Aniruddha Singh **Kushwaha**

PhD Candidate

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Research Interest

- Programmable Dataplane in Network.
- Software Defined Networking (SDN).
- Datacenter Network Architecture.
- High Speed Optical Networks.

Education

Indian Institute of Technology, Bombay

Mumbai, India

PH.D. IN COMPUTER SCIENCE AND ENGINEERING

July 2015 - Aug. 2018

- Thesis: SDN Architectures for Data-center and Provider Networks (Funded by Google).
  - Designed and developed a scalable and fault tolerant data-centre architecture based on SDN philosophy.
  - The data-centre architecture can scale to a large number of servers (even up to 1 million servers) using off-the-shelf optics and electronics technology.
  - Developed a customized SDN protocol for the efficient working of the control-plane and data-plane of the architecture.
  - Developed an analytical model to calculate the cost and power of the proposed architecture.

Academy of Scientific and Innovative Research (AcSIR)

New Delhi, India

MASTER OF TECHNOLOGY IN ADVANCE SEMICONDUCTOR ENGINEERING

Aug. 2010 - July 2012

- Thesis: GaN/InGaN Solar Cell Design and Fabrication
  - Designed and developed the GaN/InGaN solar cell on the sapphire substrate.
  - Designed an eight layer mask for different fabrication stages.

Work Experience

Department of Computer Science and Engineering, Indian Institute of Technology, Bombay

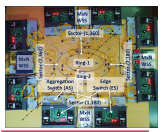
Mumbai, India

RESEARCH SCHOLAR

July. 2015 - Present

- Bitstream: A Flexible and Scalable SDN Protocol (Funded by Ministry of Defence, Govt. of India).
  - Contributed in conceptulizing an SDN protocol for dataplane programmability on a customized hardware.
  - Proposed the hardware and software architecture to realize the concept.
  - Developed the hardware model for the bitstream architecture and implemented on the FPGA.
  - Developed an analytical model to compare the performance of bitstream to other protocols.
  - Created an experimental setup to performed various experiments on the bitstream prototype to evaluate the performance.
  - Led to publications in the top tier journals and conferences.

- FISSION: Flexible Interconnection of Scalable Systems Integrated using Optical Networks
  - Designed and developed a scalable and fault tolerant data-centre architecture based on SDN philosophy.
  - The datacentre architecture can scale to a large number of servers (even up to 1 million servers) using off-the-shelf optics and electronics technology.
  - Developed a customized SDN protocol for the efficient working of the control-plane and data-plane of the architecture.
  - Developed an analytical model to calculate the cost and power of the proposed architecture.
  - Developed optimization models for different traffic scenarios to evaluate the datacenter characteristics.
  - Proposed the wavelength assignment scheme for the backplane of the architecture and evaluated the blocking probability.
  - Created a small experimental setup to measure different metrics of the datacenter.
  - Led to the patent and publications in the top tier journals and conferences



- Network Disaster Management
  - Examined the issue of zonal outages in core networks, especially IP-over-WDM multi-layer networks due to the occurrence of man-made or natural disaster.
  - Developed an optimization model with a goal to provide a network with minimal impact of such disaster by employing the protection schemes.
  - Simulated over network topologies for different disaster radius to evaluate additional netwrok and node capacity required to subdue the effect of disaster on network.

Department of Computer Science and Engineering, Indian Institute of Technology, Bombay *Mumbai, India*

Senior Project Research Scientist *Jan. 2015 - July 2015*

- FISSION: Flexible Interconnection of Scalable Systems Integrated using Optical Networks
  - Worked towards conceptualizing the novel datacenter architecture using off-the-shelf optics and electronics technology.
  - Contributed in improving the backbone of the architecture comprises multiple, concentric bus-based fiber rings to create a switchless core.

Department of Computer Science and Engineering, Indian Institute of Technology, Bombay *Mumbai, India*

Design Engineer *Oct. 2012 - Dec. 2014*

- Segment routing implementation in Carrier Ethernet Switch Router (CESR) (Funded by ECIL, India)
  - Contributed in improving the Carrier Ethernet Switch Router (a FPGA based design which uses source routing scheme for packet forwarding).
  - Implemented the segment routing feature for the CESR to improve the node rechability.
  - Modified the CESR architecture to support jumbo frames.
  - Led to several publications in top tier journals and conferences.
- Partial Colorless-Directionless-Contentionless ROADM design
  - Developed a prototype of the Partial Colorless-Directionless-Contentionless reconfigurable optical add drop multiplexer (ROADM) using LCOS WSS.
  - Simulated the ROADM architecture over various network topologies.
  - Led to several publications in top tier journals and conferences.

Council of Scientific and Industrial Research – Central Electronics Engineering Research Institute (CSIR-CEERI)-Pilani *Rajasthan, India*

Quick Hire Scientist (trainee) *Aug. 2010 - July. 2012*

- Designed and fabricated InGaN/GaN based solar cell on a sapphire substrate.

Teaching Experience

Department of Computer Science and Engineering, Indian Institute of Technology-Bombay *Mumbai, India*

Guest Lecture *Jan-May 2018*

- CS756: Software Defined Networking (SDN) and Network Function Virtualization(NFV).

Department of Computer Science and Engineering, Indian Institute of Technology-Bombay *Mumbai, India*

Teaching Assistant *Jan 2013 - May 2017*

- CS226/254: Digital Logic Design (Spring-2017).
- CS226/254: Digital Logic Design (Spring-2016).
- CS226/254: Digital Logic Design (Spring-2015).
- CS210/288: Digital Logic Design (Spring-2014).
- CS210/288: Digital Logic Design (Spring-2013).

Publications

Patent

1. A. Gumaste, *A. Kushwaha*, "Scalable ultra dense hypergraph network for data centers," USPTO number: 9,960,878, May 2018.

Journals

1. *A. Kushwaha*, S. Sharma, N. Bazard, T. Das and A. Gumaste, "A 400Gbps Carrier-Class SDN White-Box Design and Demonstration: The Bitstream Approach," IEEE/OSA Journal of Lightwave Technology, Vol. 36, no. 15, pp 3115-3130, 2018.
2. A. Gumaste, S. Sharma, T. Das and *A. Kushwaha*, "How Much NFV Should a Provider Adopt?," IEEE/OSA Journal of Lightwave Technology, Vol. 35, no. 13, pp 2598-2611, 2017.
3. *A. Kushwaha*, A. Gumaste, T. Das, S. Hote and Y. Wen, "FISSION (Flexible Interconnection of Scalable Systems Integrated using Optical Networks) Data-Center – Concepts and Demonstration," IEEE/OSA Journal of Optical Communications and Networking (JOCN), Vol. 9 no. 7, pp 585-600, 2017.
4. S. Hote, P. Ghodasara, T. Das, *A. Kushwaha*, S. Sharma, S. Bidkar and A. Gumaste, "Developing and Deploying a Carrier Class SDN-Centric Network Management System for a Tier-1 Service Provider Network," IEEE/OSA Journal of Optical Communication networking (JOCN), Vol. 9 no. 8, pp 711-729, 2017.
5. A. Gumaste, *A. Kushwaha*, B. M. K. Bheri and T. Das, "On the Unprecedented Scalability of the FISSION (Flexible Interconnection of Scalable Systems Integrated Using Optical Networks) Datacenter," IEEE/OSA Journal of Lightwave Technology, vol. 34, no. 21, pp. 5074-5091, 2016.
6. S. Bidkar, A. Gumaste, P. Ghodasara, *A. Kushwaha*, J. Wang and A. Somani, "Scalable Segment Routing – A New Paradigm for Efficient Service Provider Networking using Carrier Ethernet Advances," IEEE/OSA Journal of Optical Communication and Networking Vol. 7 No. 5. pp. 445-460, 2015.

Conferences

1. *A. Kushwaha*, D. Kakadia, A. Gumaste and A. Somani, "Designing Multi-Layer Provider Networks for Circular Disc Failures" to appear in ONDM 2018 : 22th International Conference on Optical Network Design and Modeling, Dublin, Ireland, May 2018.

2. T. Das, *A. Kushwaha*, A. Gumaste and M. Gurusamy, "Leveraging Optics for Network Function Virtualization in Hybrid Data Centers" to appear in ONDM 2018: 22th International Conference on Optical Network Design and Modeling, Dublin, Ireland, May 2018.
3. *A. Kushwaha*, S. Sharma, N. Bazard, and A. Gumaste, "Bitstream: A Flexible SDN Protocol for Service Provider Networks," IEEE Int'l Conference on Communications (ICC) 2018, Kansas City, USA, May 2018.
4. A. Gumaste, *A. Kushwaha*, A. Jukan, "On the Benefits of Programmable Optics for Post-Failure VM Migrations in Data-Centers," Optical Fiber Communication Conference (OFC) 2018, San Diego, USA, March 2018.
5. A. Gumaste, S. Sharma, T. Das and *A. Kushwaha*, "Analyzing the Impact of NFV in Large Provider Networks: A Use Case Perspective" IEEE Int'l Conference on Communications (ICC) Paris, France, May 2017.
6. *A. Kushwaha*, T. Das, A. Gumaste, "Does it Make Sense to put Optics in Both the Front and Backplane of a Large Data-Center?," Optical Fiber Communication Conference (OFC), Los Angeles, California, March 2017.
7. A. Gumaste, S. Sharma, T. Das, *A. Kushwaha*, "Strategies for VNF Placements in Large Provider Networks," Optical Fiber Communication Conference (OFC), Los Angeles, California, March 2017.
8. A. Gumaste, *A. Kushwaha* and T. Das, "DOSE: Double Optics Single Electronics Data-Center using a Switchless Optical Frontplane and Backplane," IEEE International Conference on Communications (ICC), Kuala Lampur, Malaysia, May 2016.
9. A. Gumaste, S. Mahale, *A. Kushwaha*, N. Bajaj and V. Tamarapalli "A Novel pCDC ROADM Architecture using MxN WSS," Twenty Second National Conference on Communications (NCC), Guwahati, India, March 2016.
10. *A. Kushwaha*, S. Mahale, T. Das and A. Gumaste, "A pCDC ROADM Architecture using M×N WSS for Core Networks", IEEE Workshop on Recent Advances in Photonics (WRAP), Bangalore, India, December 2015.
11. A. Gumaste, S. Bidkar, *A. Kushwaha*, S. Hote, P. Ghodasara, P. Agrawal, "Demonstrating a Software Defined Network (SDN) using Carrier Ethernet Switch Routers in a Provider Network," Optical Fiber Communication Conference and Exposition (OFC), Los Angeles, CA, USA, March 2015.
12. S. Bidkar, A. Gumaste, P. Ghodasara, S. Hote, *A. Kushwaha*, G. Patil, S. Sonnis, R. Ambasta, B. Nayak, P. Agrawal, "Field Trial of a Software Defined Network (SDN) using Carrier Ethernet and Segment Routing in a Tier-1 Provider," IEEE Global Communications Conference (GLOBECOM), Austin, TX, USA, December 2014. (Finalist for Best Paper Award)

Skills

Programming	Python, C/C++
HDL Languages	Verilog, VHDL
Optimization Tools	Gurobi
Other Applications/Tools	MatLab, Vivado, ModelSim, VPI transmission Maker

Honors & Awards

Fellowships

- Google India PhD Fellowship-2016 (First awardee from IIT Bombay).
- Quick Hire Scientist (QHS-Trainee) Fellowship by CSIR for the duration 2010-2012.
- Merit based scholarship during undergraduate studies (2006-2010).

Others

- Best Teaching Assistant award in Spring 2016 from the Department of Computer Science and Engineering for an undergraduate course on digital logic design that included a lab and had 100+ students.

Presentation

IEEE International Conference on Communications (ICC) — *Paris, France*

Presenter for <Analyzing the Impact of NFV in Large Provider Networks: A Use Case Perspective> — *May. 2017*

- Introduced the impact of virtualization on the revenue of the provider networks.

IEEE International Conference on Communications (ICC) — *Kuala-Lumpur, Malaysia*

Presenter for <DOSE: Double Optics Single Electronics Data-Center using a Switchless Optical Frontplane and Backplane> — *May. 2016*

- Introduced the use of optics in backplane as well as the frontplane of the datacenter.

National Conference on Communications (NCC) — *Guwahati, India*

Presenter for <A Novel pCDC ROADM Architecture using MxN WSS> — *Mar. 2016*

- Introduced an architecture for partial-CDC ROADM architecture having lower cost and performance comparable to a full CDC ROADM.

Service

Reviewer for

- IEEE Communications Magazine.
- Elsevier Journal on Optical Switching and Networking (OSN)