Multi-hop Multi-flow Wireless Networks

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Background & Research Interests/Areas

- Background
  - PhD (2001): Rice University, Houston, TX, USA
    - MIMO and CDMA systems
  - Qualcomm, Campbell, CA (June 2001 – March 2003)
    - WCDMA modem design
  - At IIT Madras since May 2003

- Research interests/areas
  - Wireless Communications
  - Information Theory
  - Statistical Signal Processing

Wireless networks: Challenges & Approaches

- Wireless channel
  - Time-variations (fading)
  - Interference (shared medium)
- Multiple flows → Interference
- Multiple hops → Relaying with interference

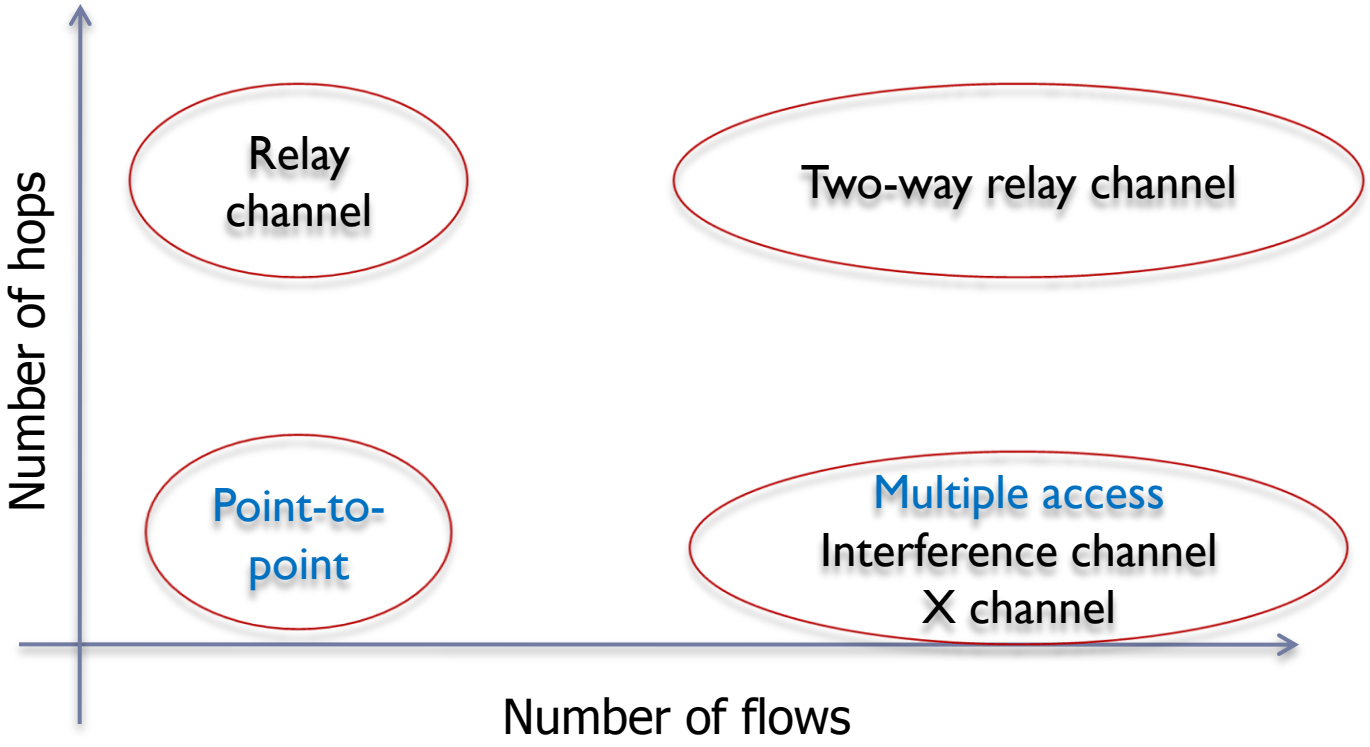
- Evolution of design approaches
  - Time-variations: Static → Dynamic resource allocation
  - Interference: Avoidance → Processing/decoding/etc.

Dynamic Resource Allocation

- Adaptive transmission
  - Adapting to the channel
- Cross-layer scheduling
  - Adapting to the channel and traffic
- Adapting to partial/imperfect state information
  - Delayed feedback, Strategic behavior, Partial information

- Context:
  - Downlink/Uplink of cellular systems
  - Base-station cooperation
    - Joint scheduling and cooperation mode selection

Interference in wireless networks



- Information-theoretic limits
- Multi-hop: Relaying protocols
- Multi-flow: Are simple interference management schemes ever optimal or close to optimal?

Statistical Signal Processing: Interests

- Detection and Estimation for Communication
  - OFDM channel estimation
- Change detection in sensor networks
  - Sequential detection with composite hypothesis
- Anomaly detection

Publications: Resource Allocation

Joint subcarrier and power allocation

- C. Mohanram, S. Bhashyam, "A Sub-optimal Joint Subcarrier and Power Allocation Algorithm for Multiuser OFDM," IEEE Communications Letters, vol. 9, no. 8, pp. 685-687, August 2005

Cross-layer scheduling

- C. Mohanram, S. Bhashyam, "Joint Subcarrier and Power Allocation in Channel-Aware Queue-Aware Scheduling for Multiuser OFDM," IEEE Transactions on Wireless Communications, vol. 6, no. 9, pp. 3208-3213, September 2007

Adaptation to partial/imperfect state information

- C. Manikandan, S. Bhashyam, R. Sundaresan, "Cross-layer scheduling with infrequent channel and queue measurements," IEEE Transactions on Wireless Communications, vol. 8, no. 12, pp. 5737-5742, December 2009
- A. K. Chorppath, S. Bhashyam, R. Sundaresan, "A convex optimization framework for almost budget balanced allocation of a divisible good," IEEE Transactions on Automation Science and Engineering, vol.8, no.3, pp.520-531, July 2011
- H. Ahmed, K. Jagannathan, S. Bhashyam, "Queue-Aware Optimal Resource Allocation for the LTE Downlink with Best M Sub-band Feedback," IEEE Transactions on Wireless Communications, vol. 14, no. 9, pp. 4923-4933, Sep. 2015

Publications: Interference & Relaying

- Single-hop multi-flow
  - R. Prasad, S. Bhashyam, A. Chockalingam, "On the Sum-Rate of the Gaussian MIMO Z Channel and the Gaussian MIMO X Channel," IEEE Transactions on Communications, vol. 63, no. 2, pp. 487-497, Feb. 2015
  - Praneeth Kumar V., S. Bhashyam, "MIMO Gaussian X Channel: Noisy Interference Regime," IEEE Communications Letters, vol. 18, no. 8, pp. 1295-1298, Aug. 2014

- Multi-hop single-flow
  - Relaying protocols for layered networks
    - Bama Muthuramalingam, S. Bhashyam, A. Thangaraj, "A Decode and Forward Protocol for Two-stage Gaussian Relay Networks," IEEE Transactions on Communications, col. 60, no. 1, pp. 68-73, January 2012
    - P. S. Elamvazhuthi, B. K. Dey, S. Bhashyam, An MMSE strategy at relays with partial CSI for a multi-layer relay network, IEEE Transactions on Signal Processing, Vol. 62, No. 2, pp. 271-282, Jan. 15, 2014

Publications: Interference & Relaying

- Multi-hop multi-flow
  - Two-way relaying
    - K. Ravindran, A. Thangaraj, S. Bhashyam, "LDPC Codes for Network-coded Bidirectional Relaying with Higher Order Modulation," IEEE Transactions on Communications, vol. 63, no. 6, pp. 1975-1987, Jun 2015
  - Multiple multicast in random networks
    - V. N. Swamy, S. Bhashyam, R. Sundaresan, P. Viswanath, "An asymptotically optimal push-pull method for multicasting over a random network," IEEE Transactions on Information Theory, Vol. 59, No. 8, pp. 5075-5087, Aug. 2013

Publications: Statistical Signal Processing

OFDM channel estimation

- M. R. Raghavendra, S. Bhashyam, K. Giridhar, "Exploiting Hopping Pilots for Parametric Channel Estimation in OFDM Systems", IEEE Signal Processing Letters, vol. 12, no. 11, pp. 737-740, November 2005
- M. R. Raghavendra, E. Lior, S. Bhashyam, K. Giridhar, "Parametric Channel Estimation for Pseudo-Random Tile-Allocation in Uplink OFDMA," IEEE Transactions on Signal Processing, vol. 55, no. 11, pp. 5370-5381, November 2007
- M. R. Raghavendra, S. Bhashyam, K. Giridhar, "Interference Rejection for Reuse-1 Cellular OFDM Systems using Parametric Channel Estimation," IEEE Transactions on Vehicular Technology, vol. 58, no. 8, pp. 4342-4352, October 2009

Sequential change detection

- P. Sarath Kumar, B. Sai Kiran, A. P. Kannu, S. Bhashyam, "Algorithms for Change Detection with Unknown Number of Affected Sensors," Proceedings of NCC 2013, IIT Delhi, India, Feb 2013

Publications: MIMO

- MIMO with limited feedback
  - T. R. Ramya, S. Bhashyam, "Using delayed feedback for antenna selection in MIMO systems," IEEE Transactions on Wireless Communications, vol. 8, no. 12, pp. 6059-6067, December 2009
  - V. S. Annapureddy, D. V. Marathe, T. R. Ramya, S. Bhashyam, "Outage Probability of Multiple-Input Single-Output (MISO) Systems with Delayed Feedback," IEEE Transactions on Communications, vol. 57, no. 2, pp. 319-326, Feb 2009

- Co-ordinate interleaving for spatial multiplexing
  - K. V. Srinivas, R. D. Koilpillai, S. Bhashyam, K. Giridhar, "Co-ordinate Interleaved Spatial Multiplexing with Channel State Information," IEEE Transactions on Wireless Communications, vol.8, no.6, pp. 2755-2762, June 2009

Collaborations

- Rajesh Sundaresan, IISc Bangalore
- A. Chockalingam, IISc Bangalore
- Bikash Kumar Dey, IIT Bombay
- Ashu Sabharwal, Rice University
- P. Viswanath, UIUC
- IITM colleagues
  - Andrew Thangaraj, Arun Pachai, K. Giridhar, Krishna Jagannathan, David Koilpillai, Radhakrishna Ganti, Venkatesh Ramaiyan, D. Jalihal

Students

- Alumni
  - PhD: 3
    - Imagination Technologies, Tata Elxsi, Qualcomm
  - MS: 7
    - L & T Infotech, CDAC, CSR, TU Munich, Accord Systems, Continental, Audience
- Current
  - PhD: 4
  - MS: 2