

IEEE Information Theory

As I write this in April, spring has finally arrived in the north central US and the academic year is winding down. It is a pleasure to look ahead to a summer of outdoor activities and indoor research, with special attention to my favorite information theory topics. Of course, the highlight of the summer will be the IEEE International Symposium on Information Theory (ISIT 2006) in Seattle in July, being organized by

Jodi O'Sullivan, John Anderson, and a host of others. See www.isit2006.org.

Thinking ahead to ISIT reminds me of the two workshops I have already attended in 2006. The information theory year began in February with the Information Theory and Its Applications (ITA) Workshop, sponsored by the newly formed Information Theory and Applications Center at UC San Diego, organized with exquisite detail and humor by Alon Orlitzky and a number of others. Attendees who received the "ITA without tears" email from Alon before departing for San Diego will know just what I mean. This workshop included the inauguration of the new center. With over 400 attendees, it was a smashing success. We are all wondering if they will continue this fine workshop next year. Whether or not they do, we can expect to hear





2005 Joint Information Theory/Communications Society Paper Award: Reflections on MAC-BC Duality

Nihar Jindal, Andrea Goldsmith and Sriram Vishwanath

$$y_{MAC} = \sum_{i=1}^K h_i x_i + z,$$

where z

After a few years of hindsight, we are now able to more clearly see the implications of the MAC-BC duality. First, and most obviously, duality provided a unification of research on the capacity of the MAC and BC, particularly in the fading versions of these channels. There is a great body of literature on optimal power/rate control for the fading Gaussian MAC and BC (c.f. [8] [3] [9] [4]), and one can now see that these two bodies share a direct relationship. Perhaps more important, though, has been the use of duality in the study of the multiple antenna BC, which we discuss next.

In light of Caire & Shamai's groundbreaking work on the multiple antenna BC, an obvious question that followed our initial duality work was whether the same duality relationship applied to the multiple antenna versions of the Gaussian BC and MAC? While it was not yet known that dirty paper coding, which can be used to perform interference pre-cancellation at the transmitter in the BC, achieved the full capacity region, we were able to establish the same duality relationship between the dirty paper coding achievable region (which is now known to be the actual capacity region [10]) and the capacity region of the multiple antenna MAC. Using the same idea as for the single antenna channel, the dual MAC was formed by reversing the roles of transmitters and receivers, and thus corresponds mathematically to taking the transpose of each channel matrix. The equivalence of these two regions was shown by establishing a more complicated transformation between BC input covariances and MAC input covariances that preserves user rates and sum power [11].

The dual MAC expression for the dirty paper coding region led to proofs of the sum capacity-optimality of dirty paper coding [11] [12] (reference [13] provides a proof of the same result not requiring duality), as well as bounds to the full capacity region [14] [15]. Efforts in this field culminated with the work of Weingarten, Steinberg, and Shamai showing that the dirty paper coding region is indeed the capacity region of the multiple antenna BC, although ultimately a proof not requiring duality was derived [10]. In addition, duality has continued to play an important role in research on the multiple antenna BC by allowing for efficient computation of the BC capacity region. The dirty paper coding-based rate equations describing the multiple antenna BC capacity region are not concave functions of the input covariances, and thus are extremely difficult to analyze or numerically optimize. The multiple antenna MAC, on the other hand, can be described by concave functions and thus allows for efficient convex optimization techniques to be employed. As a result, a large majority of information theoretic research on the multiple antenna BC studies the equivalent dual multiple antenna MAC.

Although the treatment of the Gaussian MAC and BC has been a relative success, an unanswered and lingering question is whether the MAC-BC duality can be generalized to other channel models? In the discrete memoryless setting, the challenge is to find a meaningful yet simple relationship between BC's and MAC's. We attempted to attack this question by first considering one of the simplest class of channels: deterministic, or noiseless, channels. While we were able to establish a meaningful dual MAC for the well-known ternary-input, binary-output Blackwell BC [16], we also showed that there exist simple deterministic BCs for which no dual MAC (within our specific framework) exists [17]. These initial results lead to a somewhat pessimistic outlook on the possibility of a very general MAC-BC duality.

Another, possibly more promising, avenue for expanding duality is in the realm of multi-user Gaussian networks, by which we mean multi-transmitter/multi-receiver networks subject to additive Gaussian noise at all receivers. The dual BC and MAC's are formed simply by reversing the roles of transmitters and receivers, and the same idea can be applied to an arbitrary multi-user Gaussian network as well. Thus, it is very tempting to conjecture a similar duality result holds in such networks, but of course such a result cannot be verified since capacity results are in general unknown for such networks.

While it remains to be seen if any such extensions come to fruition, if nothing else the MAC-BC duality was able to unite two seemingly separate branches of the knowledge tree, which, according to Robert Gallager, is the role of theory.

- [1] T. M. Cover and J. A. Thomas, *Elements of Information Theory*. Wiley, 1991.
- [2] P. Bergmans, "A simple converse for broadcast channels with general unknown for such networks.

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- [12] P. Viswanath and D. N. Tse, "Sum capacity of the vector Gaussian broadcast channel and uplink-downlink duality," *IEEE Trans. Inform. Theory*, vol. 49, no. 8, pp. 1912 – 1921, Aug. 2003.
- [13] W. Yu and J. M. Cioffi, "Sum capacity of Gaussian vector broadcast channels," *IEEE Trans. Inform. Theory*, vol. 50, no. 9, pp. 1875 – 1892, Sept. 2004.
- [14] S. Vishwanath, G. Kramer, S. Shamai(Shitz), S. A. Jafar, and A. Goldsmith, "Outer bounds for multi-antenna broadcast channels," in *Proceedings of DIMACS workshop on Sig. Proc. for Wireless Commun.*, Sept. 2002.
- [15] P. Viswanath and D. Tse, "On the capacity of the multi-antenna broadcast channel," in *Proceedings of DIMACS workshop on Sig. Proc. for Wireless Commun.*, Sept. 2002.
- [16] S. I. Gel'fand, "Capacity of one broadcast channel," *Probl. Peredachi Inf.*, vol. 13, no. 3, pp. 106 – 108, July-Sept. 1977, translated in *Probl. Inform. Transm.*, pp. 240-242, July-Sept. 1977.
- [17] N. Jindal, S. Vishwanath, and A. Goldsmith, "On the duality between general multiple-access/broadcast channels," in *Proceedings of Int. Symp. Inform. Theory*, July 2003, p. 313.

On the occasion of Thomas Kailath's 70th birthday, a group of his former students and associates joined to honor his influence and contributions by endowing a fund to support an annual lecture, as well as colloquia, workshops and other research-enhancing activities. Following the example of his remarkably wide-ranging career, the aim of this fund is to foster greater awareness of the power of the mathematics-based disciplines of information theory, communications, computation, control and signal processing to address challenging problems in engineering and, increasingly, the physical, biological and social sciences.

The first of these events - the Kailath Lecture and Colloquium - was held at Stanford during June 9-10, 2005, with a standing-room crowd of more than 200, including many members of the Information Theory Society. The Colloquium began with a morning session on June 9, with talks by John Cioffi and A. Paulraj of Stanford, and Vwani Roychowdhury of UCLA, who was a principal organizer of the event and of the Kailath Fund. A highlight of the occasion was a "Q&A with TK" session in which Prof. Kailath reminisced about his career and fielded questions from the audience about his philosophies of teaching and research. The final event of the day was Prof. Gallager's Kailath Lecture, entitled "The Golden Years of Information Theory." The basic thesis of this lec-

ture was that much of the power and simplicity of the field of information theory has been lost in the exigencies of today's research environment. Rather than being a mere lament, however, the lecture was a call to arms for the community to return to its roots by focusing on elegance and fundamentals.

A video of the Gallager and Kailath sessions can be found at <http://isl.stanford.edu/kailathlecture/>. Slides used in the other talks of the day are also included there.

Following the day's events, a reception and dinner were held at Stanford's Arrillaga Alumni Center, during which many of Profs. Gallager's and Kailath's friends, former students and colleagues, paid tribute to these two giants of our field. It was a remarkable evening, as the many and diverse influences of these two men were recounted. At the end of the evening, Prof. Kailath took the podium and, in a very gracious and moving speech, thanked his family, friends, students and colleagues for their contributions to his life and career.

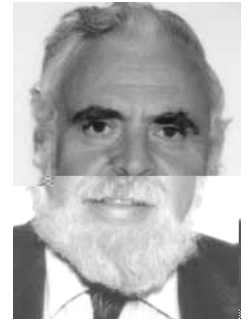
UC-Davis and Dirk Slock of Eurocom. This event concluded with a panel session entitled, "The Next Big Thing in Signal Processing and Communications." This panel, organized by Stanford's Ozgur Oyman and Erik Stauffer, included panelists Helmut Bolcskei of ETH-Zurich, Vincent Poor of Princeton, and David Tse of Berkeley, who opined on future directions in these fields. Again, slides of the day's talks can be found on the above website.

Overall, these events of June 9 and 10, 2005, comprised a very significant occasion. The speakers provided much food for thought about the directions of information theory and related fields, and the inspiring messages from Profs. Kailath and Gallager are certain to influence all of the generations of researchers present.






The next Kailath Lecture is eagerly awaited, and will be delivered on July 6, 2006 by another of Prof. Kailath's MIT classmates, Prof. Jacob Ziv of the Technion. There will also again be two colloquia (on July 6 and 7); one of these colloquia will celebrate the 40th anniversary of the Schalkwijk-Kailath paper on a simple scheme for exploiting noiseless feedback on the Gaussian channel to communicate at channel capacity with the error probability

Classic Mathematical Quickies

Solomon W. Golomb



What these problems have in common is that in each case there is a simple way to arrive at the solution, with minimal computation.

- Suppose that 163 people enter a singles tennis elimination tournament. In the first round, 81 matches are played, and one player has a bye. In the next round, the 81 first-round winners and the bye-holder are paired, and 41 matches are played. In each subsequent round, winners advance, losers are eliminated, and bye-holders (if any) also advance to the next round. Eventually a single overall winner emerges. How many actual matches (not counting byes) are played in the entire tournament?
- There are 200 green marbles in a green jar, and 200 red marbles in a red jar. Thirty green marbles are taken from the green jar and inserted into the red jar, which is then thoroughly shaken. Then thirty marbles are taken from the shaken red jar and put into the green jar. Are there now more red marbles in the green jar, or green marbles in the red jar?
- A cubic ice cube, 2 cm on each edge, is floating in a level cylindrical jar of water, filled to the brim, at a temperature of 4°C. The inner dimensions of the jar are that the circular base has an 8 cm diameter, and the height is 6 cm. When the ice cube has melted completely, how much water (in cm³) will have spilled over the rim of the jar?
- You bought 650 shares of ZYX Corp. at \$86.50 per share. Over the next three months, the stock declined in value by exactly 20%. However, over the following three months, the stock then went up by 25%. Six months after your original purchase, by how much (in dollars) are you now ahead (ignoring any commissions for buying or selling)?
- John and his grandmother both celebrate their birthdays on January 16. Next year, on their common birthday, John's age will be exactly half that of his grandmother's. When will John be as old as his grandmother was on the day that John was born?
- Evaluate the product $(x - a)(x - b)(x - c) \cdots (x - z)$ in the case that $a = 1, b = 2, c = 3, \dots, z = 26$.
- Mr. and Mrs. Jones have invited five other (heterosexual) couples to a dinner party. Their rectangular dinner table has one chair at each narrow end, and five chairs along each of the two long sides. Mr. and Mrs. Jones wish to sit at the two narrow ends of the table, and to seat their guests along the two long sides in such a way that men and women alternate all around the four sides of the table. In how many ways can this seating be accomplished?
- The five *tetrominoes* are the five shapes, , , , , and , each consisting of four unit squares. Can you assemble these shapes to form a 4 × 5 rectangle? (The shapes can be rotated and turned over as you wish.)

two thirds of the attendees (in roughly equal parts), with the rest hailing from Argentina, Australia, Austria, Brazil, Britain, Canada, Finland, France, Germany, Greece, Hungary, Israel, Italy, Japan, Korea, Mexico, Norway, Portugal, Spain, and Switzerland.

Elwyn Berlekamp and Jorma Rissanen gave the keynote lectures and the invited and contributed sessions covered most major topics within the purview of the IT Society. The full lineup of talks along

The 2006 IEEE Information Theory Workshop took place in Punta del Este, Uruguay, on March 13-17, 2006. Gadiel Seroussi and Alfredo "Tuba" Viola chaired the Workshop and Ron Roth and Marcelo Weinberger chaired the Program Committee.

Playground of the Argentinean upper crust, Punta de Este is a Summer resort of manicured lawns, manor houses, high-rise apartment buildings, and endless beaches.

With 155 registrants the workshop was a great success technically and otherwise. Uruguay and the United States supplied

Last year, our Societies Symposium visited the Southern Hemisphere for the first time, and was held at the Adelaide Convention Centre, Adelaide, Australia, 4-9 September.

There were 634 participants, including 191 students, and 500 technical papers were presented. 137 delegates received financial aid in the form of free registration and partial travel support. Most of the financial support went to students presenting papers. For the first time in the history of ISIT, published papers were up to 5 pages in length, and were distributed on CDROM.

around speaks for itself. In total, we had just over 100 attendees, not counting family members. Financially, we are proud to have been able to return a solid profit to the society's coffers.

Monday night saw the second social event in the form of a Maori hangi and concert. Trevor Maxwell had encouraged us to "let your hair down" and - as we found out - this didn't have to be particularly encouraged - there was widespread enthusiastic participation in the various performances. I'm sure many of the participants will put their newly-learned haka or poi skills to good use when confronting their local beancounters next time!

Tuesday afternoon was excursion time - in Rotorua that basically means visiting one of the many geothermal areas in the vicinity. Having traipsed around Waimangu Volcanic Valley and cruised around Lake Rotomahana for a few hours, it was time to do the local thing and soak in a natural hot creek in the bush. About half of the participants donned their bathing trunks and

swimsuits and headed straight into Kerosene Creek at dusk. Thanks to the late hour, only fuzzy photographs are available, but we were able to witness some serious mudslinging (literally) among senior academics, with the remaining landside crowds cheering them on!

At the workshop dinner on Wednesday, Masahiro Nakamura received a Best Paper Award for his paper "Ergodic Theorems for Algorithmically Random Sequences".

On behalf of Des and myself, I would once again like to take this opportunity to say thanks to everybody who has helped along the road: You've all been absolutely fabulous and I am looking forward to seeing you soon again, perhaps at ISITA2008, which is planned for New Zealand as you read this. On a personal note, I'd especially like to thank Des for sharing the chair role with me - it's been tremendously reassuring to have such an experienced hand at my side.

This year, the Australian Communications Theory Workshop (AusCTW) visited the West Coast of Australia for the first time, and was held at the University of Western Australia, Perth, Australia, 1-3 February. Since its inception in 2000, AusCTW has been immensely successful in bringing together researchers from Australia and New Zealand working in theoretical aspects of the physical layer, in particular communications and information theory. This 2.5-day workshop provides an opportunity for researchers and postgraduate students to gather in a largely informal environment to share ideas, make contacts and foster collaborative research links. This year there were some 101 participants, including 48 postgraduate students, in attendance.

The workshop was generously sponsored by the Western Australian Telecommunications Research Institute (WATRI), National ICT Australia (NICTA), the Australian Telecommunications Cooperative Research Centre (ATCRC), Agere Systems Australia, the University of Western Australia, the Institute for Telecommunications Research (ITR) at the University of South Australia, and the ARC Communications Research Network (ACoRN), with in-kind support from the University of Newcastle, and technical co-sponsorship by the IEEE Information Theory Chapter (SA/ACT/VIC).

Following the pattern of recent workshops, this years AusCTW ran over two and a half days, with a 45-minute Research Overview presentation starting the technical program on each day. This years Research Overviews were given by Prof. Alex Grant (University of South Australia, "Network coding"); Prof. Tony Cantoni (University of Western Australia, "The jitter equation and its applications in communications and electronics"); and Dr. Alan Coulson (Industrial Research Ltd. New Zealand, "Narrowband interference in OF SCN0 J 0 j 6 w 102445nterference in O5 1 Tc0.240dhops, this yea WestemesearnS6the Uni7ears

Early this year, the IT Society Board of Governors (BoG) approved the new position of Online Editor, which formalizes and extends the former Webmaster role. Shortly thereafter, I was honored to be appointed as the Society's first Online Editor, and officially took the reigns of the Society website effective April 1, 2006. The purpose of this article is to provide context for these developments, summarize goals, and seek the community's input.

The Society website <http://www.itsoc.org/> can increasingly offer valuable services for individual members as well as Society operations as a whole. The most notable recent example of this is Pareja, the Society's web-based paper submission and reviewing system. Other potential examples include mailing lists, discussion forums, conference websites, arXiv updates, and other services. Such services require more than a single person editing static HTML files; they also include writing scripts, administering database servers, and so forth.

In this context, the approved job description for the Online Editor position includes the following responsibilities:

- Oversee all information gathering and dissemination on the IT Society Website.
- Oversee all website planning, development, and implementation efforts.
- Communicate with society volunteers who are involved in ongoing programs (e.g., Student Committee and ArXiv efforts), and develop new programs and initiatives within the Society.
- Communicate all activities and needs with the BoG.
- Communicate with all other Society partners.
- Report to the Society President and BoG.

With these responsibilities in mind, my short-term goals for serving as Online Editor include:

- Leverage existing content in web-readable forms, e.g., Newsletter articles, Journal archives, arXiv updates,
- Evolve the process and tools for member-contributed content, e.g., news, events, tutorials, discussions,
- Identify and staff larger projects, e.g., Pareja and arXiv inte-

gration, Symposium and Book archives,

Many of our objectives can be met by a suitable content management system (CMS) along with appropriate customizations. To wet the Society's appetite for such tools, I have setup a development website at <http://itsoc.ee.nd.edu/>, with submission instructions at <http://itsoc.ee.nd.edu/submissions/>. Currently anyone wishing to serve as a "beta tester" can setup an account on the site and begin contributing structured content such as News, Events, Files, and Folders. Before being officially "published" on the site, each piece of content must be submitted by the author and approved by a "reviewer". Although I am currently the only reviewer, others are welcome to volunteer to review content, especially as things scale. In the short term, I will be moving approved content manually from the development website to static HTML on the official Society website. This process has already occurred for several news items, and the response has been positive.

At this point, we suffer from having more ideas than time, so there are a number of ways that Society members can contribute to the effort. First, those interested in contributing content can kick the tires on the development website and provide feedback. One major area of effort is the translation of the static content from the official website to the development website. Second, those interested in reviewing content or even managing sections of the development website should contact me. If things scale as we would like, there will be plenty of room for such help. Finally, members can take a fresh look at the official website at <http://www.itsoc.org/>, point out items that may be out of date, and suggest other content or services that could be useful to include.

Before wrapping up, I would like to thank several people for their time and energy in establishing the Online Editor position and helping me transition into the role. Junior Past President Steve McLaughlin initiated discussions about the Society website and listened to many of my initial thoughts. He and BoG member Dave Forney helped crystallize ideas through a number of rounds of email. Secretary and former Webmaster Mehul Motani offered some useful brainstorming and helped make taking the reigns of the Society website seamless. Finally, the new leadership of President Dave Neuhoff and First Vice President Bixio Rimoldi have endorsed these efforts and been very encouraging, which is much appreciated. I look forward to working with these and all Society members to make the website an even more useful and valuable part of our community. Please do not hesitate to email me at the link above.

This article is also available at <http://itsoc.ee.nd.edu/Members/jnl/new-online-editor/>.

An Update on the Information Theory Society Student Committee Activities

Andrea Goldsmith, Ivana Maric, Brooke Shrader, and Lalitha Sankaranarayanan

The Information Theory Student Committee is continuing its efforts to make the society of more value to students. The committee is chaired by Andrea Goldsmith and mostly student-run with active volunteers for event planning, website development, and outreach. There is a small advisory committee of regular society members as well.

Among other activities, we are currently planning student events for the upcoming ISIT to be held on July 9 – July 14 in Seattle, Washington. The IT-Soc student committee meeting and the panel will be held on Thursday, July 13 during the lunch. A round table research lunch discussion will also be organized on Monday July 10 around several hot topics, recent results, and tutorial papers in information theory, where groups of students interested in one of these research topics can get together to discuss them. The IT Student Committee is also sponsoring a T-shirt design contest. Designs can be submitted in jpg or pdf format by May 15, 2006 to Ivana (ivanam@winlab.rutgers.edu), Lalitha (lalitha@winlab.rutgers.edu), and Brooke (bshrader@umd.edu). The design selected by student judges will win \$100 USD. The T-shirts will be free to all students that attend the ISIT student committee meeting. We are currently seeking student volunteers to help in organizing these activities, coordinate the contest and help judge the designs. Anyone interested in being a judge for the contest should send email to Lalitha (lalitha@winlab.rutgers.edu) by May 10, 2006. We are also seeking ideas for the ISIT panel discussion.

Furthermore, we are proposing a student paper award to the Board of Governors, as well as discounted ISIT rates for local students, and discounted student membership rates for students that attend ISIT. These proposals will be made at the Board of Governors meeting in July at ISIT. We welcome your input for other initiatives that we might propose.

On Friday, March 24, at the CISS conference, the committee hosted a panel discussion on the tradeoffs between industry and academic jobs, “Academia versus Research Labs: Tales from the Front Lines”. Approximately 40 students were in attendance to hear the views of panelists – Prof. Vincent Poor (Princeton University), Dr. Emina Soljanin (Bell Labs), Dr. Stefano Galli (Telcordia) and Prof. Christopher Rose (Rutgers University). The panelists offered invaluable insights about the careers that lie ahead for students. They pointed out the rewards of working in academia such as freedom in choosing a research path and working with students; and that of the industry in seeing one’s ideas being turned into products and financial benefits. But, they also talked about the drawbacks – distraction from research in academia, current short term goals of industry. It is apparent that the two paths are significantly different and that the gap may be getting even bigger with industry less interested in fundamental problems. Industry these days is interested in “more breath and less depth” noticed Dr. Galli. But once aware of what each job brings, of their rewards and drawbacks, one message was clear – students cannot predict what the hot research field will be by the time they graduate - they cannot “engineer their careers”. An

encouraging and inspiring message that all panelist agreed with was Prof. Goldsmith’s advice: “Do what you love, then you’ll be creative, do good work and you will have a lot of opportunities open to you”. A part of the panel discussion has been recorded and it is available, along with the panel summary and the panelist’s short biographies, on the committee website: <http://itsoc-students.ece.cornell.edu/>

The website contains other valuable resources, including guidelines for getting started and being successful in research; pointers to information theory books, tutorials, and lecture notes/slides; links to research groups working in information theory and local IEEE information theory chapters; how-to guides on topics such as getting started on information theory research, writing journal papers, and job hunting; job listings and resume postings; dissertation postings; a list of upcoming conferences with information theory sessions; and a list of upcoming committee meetings and related events. The society also plans to start taping all Shannon and plenary lectures at ISIT, and links to these recordings will be available on the student website. Visitors to the website will also find instructions for signing up to our mailing list itsoc-students-l@lists.cornell.edu. The mailing list has been quite successful, with students participating from all over the world including North America, Europe, India, and Iran. The list has not been as active as we would like it to be, and we are working to initiate regular interactions via the list.

We are seeking student volunteers for the roles listed below. All interested volunteers should contact our Volunteer Coordinator, Lalitha Sankar (lalitha@winlab.rutgers.edu).

Please note that our activities are open to all students, whether they are IT Society members or not:

- Event planning - Bring us your ideas for and help in organizing panel discussions or social events at upcoming conferences. Is there a particular panel discussion topic you would like to hear? Should we organize a student soccer match during a conference lunch break?
- Website development - Is there something you think should be added or expanded in our website? You can help us by contributing website content!
- Committee outreach - Do you have ideas for how IT-Soc students can get involved with your university or in your country? Let us know!

While we are pleased with the progress of the committee so far, we would like to have more widespread participation and provide more resources to students. The main challenge in doing this is getting the word out to students about the existence of the committee and its activities, getting more students to participate, and to avoid too much of a demand on the volunteers coordinating the committee efforts.

Dear all,

Welcome to our Treasurer's corner, which seeks to provide you with updates on our Society's finances. First, the good news is that our finances are well on the mend (see figure below). One of the reasons is an excellent crop of income from conferences. This however includes a change of accounting rules at the IEEE level. We now account for conferences as they happen, rather than the year after they happen. Thus, we received in 2005 some of the 2005 conference revenue as well as past revenue. Overall, conference income was of \$ 743.4 K rather than the budgeted \$ 348.5 K (we had also slight higher expenses \$ 266.3 K budgeted versus \$ 363.5 K, because of high attendance). Our fortunes were also buoyed by investment income of \$ 67.4 K. Other elements also came in slightly better than budget. The bottom line is that we have for 2005 an expected surplus of \$ 436.1 K, but because of the one-time factors discussed above, we cannot count on this as a repeatable experiment. However, it does put us in the position to consider some initiatives.

Our initiatives address membership growth and reversing the decline of our student membership. We plan to allot \$ 10 K to this initiative. The desired outcome is to allow non-members to receive the member rate if they join IEEE and the Society onsite at the ISIT conference. The member rate will be provided as a credit online that can be applied to join the society online. Moreover, for students, a credit will be issued for society membership, which can be used for the following year in the case of students who already belong to the society.

A further student initiative, in conjunction with Andrea Goldsmith's committee on student members, seeks to recognize student contributions and to encourage students to participate in ISIT and become active participants in the Society's life. This initiative involves:

1. allowing inexpensive day passes to the conference, to allow local students to attend ISIT and become interested in the activities of our society
2. recognizing our student contributions by sponsoring a small number of best student paper awards

As a final note, I would like to remind all that conferences are a vital part of our financial health. If you are contemplating putting

Information Theory Society Board of Governors Meeting

Levering Hall, Johns Hopkins University, Baltimore, MD, March 16, 2005

Mehul Motani

Attendees: Daniel Costello, Anthony Ephremides, Dave Forney, Marc Fossorier, Andrea Goldsmith, Ryuji Kohno, Steven W. McLaughlin, Muriel Medard, Mehul Motani, David L. Neuhoff, Vincent Poor, Gadiel Seroussi, Shlomo Shamai, Joseph A. O'Sullivan, Venugopal V. Veeravalli

The meeting was called to order at 18:15 by Society President Steven W. McLaughlin. The members of the Board were welcomed and introduced themselves.

1. The agenda was approved and distributed.
2. The action items from the previous Board meeting at ISITA in Parma, Italy on October 11, 2004 were reviewed.

The Board reviewed the following action item regarding the open meeting on IT Society Publications that was held at ISIT 2004 in Chicago.

Action Item The Board requested John Anderson to call for an open meeting on IT Society Publications at the next ISIT.

The Board unanimously approved the minutes of the previous meeting with minor amendments.

3. The President presented his report and miscellaneous announcements.

The President reported that he had convened a two-day planning meeting of IT Society officers in Metz, France.

It was noted that membership had dropped from approximately 6000 members in 2001 to approximately 3300 in 2005. Membership development will be a priority for the Society.

It was suggested that it was important to get younger members (e.g., students) involved. This is to be addressed by the formation of an ad-hoc student committee to get them involved in Society activities. This was discussed later as part of membership development.

The Board will consider a proposal on membership development at the next Board meeting.

It was reported that the position of Education officer was to be reinstated.

The relation of the Society to IEEE was discussed, specifically the ever changing revenue structure of our parent organization. This implied an evolving model for the Society.

The Society budget was discussed and it was reported that our largest source of income is non-member subscriptions such as libraries and IEL. It was mentioned that paper members (meaning those who elected to receive paper copies of the Transactions) cost the Society \$100 per member.

That the Society should increase its ties to other Societies and conferences was discussed. There was a discussion about how to get IT related conferences (such as Allerton and CISS) to work with us to put their papers online.

Action Item The Board will consider a proposal on the maintenance of the Society's collection of the Transaction on DVD.

4. Marc Fossorier discussed matters related to Symposia and Workshops.
 - (a) ISIT 2004, Chicago: The final report for ISIT 2004 was presented.
 - (b) ITW 2004, San Antonio: Nothing to report.
 - (c) ISIT 2005, Adelaide: It was reported that things are progressing smoothly. There were 775 papers received. The TPC has met and decided on the papers and sessions, with an acceptance rate of 65%.
 - (d) ITW 2005, New Zealand: It was reported that things are progressing smoothly and that the workshop had received over 80 paper submissions.
 - (e) ITW 2005, Japan: Nothing to report.
 - (f) HISC 2005, Hawaii: Nothing to report.
 - (g) ISIT 2006, Seattle: It was reported that things are progressing smoothly. The organizing committee had held a planning meeting. The program committee is finalized and the plenaries are being worked out.
 - (h) ITW 2006, Uruguay: Gadiel Seroussi presented a proposal for an Information Theory Workshop in Punta del Este, Uruguay. He presented a comprehensive proposal.

The Board unanimously approved the proposal for the IT workshop in Uruguay.

- (i) ISIT 2007: It was reported that things are progressing smoothly. The conference services organization has been selected and the hotel selection is in progress.
- (j) ISIT 2008: There was discussion of a preliminary proposal for ISIT 2008 to be held in Toronto.

The Board will discuss the matter and make the decision at the next Board meeting in Adelaide in

September 2005.

5. Muriel Medard presented the Treasurer's report.

The Society's net worth as of November 2004 was reviewed. The financial activities of the Society conferences and workshops was also reported.

The relative costs of paper and electronic members were discussed and the possibility of increasing the charges for paper members was put forth. There was some concern of loss of membership due to the increased charges.

It was noted that the cost of a paper member is \$100 and the current membership charges are \$30. After much discussion, there was a proposal to increase the paper member fees by \$45. The resulting fee structure is as follows: Electronic member - \$30, Paper member - \$75.

The Board unanimously approved this proposal.

6. The IT Transactions Editor-in-Chief gave an update on the Society Transactions.

The meeting was called to order at 12:30 by Society President Steven W. McLaughlin. The members of the Board were welcomed and introduced themselves.

1. The agenda was approved and distributed.
2. The following action items from the previous Board meeting

- (c) ISIT'05, Adelaide: 500 papers accepted, 7 parallel sessions.
- (d) ITW'05, Japan: Report was presented. Progress going well.
- (e) ITW'06, Uruguay: Everything on track.
- (f) ISIT'06, Seattle: Report was presented. Minor changes discussed but things are on track.
- (g) ISIT'07, Nice: Everything on track.
- (h) ISIT'08, Toronto: Proposal for ISIT to be held in Toronto made by En-Hui Yang.

The Board voted unanimously in favor of the Toronto proposal.

- (i) ITW'06, China: Proposal by Dan Costello.

The Board voted unanimously in favor of the China workshop proposal.

- (j) ITW'07, Norway: Proposal by Øyvind Ytrehus.

The Board voted unanimously in favor of the Norway workshop proposal.

- (k) ISIT'09, Korea: Proposal for symposium to be held in Seoul or Jeju Island.

The Board voted unanimously in favor of Seoul, given that it is a large city with excellent infrastructure.

Action Item The Board requested a detailed budget proposal at the next meeting.

5. Muriel Medard presented the Treasurer's report.

The Society's finances were reviewed. The financial activities of the Society conferences and workshops was also reported.

The Treasures noted that as of May 2005, IEEE TAB requires a 20% surplus on conferences. This is not retroactive but does hold for future conferences.

This matter was discussed and there was a motion to build in a 10% surplus for Society conferences.

The Board voted unanimously in favor of the motion.

6. The IT Transactions Editor-in-Chief gave an update on the Society Transactions.

The EIC reviewed the mail dates, page counts, and page budgets of the Transactions, noting that the annual page budgets for the Transactions were increasing.

There was a discussion on the growth of the Transactions

a job at the NSF, which made me feel great: I must be doing something right!

A Few Words on Process Flows at the NSF: Programs and Solicitations

In the last two issues, I offered some background on the general NSF organization and mission, with emphasis on the directorate, division, and cluster that the Communications Research Program belongs to: Directorate of Computer and Information Science and Engineering (CISE), Division of Computing and Communications Foundations (CCF), and the Theoretical Foundations (TF) Cluster, respectively. In this issue I would like to shed some light on how “program solicitations;” i.e., calls for proposals, are made, now that I have some experience in formulating new programs.

In terms of how they are funded and managed, NSF programs vary from foundation-wide to any group of program directors. Indeed, the quick description of the process that governs program formulation is that it is unstructured. Program directors update existing cyclic programs and formulate new programs. I’m proud to have had the opportunity to do both:

The Theoretical Foundations Program Solicitation is an annual program. This year’s TF [1] solicitation has been completely updated: I have re-worded the communications area and formulated a new area, Science for Internet’s Next Generation (SING). I will talk more about the scientific contents of the solicitation in the next section. The mechanism through which the write up made it to public domain; i.e., publication on NSF’s web site, was fascinating. The internal Program Information Management System (PIMS) weaves the document together out of the responses of the program director to its many prompts. PIMS also manages the authorship rights and review sequence for the document. After I uploaded our solicitation by responding to PIMS prompts, and signaled completion, PIMS started to route the document to administrative and financial reviewers, some in sequence, and some in parallel. Whenever a reviewer asked for changes, PIMS returned the document to me. In the end, what appeared on the web site is part human, part machine generated: leaving me feeling like I have taken a part multiple choice, part essay test and passed!

Recently, an internal solicitation for ideas on new foundation-wide programs was broadcast. I’m delighted that my input was well received. I can’t wait to see it in public domain, if and when it makes it through many iterations, and most importantly, funding decisions. It was not too hard to formulate a new science based on the role of information and communication theories in earth sciences, natural sciences, social sciences, education engineering, but I deem it a privilege to happen to be the program director on hand to do it. After all, is communication not intrinsic to all sciences and the catalyst for the function of the best-engineered system there is: Mother Nature? It must be embedded in all of us, the curiosity to explore how we can predict the hurricane from the wing flaps of that proverbial butterfly.

NSF continuously strives to strike a balance between leading and following the research community. We do not formulate problems in detail, nor scope out research areas to the exclusion of others. On the other hand, we do invite, encourage, and prioritize research in certain areas. As researchers ourselves, we understand that research topics, scope, and approach cannot be dictated. We

merely channel the evolution of research by introducing points of focus along its way.

I was happy to support our foundation-wide research infrastructure program again in March, this time through the MRI (Major Research Instrumentation) panels I helped with. It is my selfish wish to increase funding for infrastructure in our area through the best of proposed research.

I cheerfully continue serve as the CISE representative for the foundation-wide IGERT (Interdisciplinary Graduate Education Research Traineeship) Program [7], I described in the last issue. At the end of March, we received well over four hundred preliminary proposals. Other than the daunting task of setting up panels of boundary spanning researchers to review these brilliant interdisciplinary program proposals, I am dedicated to increasing the participation of our community in this program. We also held a one-day principal investigators' workshop for the 2005 IGERT awardees. It was one of the most gratifying days of my life: I met twenty-five scientists from all disciplines heading up twenty-five programs in new science, each contributed by an average of seven academic departments. The abstracts of these awards make for a most exciting read [8].

REFERENCES:

- [1] <http://www.nsf.gov/pubs/2006/nsf06542/nsf06542.htm> [6] <http://www.knowledgebasednetworking.org/>
- [2] <http://www.nsf.gov/cise/geni/> [7] <http://www.nsf.gov/pubs/2006/nsf06525/nsf06525.htm>
- [3] <http://www.geni.net> [8] <http://www.igert.org/programs.asp>
- [4] <http://www.nsf.gov/pubs/2006/nsf06551/nsf06551.htm> [9] <http://eeweb.poly.edu/faculty/goodman/>
- [5] <http://csc-ballston.dmeid.org/darpa/registration/intro.asp?regCode=yujjuryE> [10] Kim Stanley Robinson, *Forty Signs of Rain*, Publisher: Spectra; Reprint edition July 26, 2005, ISBN: 0553585800

GOLOMB'S PUZZLE COLUMN™

Mini-Sudoku Solution

Solomon W. Golomb



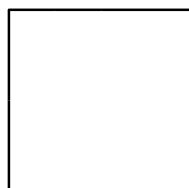
1. There are $288 = 12 \times 4!$ distinct Mini-Sudoku solutions. The factor $4! = 24$ corresponds to all permutations of the four symbols. Here are the 12 cases that differ by more than permutation of the symbols.

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2. Here is a Mini-Sudoku solution in which the four elements on each of the two diagonals are also distinct: (It is the seventh of the twelve cases shown above. The fourth case also has this property.)

1	2	3	4
4	3	2	1
2	1	4	3
3	4	1	2

3. At least four cells must be filled in to guarantee a unique Mini-Sudoku solution. Three distinct symbols must appear, since otherwise two unused symbols could be interchanged in the filled-in solution, destroying uniqueness. I tried all inequivalent ways of placing one each of 1, 2, and 3 in the 4×4 grid, and none of these led to a unique Mini-Sudoku solution. There are many ways to place four symbols that will guarantee a unique solution. Here is one of them:



, which forces .

4. The partial array  gives  very quickly. The lower right corner cannot be 2 or 3.

A 4 in that corner forces a 3 in the upper right corner,  and then the X indicates a cell that cannot be filled in consistently.

Instead, we need a 1 in the lower right corner: , which still allows further choices. Specifically, cases 1 and 3 in the solutions to Problem 1 are possible ways to complete this Mini-Sudoku.

5. Twelve of the sixteen cells can be filled in without leading to a unique solution. There are many examples, such as

, which can become either the first or the second cases in Problem 1.

6. Some, but not all, of the cases shown in the solution to Problem 1 have “orthogonal mates”. Thus, cases 1 and 10 in the solution to Problem

2006, $f_{\Gamma} = \dots$

$$f_{\Gamma} = \dots$$

June 22-26, 2006, <http://www.ieee.org/IT/06/>

IEEE Information Theory Society Newsletter

DATE	CONFERENCE	LOCATION	CONTACT/INFORMATION	DUE DATE
May 21-24, 2006	2006 IEEE Communication Theory Workshop (CTW 2006)	Dorado, Puerto Rico	http://www.ece.rice.edu/ctw2006/	March 15, 2006
May 22-25, 2006	7th ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc 2006)	Florence, Italy	http://www.sigmobile.org/mobihoc/2006/	April 3, 2006
May 30-31, 2006	Signal Processing for Wireless Communications conference (SPWC 2006)	King's College, London, United Kingdom	http://www.spwc2006.org	January 31, 2006
May 30-June 1, 2006	23rd Biennial Symposium on Communications	Kingston, Ontario, Canada	http://www.ece.queensu.ca/symposium/	February 1, 2005
June 11-15,	2006 IEEE International Conference	Istanbul, T		