



INSTITUTE OF APPLIED MATHEMATICAL RESEARCH
OF THE KARELIAN RESEARCH CENTER OF
RUSSIAN ACADEMY OF SCIENCES

STOCHASTIC MODELING
FOR COMMUNICATION
SYSTEMS
(LECTURE COURSE)

JUNE 2-10, 2025

PETROZAVODSK, RUSSIA

STOCHASTIC MODELING FOR COMMUNICATION SYSTEMS (LECTURE COURSE)

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- ABSTRACT:** The primary objective of this course is to investigate stochastic modeling in communication systems at an introductory level. This workshop offers a distinctive opportunity to improve your capacity to teach or conduct research in the field of stochastic processes, as numerous institutes and universities now offer courses at both the undergraduate and postgraduate levels. The program will encompass fundamental concepts and techniques, thus establishing a strong foundation for further study or professional application. Furthermore, efforts will be made to include invited talks that will motivate participants, providing them with valuable insights and perspectives on the latest trends and advances in stochastic modeling.
- SPEAKERS:** S. Dharmaraja (India), Raina Raj (India), Priyanka Kalita (India), Anisha Aggarwal (India), Alexander Rumyantsev (Russia)
- CONTENT:** **Module I. Introduction to Communication Systems.**
(general description of various topics related to communication systems such as 2G, 3G, 4G and 5G)
Module II. Introduction to Stochastic Modeling.
(Markov models, semi-Markov models and Markov regenerative models)
Module III. Stochastic Modeling in 2G and 3G Networks.
(performance and reliability analysis of 2G and 3G networks)
Module IV. Stochastic Modeling in 4G and 5G Networks.
(performance and reliability analysis of 4G and 5G networks)
Module V. Stochastic Modeling of Energy Issues in 3G and 4G Networks.
Module VI. Stochastic Modeling in HAP Systems.
(reliability analysis of HAP systems)
- FORMAT:** Online and offline (Institute of Applied Mathematical Research KarRC RAS, Petrozavodsk, Russia), language - English.
- HOW TO PARTICIPATE:** Registration requests are to be sent by email to smarty.karelia@yandex.ru. Motivation letter is required for registration.

TIMETABLE

(Moscow time UTC+3)

DAY I:
MONDAY
(02.06.2025)

9.30 - 10.00 Opening Ceremony
10.00 - 10.15 High Tea
10.15 - 11.45 Module I (S. Dharmaraja/A. Rummyantsev)
11.45 - 13.15 Module I (S. Dharmaraja)
13.15 - 14.15 Lunch Break
14.15 - 15.15 Lab (Raina Raj)
15.15 - 15.30 Tea Break
16.45 - 17.30. Tutorial/Question Session (Raina Raj/S. Dharmaraja)

DAY II:
TUESDAY
(03.06.2025)

9.30 - 11.00 Module II (S. Dharmaraja)
11.00 - 11.15 Tea Break
11.15 - 12.45 Module II (Raina Raj)
12.45 - 14.00 Lunch Break
14.00 - 15.00 Module II (S. Dharmaraja/Priyanka Kalita)
15.00 - 16.00 Tutorial /Lab (Raina Raj)
16.00 - 16.15 Tea Break
16.15 - 17.15 Tutorial /Lab (Raina Raj/S. Dharmaraja)

DAY III:
WEDNESDAY
(04.06.2025)

9.30 - 11.00 Module III (S. Dharmaraja)
11.00 - 11.15 Tea Break
11.15 - 12.45 Module III (Raina Raj)
12.45 - 14.00 Lunch Break
14.00 - 15.30 Module III (S. Dharmaraja)
15.30 - 15.45 Tea Break
15.45 - 17.45 Tutorial /Lab (Raina Raj/S. Dharmaraja)

TIMETABLE

DAY IV: THURSDAY (05.06.2025)

9.30 - 11.00 Module IV (S. Dharmaraja)
11.00 - 11.15 Tea Break
11.15 - 12.45 Module IV (Raina Raj)
12.45 - 14.00 Lunch Break
14.00 - 15.00 Module IV (S. Dharmaraja/Anisha Aggarwal)
15.00 - 16.00 Tutorial /Lab (Raina Raj)
16.00 - 16.15 Tea Break
16.15 - 17.15 Tutorial /Lab (Raina Raj/S. Dharmaraja)

DAY V: FRIDAY (06.06.2025)

9.30 - 11.00 Module V (S. Dharmaraja)
11.00 - 11.15 Tea Break
11.15 - 12.45 Module V (Raina Raj/Priyanka Kalita)
12.45 - 14.00 Lunch Break
14.00 - 15.00 Module V (S. Dharmaraja)
15.00 - 16.00 Tutorial /Lab (Raina Raj)
16.00 - 16.15 Tea Break
16.15 - 17.15 Tutorial /Lab (Raina Raj/S. Dharmaraja)

DAY VI: MONDAY (09.06.2025)

9.30 - 11.00 Module V (S. Dharmaraja)
11.00 - 11.15 Tea Break
11.15 - 12.45 Module V (Raina Raj/Anisha Aggarwal)
12.45 - 14.00 Lunch Break
14.00 - 15.00 Module V (S. Dharmaraja)
15.00 - 16.00 Tutorial /Lab (Raina Raj)
16.00 - 16.15 Tea Break
16.15 - 17.15 Tutorial /Lab (Raina Raj/S. Dharmaraja)

DAY VII: TUESDAY (10.06.2025)

9.30 - 11.00 Concluding lecture (S. Dharmaraja)
11.00 - 11.15 Tea Break
11.15 - 12.45 Concluding lecture (A. Rumyantsev)
12.45 - 14.00 Lunch Break
14.00 - 16.30 Discussion on Research Problems (S. Dharmaraja)
16.30 - 17.00 Valedictory
17.00 High Tea and Close

READING MATERIALS

1. Raina Raj, S. Dharmaraja: Stochastic Modeling of Multi-Layer HAP-LEO Systems in 6G for Energy Saving: Analytical Approach, Computer Communications, Vol. 210 (2023), pp. 23 - 34.
2. S. Dharmaraja, Adwaith H Sivam, Raina Raj, Vladimir Vishnevsky: Study of reliability of the on-tether subsystem of a tethered high-altitude unmanned telecommunication platform Reliability: Theory & Applications, Vol. 72(1), 2023, pp. 172-178.
3. Vidyottama Jain, Raina Raj, and S. Dharmaraja: Numerical Optimization of Loss System with Retrial Phenomenon in Cellular Networks, International Journal of Operational Research, 46(2) (2023), pp. 210 - 226.
4. S. Dharmaraja, Adwaith H Sivam, Raina Raj, Priyanka Kalita, Dmitry Kozyrev, Vladimir Vishnevsky: Optimizing Tethered HAP Networks Configuration Using Algorithms, To appear in Proceedings of IEEE International Conference on Advanced Networks and Telecommunications Systems (ANTS) 2024, Assam, India, IIT Guwahati, 2024.
5. Raina Raj, Dharmaraja Selvamuthu and Deepak Mishra: Traffic Control Analysis in High Altitude Platforms using a Semi-Markov Process Approach, To appear in Proceedings of IEEE International Conference on Advanced Networks and Telecommunications Systems (ANTS) 2024, Assam, India, IIT Guwahati, 2024.
6. Raina Raj, Dharmaraja Selvamuthu and Deepak Mishra: Traffic Control and Energy Harvesting in High Altitude Platforms: A Semi-Markov Process Approach, To appear in Proceedings of IEEE Global Communications Conference, December 8 - 12, 2024, Cape Town, South Africa, 2024.
7. S. Dharmaraja, Kishor S. Trivedi and D. Logothetis: Performance modelling of wireless networks with generally distributed hand-off interarrival times, Computer Communications Journal, 26(2003) pp.1747-1755.
8. S. Dharmaraja, Vaneeta Jindal and Attahiru Sule Alfa: Phase Type Models for Cellular Networks Supporting Voice, Video and Data Traffic, Mathematical and Computer Modelling, 47 (2008) pp. 1167 - 1180.
9. Vandana Gupta and S. Dharmaraja: Semi-Markov modeling of VoIP dependability in the presence of resource degradation and security attacks, Reliability Engineering and System Safety, 96(2011) pp. 1627 - 1636.
10. S. Dharmaraja, Resham Vinayak and Kishor S. Trivedi: Reliability and Survivability of Vehicular Ad hoc Networks: An Analytical Approach, Reliability Engineering and System Safety, 153(2016) pp. 28-38.
11. Anupam, Gautam Choudhary and S. Dharmaraja: Performance analysis of DRX mechanism using batch arrival vacation queueing system with N-policy in LTE-A networks, Annals of Telecommunications, 75 (2020) pp. 353-367.
12. S. Dharmaraja, Anisha Aggarwal, R. Sudhesh: Analysis of Energy Saving in User Equipment in LTE-A using Stochastic Modelling, Telecommunication Systems, 80(2022) pp. 123 - 140.
13. Priyanka Kalita and S. Dharmaraja: Stochastic Modelling for Energy Efficiency in Modified Discontinuous Reception (MD-DRX) For LTE-5G Networks, International Journal of Communication Systems, Vol. 36 (Issue 6), (2023) e5434, 33 pages.

SPEAKERS

**DHARMARAJA
SELVAMUTHU**

S. Dharmaraja received his Ph.D. degree in Mathematics from the Indian Institute of Technology Madras, Chennai, in 1999. He has been with the Department of Mathematics, IIT Delhi, since 2003, where he is currently a Professor, Department of Mathematics and joint faculty of Bharti School of Telecommunication Technology and Management from June 2013. He is a 'Professor (HAG)' from Oct. 2020. His research interests include applied probability, queueing theory, stochastic modeling, performance analysis of computer and communication systems and financial mathematics.

RAINA RAJ

Raina Raj received the Ph.D. degree in stochastic modeling of cellular networks with optimization methods from Central University of Rajasthan, Ajmer, India. Since 2022, she has been with the Department of Mathematics, Indian Institute of Technology Delhi, India, where she worked as a postdoctoral fellow. Since 2023, she has been with the Bharti School of Telecommunication Technology & Management, Indian Institute of Technology Delhi, India, where she currently holds an institute postdoctoral position. Her research interests include wireless resource allocation and management, wireless communications, networking, reliability analysis of anti-drone systems and high altitude platforms, game theory, queueing theory, cyber security, and optimization techniques.

**ANISHA
AGGARWAL**

Anisha Aggarwal received the Ph.D. degree with a thesis entitled 'Stochastic modeling of Energy Aspects in 5G Wireless Networks: Analytical Approach' from Indian Institute of Technology, Delhi, India in 2024. She is currently working as postdoctoral student in Telecom SudParis, France. Her research interests include stochastic modelling, energy saving features in wireless networks.

**PRIYANKA
KALITA**

Priyanka Kalita completed her Ph.D. from Institute of Advanced study in Science and Technology" a DST Institute of India in 2020. In 2021, She joined IIT Delhi as a post doctoral fellow in department of Mathematics. Currently, She is working as a Assistant Professor in Bhattadev university, Assam. Her research interest includes stochastic modelling, reliability, telecommunications system, energy optimization.

**ALEXANDER
RUMYANTSEV**

Alexander Rumyantsev is Leading Researcher in the Laboratory for Stochastic modeling of information-computing and telecommunication systems, Institute of Applied Mathematical Research KarRC RAS. He received the Doctor degree (DSc) in Physics and Mathematics in 2022. The main research interest is in the field of queueing theory, stochastic modelling and performance evaluation.

VENUE

KARELIA

The Republic of Karelia is a national republic located in the North-West part of Russia, with its territory stretched from north to south, touching the Arctic Circle in the northern part, and having the longest border with Finland in the west. With beautiful nature, taiga forest, plenty of lakes and rivers (more than 40,000, including the two largest lakes in Europe), and a long history (archaeologists here uncover settlements older than the Pyramids of Egypt), Karelia is recognized as the “County of thousand lakes”. However, due to the tough living conditions of the North, it is rather loosely populated.

PETROZAVODSK

The capital of the Republic of Karelia, **Petrozavodsk**, has the status of the historical city. The city emerged due to Emperor Peter the Great and impetuous historic events of the early XVIII century, i.e. Russia's struggle for the access to the Baltic Sea, switching the life of the whole country to “western traditions”, and boisterous development of industries in an agricultural state. Today, Petrozavodsk covers 113 square kilometers and is home to over a third of the population of the republic (about 261,000 citizens). It stretches 25 km along the shores of Lake Onego. The center of the city is bounded by Onezhskaya embankment and a railroad in the north and south, and by the Neglinka and the Lososinka rivers in the east and west. Petrozavodsk is one of the greenest cities of Russia. Nowadays, the city yields almost half of the national income of Karelia by its machine building, power generation, woodworking, transport, food, and light industries.

INSTITUTE OF APPLIED MATHEMATICAL RESEARCH

Institute of Applied Mathematical Research of the Karelian Research Center of RAS was founded in 1999. About 40 scientific researchers work on the following research trends: probability theory and stochastic processes, queueing theory, simulation modelling, game theory, discrete mathematics, mathematical programming, mathematical and applied statistics, development of information and telecommunications systems. Being a dynamic and young institute (with more than half of the staff being young scientists), the Institute has close collaboration with research groups in France, Italy, Hungary, Belgium, Spain, Germany, China, India and other countries, as well as cities of Russia. Many of the researchers are active in teaching, holding lecturer and professor positions at the Petrozavodsk State University.