase and revised timelines. It should appear by June- please stay tuned!

In the meantime, the CISE-wide Network Science and Engineering (NetSE) Program will be making its first appearance soon, with funding allotted for 2009. I have co-authored the text for the solicitation with my two other colleagues, representing the two other divisions in the directorate.

Speaking of 2009 funding, the entire directorate has joined in synchronizing its solicitations so that all communities served by the Directorate for Computer Information Sciences and Engineering (CISE) can consolidate their research proposal plans accordingly. Here is a deliberately sketchy description of what might happen as a result of our current efforts. Please treat this as work in progress, subject to deviate from the depiction below. Under the CISE umbrella, we will have three "core" programs, corresponding to the three divisions in the directorate. One of these three, Computing and Communications Foundations (CCF), of course includes what is currently "Theoretical Foundations- Communications Research, Signal Processing Research, Theory of Computing, etc." Then, a fourth program will include cross-cutting, CISE-wide program elements. Science for Internet's Next Generation (SING) is now part of NetSE, which is one of these four program elements. The general structure is meant to streamline the submissions to better serve the research community by introducing synchronized, structured timelines for different project sizes and content by staggering the due dates for small, medium and large projects, and introducing limits

on annual submissions to core and cross-cutting programs. What is for certain is that the spirit of this activity is to broaden the scope of impact of collective research output by CISE without sacrificing the usual depth of sharply focused projects.

New o Co - a so Pe o ea

The Theoretical Foundations 2008 Program Solicitation [3] (TF08) closed on March 19, 2008. We ended up receiving about four hundred and fifty proposals, with one hundred and fifty in Communications Foundations. The panels are formed, and we are about to start holding the panel meetings. The last of these meetings will take place mid-June, after which award decisions will have to be made efficiently in order to meet the grants administration deadline so that the awards can be granted by the federal close out. Thank you all for keeping up the submission volume and for all your help in the review process. I am committed to announcing the award decisions by the end of June.

That should give us and the reviewers a breather until we receive the CAREER proposals mid-July.

In addition to being part of the CISE solicitation in the 2009 cycle, I am happy to announce that the communications program element has now grown into a cluster of "Communications and Information Foundations." This cluster will include Communication Theory, Information Theory, and Signal Processing, in addition to emphasis areas of Foundations of Secure Communications, and Quantum Information and Communication Theory. The subtopics that will be covered by the cluster will be grouped together in the new CISE-CCF solicitation.

As of February 8, 2008, Ms Laurin Battle, Assistant to the Communications Program, has moved onto the position of Program Specialist with Cross-Directorate Programs in CISE, after four years of excellent service to our community. If you ever called our office, traveled to NSF, participated in a panel, sent in an inquiry, filed a mail review, in short, interacted with your NSF program in any way, chances are, you already know Laurin. With her professionalism, keen sense of duty, responsiveness, and whirlwind efficiency, she has made it not only easy, but also, with her confident, positive attitude, a pleasure, to run the program with her. Our new program assistant is no stranger to our community: Ms Dawn Patterson, who had filled in for Laurin during her maternity leave last year, is our new program assistant. Dawn will in fact support not only Communications Foundations, but the entire Theoretical Foundations Program. She has already rolled up her sleeves to take on the workload, with her cheerful disposition. The administrative support for our program is in her capable, safe hands.

NSF Pe o e

In every column, I introduce some of the people I work with; who embody the culture and spirit of NSF. This time I would like to introduce the newest Program Director in CCF: Professor Chita

Das, who has been on the faculty at the Pennsylvania State University since 1986, currently a professor in the Department of Computer Science and Engineering, has joined the Computing

Final Manuscript Due: April 1, 2009
Publication Date: Third Quarter 2009

The Guest Editors for this issue are:

Prof. David Costello
University of Notre Dame
Email: costello.2@nd.edu

Prof. Shulin
University of California, Davis
Email: shulin@ece.ucdavis.edu

Prof. Warren
University of Arizona

Email: ryan@ece.arizona.edu

Dr. Tom Rago
Qualcomm, Inc.
Email: tomr@qualcomm.com

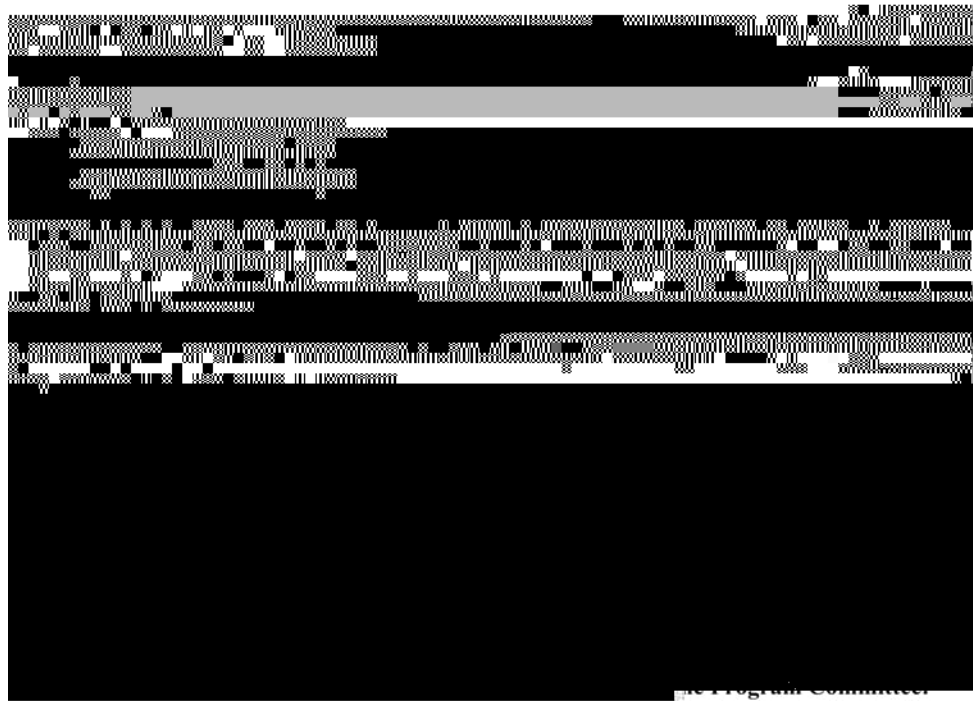
Prof. Ruediger Urbanke
EPFL
Email: ruediger.urbanke@epfl.ch

Prof. Ralf Wesel
University of California, Los Angeles
Email: wesel@ee.ucla.edu

Institute of Information Transmission Problems RAS
IEEE Information Theory Society
Cubana Street 23, Moscow State University of Aerospace Instrumentation

The Workshop "Coding Theory Days in St. Petersburg 2007"

October 10-11, 2007 Friday 10th in St. Petersburg, Russia



Ilya Dumer, Program Co-Chair

Georgiy Kabatazhsky, Program Co-Chair



DATE	CONFERENCE	LOCATION	CONTACT/INFORMATION	DUE DATE
June 16, 2008	IEEE International Workshop on Wireless Network Coding (WNC 2008)	San Francisco, California, USA	http://wine.dnsalias.org/winc2008/	March 30, 2008
June 24 - 26, 2008	24th IEEE International Symposium on Information Theory (ISIT 2008)	Ontario, Canada	http://www.ece.queensu.ca/symposium/	February 15, 2008
July 6 - 11, 2008	2008 IEEE International Symposium on Information Theory (ISIT 2008)	Toronto, Canada	http://www.isit2008.org	January 7, 2008
July 6-9, 2008	IEEE International Workshop on Signal Processing and Communications (SPAWC 2008)	Recife, Brazil	http://spawc2008.org/	February 11, 2008
July 14 - 15, 2008	2008 International Theory of Systems and Information Science (ITSIS 2008)	Las Vegas, Nevada	http://www.bio-complexity.com/ITSIS/ITSIS_index.html	Feb. 25, 2008
August 18 - 19, 2008	Workshop on Information Theory in Tampere (WIT 2008)	Tampere, Finland	http://???fi	--
September 1 - 5, 2008	2008 International Symposium on Turbo Coding and Related Topics (TURBOCODING 2008)	Lausanne, Switzerland	http://www.turbo-coding-2008.org/	March 27, 2008
Sept. 15-19, 2008	2008 International Conference on Communications, Information and Systems (ICCIS 2008)	Valladolid, Spain	http://wmatem.eis.uva.es/2icmcta/	May 15, 2008
Sept. 24-26, 2008	The American Association of Communication Engineers (AAACE) 2008	Monticello, IL, USA	http://www.comm.csl.uiuc.edu/allerton/	July 1, 2008
Oct. 6-10, 2008	Workshop on Coding Days (CODING DAYS)	St. Peterburg, Russia	http://k36.org/codingdays/	June 1, 2008
Dec. 7 - 10, 2008	2008 International Symposium on Information Theory (ISITA 2008)	Auckland, New Zealand	www.sita.gr.jp/ISITA2008/	May 7, 2008