

# Chiranjib Saha

Graduate Research Assistant

Wireless@Virginia Tech

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## CONTACT INFORMATION

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## RESEARCH INTERESTS

Wireless communications; 5G networks; Heterogeneous cellular networks (HetNETs); LTE/LTE-A, WiFi; Internet of Things (IoT); Device-to-device (D2D) communications; Integrated access and backhaul (IAB) design; Spectrum sharing; Machine learning; Signal processing; Stochastic geometry.

## EDUCATION

**Virginia Tech**, Blacksburg, VA, USA. Ph.D. in Electrical and Computer Engineering **Aug. 2015- Present**

- **Expected Graduation: May, 2020**
- Advisor: Harpreet S. Dhillon
- Dissertation: “Advances in Stochastic Geometry for Cellular Networks”
- Current GPA: 3.87

**Jadavpur University**, India. B.E. in Electronics and Telecommunication Engineering **2011-2015**

- Final year Project Topic: Gesture driven control of an Arduino based robot using Kinect
- Advisor: Amit Konar
- CGPA: 9.22

## PROFESSIONAL EXPERIENCE

**Virginia Tech**, Blacksburg, VA

*Graduate Research Assistant*

- **Machine Learning and stochastic geometry** **Feb. 2019-Present**
  - \* Studying subset selection problems in wireless networks, connection with determinantal point processes used both in machine learning and stochastic geometry.
  - \* Application of the submodular optimization framework to signal processing problems, e.g., antenna selection in a pulsed Radar system.
- **Modeling and analysis of mm-wave IAB networks** **May 2017-Present**
  - \* Proposed new stochastic geometry-based model for mmWave IAB-enabled HetNet
  - \* Load modeling, coverage and data-rate analysis, studying resource partition strategies in IAB.
- **3GPP-inspired stochastic geometry models for HetNets** **Sep. 2015-May 2017**
  - \* Proposed new stochastic geometry-based models closely resembling 3GPP HetNet models, coverage analysis and model comparisons.
- **Performance analysis of D2D-enabled cellular networks** **Jan. 2016-May 2016**
  - \* Proposed new spatial models for D2D communication in user hotspots, analyzed downlink coverage and rate trends.

**Samsung Research America**, Plano, TX

**May 2019-Aug. 2019**

*Research Intern*

- **Localization in Ultra-wide band (UWB) systems**
  - \* Studied and designed localization algorithms (e.g. nonlinear least squares and extended Kalman filter). Designed anchor selection and placement optimization heuristics.
  - \* Filed for 4 disclosure of inventions (DOIs).
  - \* Received the *best intern poster presentation award*.

**Nokia Bell Labs**, Naperville, IL

**May 2018-Jul. 2018**

*Research Intern*

- **Beamforming and beam tracking in 3GPP new radio**
  - \* Studied beam tracking when a mm-wave receiver is moving along a trajectory in an urban environment. Integrated spatially correlated channels from a ray tracer to the link and system level simulator of 5G new radio (NR). *Selected for distinguished Bell Labs Summer Internship Project.*

– Day-ahead thermal scheduling Problems

- \* Used multi-objective optimization algorithms for generator scheduling in a thermal power plant. Results published in *IEEE Trans. on Ind. Informat.*

PUBLICATIONS

Book

- H. S. Dhillon, **C. Saha**, and M. Afshang, *Poisson Cluster Processes: Theory and Applications to Wireless Networks*, Cambridge university press, under preparation.

Journals

- [J12] **C. Saha**, M. Afshang, and H. S. Dhillon, “Meta Distribution of Downlink SIR in a Poisson Cluster Process-based HetNet Model”, submitted to *IEEE Wireless Commun. Letters*.
- [J11] **C. Saha** and H. S. Dhillon, “On the Load Distribution of a Cellular Network with User Clustering”, submitted to *IEEE Wireless Commun. Letters*.
- [J10] **C. Saha** and H. S. Dhillon, “Millimeter Wave Integrated Access and Backhaul in 5G: Performance Analysis and Design Insights”, in *IEEE Journal on Sel. Areas in Commun.*, vol. 37, no. 12, pp. 2669-2684, Dec. 2019.
- [J9] **C. Saha**, H. S. Dhillon, N. Miyoshi, and J. G. Andrews, “Unified Analysis of HetNets using Poisson Cluster Process under Max-Power Association”, in *IEEE Trans. on Wireless Commun.*, Aug. 2019.
- [J8] **C. Saha**, M. Afshang and H. S. Dhillon, “Bandwidth Partitioning and Downlink Analysis in Millimeter Wave Integrated Access and Backhaul for 5G,” in *IEEE Trans on Wireless Commun.*, Dec. 2018.
- [J7] M. Afshang, **C. Saha**, and H. S. Dhillon “Equi-coverage Contours in Cellular Networks”, in *IEEE Wireless Commun. Letters*, Oct. 2018.
- [J6] **C. Saha**, M. Afshang, H. S. Dhillon, “3GPP-inspired HetNet model using Poisson cluster process: sum-product functionals and downlink coverage”, in *IEEE Trans. on Commun.*, May 2018.
- [J5] M. Afshang, **C. Saha**, and H. S. Dhillon, “Nearest-neighbor and contact distance distributions for Matérn cluster process”, in *IEEE Commun. Letters*, Dec. 2017.
- [J4] M. Afshang, **C. Saha**, H. S. Dhillon, “Nearest-neighbor and contact distance distributions for Thomas cluster process”, in *IEEE Wireless Commun. Letters*, Dec. 2016.
- [J3] **C. Saha**, M. Afshang, and H. S. Dhillon, “Enriched  $K$ -tier HetNet model to enable the analysis of user-centric small cell deployments”, in *IEEE Trans. on Wireless Commun.*, Mar. 2016.
- [J2] **C. Saha**, K. Pal, S. Mukherjee, S. Das, “A fuzzy rule based penalty function approach for solving constrained optimization”, in *IEEE Trans. on Cybern.*, Dec. 2016.
- [J1] A. Trivedi, D. Srinivasan, K. Pal, **C. Saha** and T. Reindl, “Enhanced multiobjective evolutionary algorithm based on decomposition for solving the unit commitment problem”, in *IEEE Trans. on Ind. Informat.*, Dec. 2015.

Conference Proceedings

- [C9] **C. Saha** and H. S. Dhillon, “Interference Characterization in Wireless Networks: A Determinantal Learning Approach”, in *Proc. IEEE Int. Workshop in Machine Learning for Sig. Processing*, Pittsburgh, PA, Oct. 2019.
- [C8] **C. Saha** and H. S. Dhillon, “Machine Learning meets Stochastic Geometry: Determinantal Subset Selection for Wireless Networks”, in *Proc. IEEE Globecom*, Waikoloa, HI, Dec. 2019.
- [C7] **C. Saha** and H. S. Dhillon, “On Load Balancing in Millimeter Wave HetNets with Integrated Access and Backhaul”, in *Proc. IEEE Globecom*, Waikoloa, HI, Dec. 2019.
- [C6] **C. Saha**, M. Afshang, and H. S. Dhillon, “Integrated mmWave access and backhaul in 5G: Bandwidth partitioning and downlink analysis”, in *Proc. IEEE ICC*, Kansas city, KS, 2018.
- [C5] **C. Saha**, M. Afshang, and H. S. Dhillon, “Poisson cluster process: Bridging the gap between PPP and 3GPP HetNet models”, in *Proc., ITA*, San Diego, CA, 2017.
- [C4] **C. Saha** and H. S. Dhillon, “D2D underlaid cellular networks with user clusters: Load balancing and downlink rate analysis”, in *Proc. IEEE WCNC*, San Fransisco, CA, Mar. 2017.
- [C3] **C. Saha** and H. S. Dhillon, “Downlink coverage probability of  $K$ -tier HetNets with general non-uniform user distributions”, in *Proc. IEEE ICC*, Kuala Lumpur, 2016.

- [C2] **C. Saha**, D. Goswami, S. Saha, A. Konar, A. Lekova and A. K. Nagar, “A novel gesture driven fuzzy interface system for car racing game”, in *Proc. FUZZ-IEEE*, Istanbul, 2015.
- [C1] K. Pal, **C. Saha**, S. Das, C. A. Coello Coello, “Dynamic constrained optimization with offspring repair based gravitational search algorithm”, in *Proc. IEEE CEC*, Cancún, Mexico, Jun., 2013.

#### SELECTED GRADUATE COURSE PROJECTS

##### Hybrid Precoding for Massive MU-MIMO

Fall 2018

- Investigated the design of hybrid beamformers in a downlink multi-user massive MIMO scenario. Compared the performance under finite resolution phase shifters.

##### Fitting point processes to cellular network topology

Fall 2016

- Fitted point processes from Gibbs process family to analyze the location patterns of base stations in different urban regions of UK for four major telecom operators.

##### Software design of digital transmitter and receiver

Spring 2016

- MATLAB implementation of fundamental building blocks of a digital trans-receiver, e.g. modulation-coding schemes, pulse-shaping, OFDM and BER analysis for AWGN and fading channels.

##### Comparative study and analysis of MIMO techniques

Fall 2015

- Implemented SU-MIMO receivers based on pre-coding, zero-forcing (ZF), successive interference cancellation (SIC) algorithms to compare performances of multiplexing schemes.
- Analyzed antenna diversity techniques and DOA algorithms such as MUSIC, ESPRIT.

##### OFDM Channel Estimation and Receiver Algorithms

Fall 2015

- Performed OFDM channel estimation using LS and MMSE approaches and implemented receiver algorithms including ZF, MMSE and SIC.
- Simulated OFDM in frequency selective channels to capture performance.

#### OTHER POSITIONS OF RESPONSIBILITY

Reviewer of *IEEE Transactions on Wireless Communications*, *IEEE Transactions on Communications*, *IEEE Wireless Communications Letters*, *IEEE Communication Letters*, *IEEE Journal on Selected Areas in Communication*

#### GRADUATE COURSES UNDERTAKEN

Multichannel communications, Stochastic signals and systems, Information theory, Advanced digital communication, Measure and probability, Spatial statistics, Error control coding, Graph theory, Bayesian statistics.

#### AWARDS

- Wireless@VT Fellowship, 2015.
- IEEE ComSoc student travel grant, 2016.
- Received best intern poster award at Samsung Research America, 2019.

#### SKILLS

- COMMUNICATION PROTOCOLS: 5G/NR, LTE/LTE-A, GSM, CDMA2000, WCDMA, WiFi - IEEE 802.11 a/b/g/n, TCP/IP etc.
- ALGORITHMS: Transmitter/Receiver structures for MIMO and OFDM/Single Carrier Wireless systems; Water-Filling based Power Control; Linear/Non-Linear Integer programming; Convex Optimization; Back propagation and Artificial Neural Networks, Bayesian filtering (e.g. Kalman filter, extended Kalman filter, particle filter).
- PROGRAMMING LANGUAGES: C, C++, R, MATLAB, Mathematica, Python, Java
- SCRIPTING LANGUAGES: HTML5,  $\LaTeX$

REFERENCE

Harpreet S. Dhillon	Assistant Professor Virginia Tech	<a href="mailto:hdhillon@vt.edu">hdhillon@vt.edu</a>
Amitava Ghosh	Head, Radio Interface Group at Nokia Bell Labs	<a href="mailto:amitava.ghosh@nokia-bell-labs.com">amitava.ghosh@nokia-bell-labs.com</a>
Boon Loong Ng.	Research Director, Samsung Research America	<a href="mailto:b.ng@samsung.com">b.ng@samsung.com</a>