Sandeep Kumar Singh

CONTACT DETAILS & INFO

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Others	Github, LinkedIn, Google Scholar

RESEARCH INTEREST

Quantum networking, datacenter networking, optical switching, resource allocation, application of machine learning in communication networks.

EDUCATION

PhD in Computer and Network Engineering 2014-2019
Technical University (TU) of Braunschweig, Germany

- Thesis title: "Stochastic Analysis and Learning-based Algorithms for Resource Provisioning in Optical Networks" [online] **[Grade: Summa Cum Laude, highest]**
- PhD Advisor: Prof. Admela Jukan, TU Braunschweig, Germany
  Committee: Prof. Vincent Chan, MIT, USA; Prof. Krishna Sivalingam, IIT Madras, India
- Developed the first exact theoretical model and efficient machine learning-assisted algorithms for routing, spectrum allocation and defragmentation in elastic optical networks. Proposed an energy-efficient and intelligent fiber-wireless architecture for edge-cloud networks.

Master of Science by Research (M. S.) in Electrical Engineering 2010-2014
Indian Institute of Technology (IIT) Madras, India

- Thesis title: "Virtual Optical Bus: A New Paradigm for Optical Transport Networks" [**Grade: 8.9/10**]
- Developed an algorithm for the optimization of the number of virtual connections per fiber link with the objective of minimizing packet collision in optical burst-switched networks.

Bachelor of Technology (B. Tech.) in Electronics and Communication Engineering 2006-2010
SASTRA University, Thanjavur, India

- Thesis title: "High-Speed Serial Communication with FPGA" [**Grade: 8.35/10**]
- Implemented an interface for a high speed serial data transmission with a PCI Express protocol through a transceiver block of FPGA. This work was supported by a SUKHOI-30 project at DRDO, Bangalore, India.

WORK AND TEACHING EXPERIENCE

Postdoctoral Scholar-Employee 2021-present
University of California, Davis, USA

- Research: Working towards theoretical models and demonstration of distribution of entangled photons over quantum-classical channels. Developing a software defined networking-enabled datacenter testbed for intelligent routing and switching.
- Teaching: High-capacity optical data systems and networks. Primary instructor: Prof. S. J. Ben Yoo, EEC 239B, WQ 2022.
- Projects: i) Quantum wrapper networking, ii) Data center switching and interconnects
- Supervision: Two Master's theses in optical datacenter networks (ongoing)

Research Scientist 2019-2021

German Aerospace Center (DLR), IKN, Neustrelitz, Germany

- Research: Developed an anomaly detection software in Python for maritime traffic situation assessment, and a hybrid learning solution for vehicle tracking using prediction and uncertainty estimation by deep learning and Kalman filtering.
- Projects: IntelliMar & EMS III. The projects dealt with maritime security. My role was to investigate, and develop a software solution for real-time security assessment in maritime navigation using machine learning techniques.

Research Staff & PhD Student 2014-2019

Technical University of Braunschweig, Germany

- Research: Developed analytical models and algorithms for resource allocation in fiber optical networks with least spectrum fragmentation. Developed machine learning (ML) framework for allocating resources efficiently under time-varying traffic scenario, detecting power jamming attacks, and reducing energy consumption in Edge-Cloud fiber-wireless networks with sensors, ZigBee and Raspberry-Pi (R-Pi).
- Teaching: Broadband Communication (Optical transceiver and network components, OTN, WDM), Advance Topics in Telecommunication, Network Lab (OSPF, TCP/IP, BGP)
- Projects: Contributed in project proposal writing*, and worked on research projects. *EU project: mF2C- Fog-to-Cloud Management Ecosystem, *DFG project: Metrology for THz Communications. Animal Welfare project with Edge-Cloud fiber-wireless networks. DFG project: New Horizons in Optical Networking (see publications)
- Supervision: Three Master's theses in optical networks, fiber-wireless networks, and IoT

Teaching Assistant, and Internship

- Teaching Assistant: Optical networks, and Digital design lab, *Indian Institute of Technology Madras, India, 2012-2013.*
- Master's Project: Developed an algorithm for reducing packet collision in virtual optical networks, *Technical University of Berlin, Germany, 2011-2012..*
- Bachelor's Project: Implemented a high-speed serial communication interface over PCI express protocol in FPGA, *Defense Research and Development Organization (DRDO)*, Bangalore, India, 2009-2010.

PUBLICATIONS

Journals:

1. **S. K. Singh**, J. S. Fowdur, J. Gawlikowski, D. Medina, "Leveraging Graph and Deep Learning Uncertainties to Detect Anomalous Maritime Trajectories," IEEE Transaction on Intelligent Transportation Systems, 2022. DOI: 10.1109/TITS.2022.3190834. **Impact factor: 6.49**

2. **S. K. Singh** and A. Jukan, "Machine Learning-based Prediction for Resource (Re)allocation in Optical Data Center Networks," *IEEE/OSA Journal of Optical Communications and Networking (JOCN)*, vol. 10, issue 10, pp. D12-D28, 2018. DOI: 10.1364/JOCN.10.000D12.
Impact factor: 3.98

3. **S. K. Singh**, F. Carpio, and A. Jukan, "Improving Animal-Human Cohabitation with Machine Learning in Fiber-Wireless Networks," *MDPI Journal of Sensor and Actuator Networks*, vol. 7, no. 3, 2018. DOI: 10.3390/jsan7030035.
Impact factor: 1.33

4. J. Mata, I. De Miguel, R. J. Durán, N. Merayo, **S. K. Singh**, A. Jukan, M. Chamania, "Artificial intelligence (AI) methods in optical networks: A comprehensive survey," *Elsevier Journal of Optical Switching and Networking*, Vol. 28, pp.43-57, 2018. DOI: 10.1016/j.osn.2017.12.006.
Impact factor: 2.79

5. **S. K. Singh** and A. Jukan, "Efficient Spectrum Defragmentation with Holding Time Awareness in EONs," *IEEE/OSA Journal of Optical Communications and Networking (JOCN)*, vol. 9, no. 3, pp. B78-B89, 2017. DOI: 10.1364/JOCN.9.000B78.
Impact factor: 3.98

6. **S. K. Singh**, T. Das, and A. Jukan, "Analytical performance modeling of spectrum defragmentation in elastic optical link networks," *Elsevier Journal of Optical Switching and Networking*, vol. 24, pp. 25-38, 2016. DOI: 10.1016/j.osn.2016.11.001.
Impact factor: 2.79

7. **S. K. Singh**, T. Das, and A. Jukan, "A Survey on Internet Multipath Routing and Provisioning," *IEEE Comm. Surveys and Tutorials*, vol. 17, no. 4, 2015. DOI: 10.1109/COMST.2015.2460222.
Impact factor: 25.25

Conferences:

1. **S. K. Singh**, M. B. On, R. Proietti, G. Kanter, P. Kumar, and S. J. Ben Yoo, "Experimental Demonstration of Correlation between Copropagating Quantum and Classical Bits for Quantum Wrapper Networking," accepted in *European Conference on Optical Communication (**ECOC**)*, September 2022.

2. M. Ahmadian, M. Ruiz, M. B. On, **S. K. Singh**, J. Comellas, R. Proietti, S.J.B. Yoo, and L. Velasco, "Designing a Digital Twin for Quantum Key Distribution," accepted in *European Conference on Optical Communication (**ECOC**)*, September 2022.

3. **S. K. Singh**, C. Liu, S. J. Ben Yoo, and R. Proietti, "Machine-Learning-Aided Dynamic Reconfiguration in Optical DC/HPC Networks (Invited)," *International Conference on Optical Network Design and Modeling (**ONDM**)*, Poland, May 2022.

4. **S. K. Singh**, R. Proietti, C. Liu, and S. J. Ben Yoo, "Multi-Cluster Reconfiguration with Traffic Prediction in Hyper-Flex-LION Architecture," *Optical Fiber Communication Conference (**OFC**)*, San Diego, CA, USA, March 2022.

5. **S. K. Singh** and F. Heymann, "On the Effectiveness of AI-Assisted Anomaly Detection Methods in Maritime Navigation," *23rd International Conference on Information **Fusion***, virtual, July 2020. DOI: 10.23919/FUSION45008.2020.9190533

6. **S. K. Singh** and F. Heymann, "Machine Learning-Assisted Anomaly Detection in Maritime Navigation Using AIS Data," *IEEE/ION Conference on Position Location and Navigation Symposium*, Portland, USA, April 2020. DOI: 10.1109/PLANS46316.2020.9109806

7. **S. K. Singh** and A. Jukan, "Computing Blocking Probabilities in Elastic Optical Networks with Spectrum Defragmentation," in proc. of *IEEE Conference on Computer Communications (**INFOCOM**)*, Paris, April 2019. DOI: 10.1109/INFOCOM.2019.8737554

8. M. Bensalem, **S. K. Singh**, and A. Jukan, "On Detecting and Preventing Jamming Attacks with Machine Learning in Optical Networks," *IEEE Global Communications Conference (**GLOBECOM**)*, Waikoloa, HI, USA, Dec. 2019. DOI: 10.1109/GLOBECOM38437.2019.9013238

9. J. Mata, I. De Miguel, R. J. Durán, N. Merayo, **S. K. Singh**, A. Jukan, M. Chamania, "Application of artificial intelligence techniques in optical networks," *IEEE Photonics Society Summer Topical Meeting Series (SUM)*, USA, 2018. DOI: 10.1109/PHOSST.2018.8456691

10. **S. K. Singh**, W. Bziuk, and A. Jukan, "A Combined Optical Spectrum Scrambling and Defragmentation in Multi-Core Fiber Networks," *IEEE International conference on Communications (**ICC**)*, Paris, May 2017. DOI: 10.1109/ICC.2017.7997408

11. **S. K. Singh**, W. Bziuk, and A. Jukan, "Balancing Data Security and Blocking Performance with Spectrum Randomization in Optical Networks," *IEEE Global Communications Conference (**GLOBECOM**)*, USA, 2016. DOI: 10.1109/GLOCOM.2016.7841622

12. **S. K. Singh**, and A. Jukan, "Non-Disruptive Spectrum Defragmentation with Holding-Time Awareness in Optical Networks," *International Conference on Optical Network Design and Modeling (**ONDM**)*, Cartagena, Spain, 2016. DOI: 10.1109/ONDM.2016.7494083

13. **S. K. Singh**, W. Bziuk, and A. Jukan, "Balancing Security and Blocking Performance with Reconfiguration of the Elastic Optical Spectrum," *International Convention on Information and Communication Technology, Electronics and Microelectronics (**MIPRO**)*, Croatia, 2016. DOI: 10.1109/MIPRO.2016.7522214

14. **S. K. Singh**, W. Bziuk, and A. Jukan, "Defragmentaation-as-a-Service (DaaS): How beneficial is it?," *Optical Fiber Communication Conference (**OFC**)*, San Diego, CA, USA, March 2016. DOI: 10.1364/OFC.2016.W2A.55

15. **S. K. Singh** and R. Manivasakan, "Traffic Adaptive Reconfiguration in Virtual Optical Bus Networks," *IEEE International Conference on Advanced Networks and Telecommunications Systems (**ANTS**)*, Bangalore, India, 2016. DOI: 10.1109/ANTS.2016.7947824

16. A. Rostami and **S. K. Singh**, "Design of Virtual Optical Bus Networks: A Heuristic Approach," *European Conference on Networks and Optical Communications (**NOC**)*, Mumbai, India, 2012. DOI: 10.1109/NOC.2012.6249945

AWARDS, ACHIEVEMENTS AND SERVICES

IEEE Member and Reviewer 2016-present
Optical society of America (OSA) recognition for quality peer-reviews, 2020, 2021
Invited Talks 2019-2020
Resource Allocation in Optical Networks, IIT Indore, India
Application of Machine Learning in Communication Networks, VIT, Vellore, India
Summer School and Workshop Participation 2018-2020
Subsea fiber optical communication school by Google, 2019 and 2020
Cloud and edge computing workshop by SixSq, Switzerland, 2018
Outstanding Paper Award 2016
S. K. Singh, W. Bziuk and A. Jukan, "Balancing Security and Blocking Performance with Reconfiguration of the Elastic Optical Spectrum," MIPRO*, Croatia, 2016.*
Recipient of German Govt. Scholarship DAAD, Germany 2011-2012

Graduate Aptitude Test in Engineering rank 835 (99.5 percentile) 2010

Won robotics prizes and Science quizzes; Designed electronic circuits for displaying images and a Microcontroller-programmed cartoon 2007-2009

Communication head, IITM Alumni Association, Germany 2018-2020

School topper and 3rd in the district in 10th Board Exam 2003

REFERENCES

- **Prof. Krishna M. Sivalingam**
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  Dept. of Computer Science
  IIT Madras, India
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  Email: skrishnam@cse.iitm.ac.in
- **Prof. Admela Jukan**
  Department Chair and Professor
  Institute of Compute and Network Engineering
  Technical University of Braunschweig, Germany
  Hans-Sommer-Str. 66, 38106, Braunschweig, Germany
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  Lawrence Berkeley National Laboratory (NBNL)
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