Parthajit Mohapatra

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EDUCATION

- **Indian Institute of Science, Bangalore, India**   Jan. 2009 - Jan. 2015
  Ph.D. in Electrical Communication Engineering

  Topic: Fundamental Limits of Communication in Interference Limited Environments
  Advisor: Professor Chandra R. Murthy

- **National Institute of Technology, Rourkela, India**   June 2004 - June 2006
  Master of Technology in Electrical Engineering

  Topic: Color Image Segmentation using Markov Random Field Model
  Advisor: Professor Pradipta Kumar Nanda

- **National Institute of Science and Technology, Berhampur, India**   Aug. 1999 - Dec. 2003
  Bachelor of Engineering

  First Class with Honours in Electronics & Communication Engineering

RESEARCH INTERESTS

General research interests are in the areas of *information theory and its application*, *wireless communication* and *signal processing for communication*. Current research topics include *physical layer secrecy*, *advanced communication techniques for future wireless networks*, and *union of information theory and networking*.

HONORS AND AWARDS

- Received institute silver medal for securing first rank in M. Tech. in electrical engineering, *National Institute of Technology*, Rourkela, India, 2006

- Received institute silver medal for being the best graduate in electronics and communication, *National Institute of Science and Technology*, Berhampur, India, 2003

- Received *Croucher Foundation* travel grant for attending the *Croucher Summer Course in Information Theory (CSCIT)*, Hong Kong, June 2015

- Invited to present the poster work on "On the Secrecy Capacity of the Interference Channel with Transmitter Cooperation," *Croucher Summer Course in Information Theory (CSCIT)*, Hong Kong, June 2015

- The paper titled "Outer bounds on the secrecy rate of the 2-user symmetric deterministic interference channel with transmitter cooperation" was shortlisted for the best paper award in communication track, *National Conference on Communications (NCC)*, 2014, Kanpur

- Invited to present the poster work on "Secrecy in the 2-user symmetric deterministic interference channel with transmitter cooperation," *IEEE Communication Theory Workshop (CTW)*,

Phuket, Thailand, 2013

- Received Microsoft student travel grant for presenting the poster work at Communication Theory Workshop (CTW), Phuket, 2013
- MHRD fellowship from Government of India for Ph.D. during 2009-2015

EXPERIENCE

Work Experience

- **Indian Institute of Technology Kharagpur**
  Assistant Professor, Aug. 2016-Present

- **Singapore University of Technology and Design**
  Postdoctoral Research Fellow, Mar. 2015-Jul. 2016
  Affiliated Postdoc Fellow: Wireless Networks and Decision Systems Group

- **eRevMax Technologies Pvt. Ltd.**
  Associate Software Engineer, Jul. 2006-Oct. 2006

Teaching Experience

- **C. V. Raman College of Engineering**
  Bhubaneswar, India, Jan. 2007-Dec. 2008
  Lecturer
  - Digital Signal Processing (Undergraduate level course)
  - Communication Engineering (Undergraduate level course)
  - Adaptive Signal Processing (Graduate level course)

- **National Institute of Technology, Rourkela**
  Teaching Assistant, Jan. 2005-July 2006
  - Microprocessor Laboratory (8085 and 8086)
  - Computer Programming Laboratory (C and C++)

Other Experience

- **Bhabha Atomic Research Centre**
  Mumbai, India, May 2005-June 2005
  Internship
  - Recovery of depth information from 2-D images

RESEARCH HIGHLIGHTS

- **Approximate Capacity Characterization:** In network information theory, the exact capacity of multiuser systems is known in few cases and it is unclear whether it is possible to characterize the capacity in other cases. A promising approach to solving this problem is to seek for approximate solution. In this regard, the concept of Generalized Degrees of Freedom (GDOF) was introduced as a proxy for capacity at high SNR. Specific contributions in this direction include:

- **Inner bounds on the GDOF for Interference Channel:** Proposed new achievable schemes on the GDOF for the K-user Gaussian interference channel (GIC), where transmitters and receivers are equipped with multiple antennas. In many cases, the proposed scheme is found to be GDOF optimal. Several useful and interesting insights on the relative merits of different achievable schemes are obtained.

- **Outer Bounds on the GDOF for Interference Channel:** Proposed new outer bounds on the sum rate for the K-user MIMO GIC. These outer bounds are derived, under different assumptions of cooperation and providing side information to receivers. The derived bounds are simplified to obtain outer bounds on the GDOF. The relative performance of the bounds yield insight into the performance limits of multiuser MIMO GIC.

- **Advanced communication techniques for future wireless networks:** With the ever-increasing demand for high data rates and better quality of service in a multiuser wireless communication system, interference is one of the major factors limiting the performance of the system. Hence, interference management is one of the key issues that need to be addressed in current and future wireless communication system. Specific contributions in this direction include:

  - **Precoder Design Algorithms for Interference Alignment (IA):** IA is a precoding technique that attempts to align interfering signals to a reduced dimensional subspace at each receiver. The achievable results on IA require long symbol extensions or global channel knowledge at each node. Hence, in this work, we propose precoding algorithms for aligning interference at all receivers that require a limited number of symbol extensions, or require only local channel state information at each node for K-user MIMO GIC.

  - **Cognitive Interference Channel:** Achievable rate regions and outer bounds are derived for 3-user ICs where the transmitters cooperate in a unidirectional manner via a noncausal message-sharing mechanism. The three-user channel facilitates different ways of message-sharing between the primary and secondary (or cognitive) transmitters. Bounds on the capacity region are obtained for different ways of message sharing. Interesting insights are obtained on the system performance from the derived bounds.

- **Physical Layer Secrecy:** In a multi-user wireless communication system, users are susceptible to eavesdropping due to the broadcast nature of the medium. The security today relies on bit-level cryptographic techniques and associated protocols at the various levels of the data processing task. As an alternative to this, physical layer security inspired by information-theoretic security can be incorporated into the wireless communication networks of today. Specific contributions include:

  - **Secrecy in 2-user Interference Channel:** In wireless communication, interference not only limits the performance of the system, but also allows users to eavesdrop on the other users' messages. In this work, the role of limited-rate transmitter cooperation is studied in managing interference and ensuring secrecy is explored by studying 2-user IC with secrecy constraints at the receivers. First, the problem is studied in the linear deterministic setting, and achievable schemes and outer bounds are obtained on the secrecy rate. Inspired by the achievable schemes and outer bounds in the deterministic case, achievable schemes and outer bounds are derived for the Gaussian case. The results show that limited transmitter cooperation can greatly facilitate secure communications over 2-user ICs.

- **Secrecy in 2-user Z-Interference Channel (Z-IC):** In this work, the role of unidirectional limited rate transmitter cooperation on managing interference and ensuring secrecy is explored in case of 2-user Z-IC. The problem is studied under two interference models: the linear deterministic model and the Gaussian model. The secrecy capacity region is characterized for the deterministic model. Study of the deterministic model gives useful insights for obtaining achievable schemes and outer bounds on the secrecy capacity region for the Gaussian case. This work has been submitted as a two part papers for possible publication.

- **Secret Key Generation in Interference Limited Environment:** To protect the confidentiality, integrity, and authentication of the communication, nodes need to agrees on keys for securing wireless networks. In recent years, there has been increased interest in key generation methods exploiting physical layer information and techniques. However, most of the existing works do not consider the effect of interference on secret key generation. The main objective of this work is to study the impact of interference on secret key generation from information theory perspective. This work has been completed and will be submitted to journal in near future.

- **Union of Information Theory and Networking:** Information theory provides accurate model for the noise and for the interference caused by simultaneous transmissions, but it ignores random message arrivals at the transmitters. On the other hand, network oriented studies focus on the bursty nature of messages, but do not accurately describe the physical channel model. It will be interesting to analyze the networking problems from information theory perspective. One such work which is in progress is as follows.

  - **Stability Region with Secrecy Constraints:** The bursty nature of the sources in communication networks gave rise to the development of a different concept of "capacity region", which is the maximum stable throughput region or the *stability region*. In this work, the objective is to characterize the stability region of network with bursty data arrival at the transmitter and secrecy constraints at the receiver.

PUBLICATIONS

Journal Papers (Published/In Review)

1. **P. Mohapatra**, K. E. Nissar, and C. R. Murthy, "Interference Alignment Algorithms for the K-User Constant MIMO Interference Channel," *IEEE Transactions on Signal Processing*, vol. 59, no. 11, pp. 5499 –5508, Nov. 2011

2. **P. Mohapatra** and C. R. Murthy, "Inner Bound on the GDOF of the K-User MIMO Gaussian Symmetric Interference Channel," *IEEE Transactions on Communication*, vol. 61, no. 1, pp. 187–196, Jan. 2013

3. **P. Mohapatra** and C. R. Murthy, "Outer Bounds on the Sum Rate of the K-User MIMO Gaussian Interference Channel," *IEEE Transactions on Communication*, vol. 61, no. 1, pp. 176–186, Jan. 2013

4. K. G. Nagananda, **P. Mohapatra**, C. R. Murthy, and S. Kishore, "Multiuser Cognitive Radio Networks: An Information-Theoretic Perspective," International Journal of Advances in Engineering Sciences and Applied Mathematics, An IIT Madras Journal from Springer, vol. 5, no. 1, pp. 43–65, Mar. 2013

5. **P. Mohapatra** and C. R. Murthy, "On the capacity of the 2-user interference channel with transmitter cooperation and secrecy constraints," *IEEE Transactions on Information theory*, May 2016 (**Accepted**)

6. **P. Mohapatra**, C. R. Murthy, and J. Lee, "On the Secrecy Capacity Region of the 2-user Z Interference Channel with Unidirectional Transmitter Cooperation," submitted to *IEEE Transactions on Information Forensics and Security*, April 2016 (**Revised and submitted**)

Conference Proceedings (Published)

1. **P. Mohapatra**, N. Pappas, J. Lee, T. Q. S. Quek, and V. Angelakis, "Stability region of 2-user full-duplex broadcast channel with secrecy constraint," in *Proc. IEEE Int. Conf. Commun.,* Kuala Lumper, Malaysia, May 2016

2. **P. Mohapatra** and C. R. Murthy, "Capacity of the Deterministic Z-interference Channel with Unidirectional Transmitter Cooperation and Security Constraints," in *Proc. IEEE International Symposium on Information Theory (ISIT)*, Hongkong, June 2015

3. **P. Mohapatra** and C. R. Murthy, "Outer Bounds on the Secrecy Rate of the 2-User Symmetric Deterministic Interference Channel with Transmitter Cooperation," in *Proc. National Conference on Communications (NCC)*, IIT Kanpur, India, Feb. 2014

4. **P. Mohapatra** and C. R. Murthy, "Secrecy in the 2-User Symmetric Deterministic Interference Channel with Transmitter Cooperation," in *Proc. IEEE 14th Workshop on Signal Processing Advances in Wireless Communications (SPAWC)*, Darmstadt, Germany, Jun. 2013

5. **P. Mohapatra** and C. R. Murthy, "Generalized Degrees of Freedom of the K-User Symmetric MIMO Interference Channel," in *Proc. IEEE International Symposium on Information Theory (ISIT)*, St. Petersburg, Russia, Aug. 2011

6. S. Panda, P. K. Nanda and **P. Mohapatra**,"Multiresolution Approach for Color Image Segmentation using MRF Model," in *Proceedings of the National Conference on Smart Communication Technologies and Industrial Informatics, SCTII*, Rourkela, India, Feb. 2007

7. **P. Mohapatra**, P. K. Nanda and S. Panda, "Color image segmentation using MRF model and simulated annealing," in *Proceedings of Soft Computing Technique for Engineering Applications SCT-2006*, Rourkela, India, Mar. 2006

Poster Presentations

1. **P. Mohapatra** and C. R. Murthy, On the Secrecy Capacity of the 2-User Interference Channel with Transmitter Cooperation, *CSCIT (Croucher Summer Course in Information Theory)*, Hong Kong, June 2015

2. **P. Mohapatra** and C. R. Murthy, Fundamental Limits of Communication in Interference Limited Environments, *Sixth Joint Research Students Symposium at Indian Institute of Science*, Bangalore, February 2015

3. **P. Mohapatra** and C. R. Murthy, Secrecy in the 2-User Symmetric Deterministic Interference Channel with Transmitter Cooperation, *IEEE Communication Theory Workshop*, Phuket, June 2013

Journals in Preparation

1. **P. Mohapatra**, J. Lee, and T. Q. S. Quek, "Interference Assisted Secret Key Generation over Discrete Memoryless Wiretap Channel with Public Feedback," *to be submitted*

2. **P. Mohapatra**, N. Pappas, J. Lee, T. Q. S. Quek and V. Angelakis, "On the Stability Region of 2-user Full-duplex Broadcast Channel with Secrecy Constraint", *in preparation*

Theses

1. P. Mohapatra, "*Fundamental Limits of Communication in Interference Limited Environments*," Doctoral dissertation, Department of Electrical Communication Engineering, Indian Institute of Science, Bangalore, India, Jan. 2015.
Thesis advisor: Professor Chandra R. Murthy.

2. P. Mohapatra, "*Color Image Segmentation using Markov Random Field Model*," Master's thesis, Department of Electrical Engineering, National Institute of Technology, Rourkela, Odisha, June 2006.
Thesis advisor: Professor P. K. Nanda.

COLLABORATORS

- Present Collaborators

  - Chandra R. Murthy - Associate Professor, Electrical Communication Engineering, Indian Institute of Science, Bangalore, India

  - Tony Q.S. Quek, - Assistant Professor, Information Systems Technology and Design Pillar, Singapore University of Technology and Design, Singapore

  - Jemin Lee, Principal Investigator, Temasek Research Fellow, iTrust Research Centre, Singapore University of Technology and Design, Singapore

  - Vangelis Angelakis - Associate Professor, Department of Science and Technology, Linköping University, Sweden

  - Nikolaos Pappas - Assistant Professor, Department of Science and Technology, Linköping University, Sweden

- Past Collaborators

  - Shalinee Kishore - Associate Professor, Electrical & Computer Engineering, Lehigh University, PA, USA

  - Nissar K. E. - Scientist, NPOL, Defence Research and Development Organization, Kochi, India

  - K. G. Nagananda - Associate Professor, People's Education Society Institute of Technology, Bangalore, India

PROFESSIONAL ACTIVITIES

- TPC activities

- Served as a TPC member for IEEE/CIC International Conference on Communications in China, 2015

- Served as a TPC member for International Workshop on Wireless Physical Layer Security, 2016. This workshop is part of the IEEE International Conference on Communications (ICC) to be held in Kuala Lumpur, Malaysia, May 23-27, 2016

- Served as a TPC member for National Conference on Communications (NCC) to will be held at the Indian Institute of Technology Guwahati during March 4-6, 2016

- Served as a reviewer for the following journals

  - IEEE Transactions on Communication (TCOM)

  - IEEE Transaction on Wireless Communications (TWC)

  - IEEE Transactions on Information Forensics & Security (TIFS)

  - IEEE Transaction on Information Theory (TIT)

  - IEEE Communications Letters (CL)

  - EURASIP Journal on Wireless Communications and Networking

  - Sadhana - Academy Proceedings in Engineering Science

- Served as a reviewer for the following conferences

  - IEEE International Conference on Communication (ICC)

  - IEEE Global Communications Conference (GLOBECOM)

  - IEEE International Workshop on Signal Processing Advances in Wireless Communications (SPAWC)

  - IEEE/CIC International Conference on Communications in China (ICCC)

  - National Conference on Communications (NCC)

  - Signal Processing and Communications (SPCOM)

Memberships

- IEEE Member

REFERENCES

- Professor **Chandra R. Murthy**
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  Indian Institute of Science
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- Professor **Neelesh B. Mehta**
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  Electrical Communication Engineering
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- Dr. **Jemin Lee**
  Principal Investigator, Wireless Security and Communication (WSC) Lab
  Temasek Research Fellow, iTrust, Centre for Research in Cyber Security
  Singapore University of Technology and Design
  Singapore
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